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INDEX FOR VOLUME XXXIII

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Explanatory Note.

Illustrated articles are marked with an asterisk (*). Book notices are denoted by a dagger (†). Cross references to a particular initial word may apply to any cognate word beginning in the same way. Thus, a reference from "Oil" to "Lubricant" would relate equally to "Lubricating," "Lubrication" or "Lubricator." The cross references condense the matter and assist the reader, but are not to be regarded as conclusive. So, if there were a reference from "Boiler" to "Furnace" and if the searcher failed to find the required article under the latter word, he should look through the "Boiler" entries, or others that the topic might suggest, as he would have done had there been no cross reference. Letters are indexed under title or subject, general articles under writer's name as well. Not all articles relating to a given topic necessarily appear under the same entries.

A

B

POWER

NEW YORK, JANUARY 3, 1911

WE HAVE just passed a period of uplift, so to speak. Perhaps each of us who has been bowling merrily along, doing those things which he ought not to have done and leaving undone those things which he ought to have done, pulled up for a deep breath two mornings ago and solemnly swore, "Never again!"

This is all right and quite natural, for we have just put behind us another milestone; we are just one page nearer to the end of the chapter.

Changing the numerals from 1910 to 1911 drove home a realization of lost opportunities which we meant to improve, but which, somehow, we did not.

And so, with rustling ostentation, we "turn a new leaf," with the high resolve to "make up for lost time," to "brace up" and to do numerous other things plainly beneficial to ourselves. The doing of all these things probably amounts to nothing more than our simple duty; yet we feel uplifted, chastened, better men.

If the case is a usual one, this higher-thought thing wears off in the course of a few days, and the erstwhile better man is indulging in the same old sins of commissions and omissions.

This is mainly the result of force of habit.

This paper is made up of a consolidation of "Power" "The Engineer" "The Engineer's Review" "Science and Industry" "Steam" and "Steam Engineering"

Good resolutions are good resolutions—nothing more.

And of what use are good resolutions except to be broken?

* * *

Man is the victim of habit.

Think it over!

Does habit decide that three meals a day is the proper "caper"—then man eats three meals straightway.

Does habit decide that man shall wear his hair short—then man wears his hair short forthwith.

After a habit has been handed down for a generation or two it is given the pleasanter name of custom. The two habits just mentioned have borne the name custom so long that the bare thought of departing from either seems almost a sacrilege.

Study is a habit, neglect of duty is a habit. "Cussin'" is a habit, and so is surliness.

Forget about those impossible good resolutions and start sincerely to work on your habits. Start *today*, continue *tomorrow* and keep the work up *throughout the year*.

Break up a bad habit and institute a good one. Stick to this policy, and at the end of the current year you will find it hard indeed to draft a set of good resolutions.

Let all your habits be good ones!

Setting Horizontal Tubular Boilers

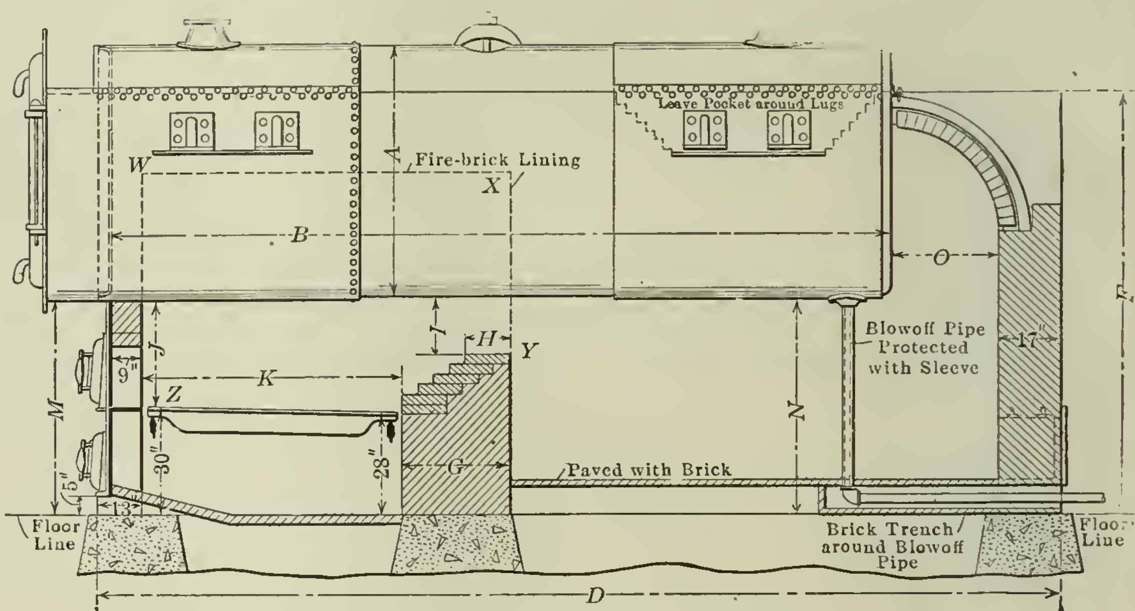
By S. F. Jeter

Directions for constructing the setting of a horizontal tubular boiler, together with the dimensions of different parts of the setting for various sizes of boiler, and the number of bricks required.

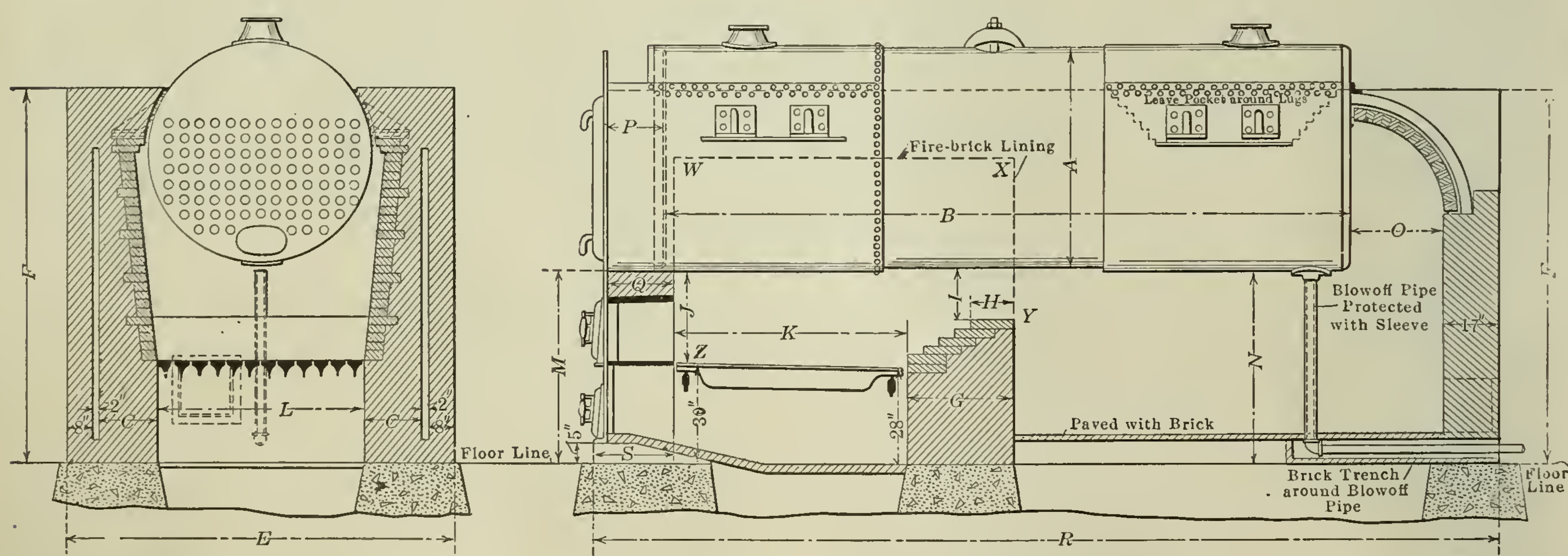
The usual method of purchasing a horizontal tubular boiler is to pay a stipulated price for the boiler, front, attachments, etc., delivered f.o.b. cars on the nearest railroad siding to the boiler room. From this point the purchaser usually makes a contract for the removal of the boiler to the plant and setting it in brickwork, or else turns the job over to his engineer to superintend, and hires a mason by the day to do the necessary brickwork. It frequently happens that in the small plant, which may be located in an out of the way place, that skilled masons cannot be procured, and even where brick masons are plentiful it is frequently difficult to procure one skilled in furnace work. A mason may be first class on general building work, without being able to lay up furnace work that will stand. Although it is impossible to give exact directions for doing such work, the principal features and requirements necessary to secure a good and lasting setting may be pointed out.

Foundations

The first thing that is necessary to secure a setting that will remain tight and free from cracking is a good foundation, which should be prepared before the arrival of the boiler. The manufacturer of the boiler should furnish a setting plan which will give the dimensions of the setting walls, and from this the proper dimensions and location of the foundation walls may be obtained. If a setting plan is not furnished, correct dimensions may be obtained from Table 1, used in connection with Fig. 1. In using these dimensions for a boiler already built, particular attention should be paid to the note, relative to the variations in the several dimensions as may be required, due to the hight of front, length of grate bars or the dimensions of the covering for the rear connection that are furnished, and which may not conform to the sizes given in the table. Also for flush fronts, on account of the depth of the extension sheet varying from that given for P in the tables, several dimensions on such settings would require modification of the figures given. The dimension Q for flush fronts is given uniformally two inches greater than P so that ample protection from the furnace heat may be afforded the extension sheet. It is impossible to give exact directions regarding the depth of foundations or the width of footings necessary, as these points depend entirely upon the nature of the soil at each plant. Formerly, stonework was used almost exclusively for building foundations, but now concrete is in general use. Where the soil is very bad and capable of supporting only light loads, a bed of concrete, properly reinforced and extending entirely over the space occupied by the setting, makes a very satisfactory foundation. It should be remembered that in arranging a foundation for boilers supported on columns, that the load on the portions of the foundations beneath the columns is more concentrated than in the case of lug-supported boilers resting directly on the brickwork, and it is necessary that additional width to the footings be provided at the base of the columns. It cannot be too strongly emphasized that the foundation must be capable of holding the boiler and setting practically rigid, for no matter how well the brickwork is set above it, a weak



Setting for Overhanging Front



Setting for Flush Front

Fig. 1. Diagram of Setting for Use with Table 1

TABLE 1. DIMENSIONS FOR BOILER SETTING

Horsepower on a Basis of 10 Square Feet of Heating Surface per Horsepower: 3-inch Tubes	3½-inch Tubes	4-inch Tubes	A Diameter of boiler in inches	B Length of tubes, feet	Number of tubes of each diameter	C Thickness of side furnace walls, inches	D Over-all width of setting at floor, feet and inches	E Height from floor line to top of setting wall, feet and inches	G Thickness of bridge-wall, inches	H Width of top of bridgewall, inches	I Top of bridgewall to shell of boiler, inches	J Top of grates at front to under side of shell, inches	K Length of furnace, inches	L Width of furnace, inches	M Floor line to bottom of shell at front, inches	N Floor line to bottom of shell at rear, inches	O Distance between tube sheet and rear wall, inches	Approximate weight of boiler and water with allowance for piping and brick covering on top of shell and flue, pounds	Approximate ratio between grate and heating surface when three-inch tubes are used	Number of firebricks required to set one boiler	Number of red bricks required to set one boiler (For Overhanging Fronts Only)	D Over-all length of setting walls at floor line, feet and inches (For Overhanging Fronts Only)	P Depth of smoke box, inches (For Flush Fronts Only)	Q Thickness of front wall, inches (For Flush Fronts Only)	R Over-all length of setting walls at floor line, feet and inches (For Flush Fronts Only)	S Thickness of front wall at floor line, inches (For Flush Fronts Only)
46	44	44	48	12	40-3", 36-3½", 30-4"	17	8'-0"	8'-0"	21½	9	10	26	48	12	36	55	22	16,000	1 to 35	800	13,500	15'-11"	15	17	16'-10"	21
51	46	45	48	14		17	8'-0"	8'-0"	21½	9	10	26	54	12	36	55	22	18,000	1 to 35	850	15,000	17'-11"	15	17	18'-10"	21
72	60	53	54	14	66-3", 44-3½", 30-4"	17	8'-6"	8'-6"	21½	9	12	28	54	18	58	57	24	21,000	1 to 35	900	16,500	18'-1"	16	18	19'-1"	22
84	70	58	54	16		17	8'-6"	8'-6"	21½	9	12	28	54	18	58	57	24	25,500	1 to 40	950	18,000	20'-1"	16	18	21'-1"	22
88	80	64	60	14	72-3", 54-3½", 46-4"	17	9'-0"	8'-8"	26	9	12	28	60	54	58	57	26	32,500	1 to 40	1,100	18,500	20'-3"	16	18	21'-3"	22
105	90	80	60	16		17	9'-0"	8'-8"	26	9	12	28	66	54	58	57	26	33,500	1 to 40	1,150	20,000	22'-3"	16	18	23'-3"	22
120	115	100	66	16	90-3", 74-3½", 60-4"	17	9'-6"	9'-6"	26	11	12	30	72	60	60	59	26	38,000	1 to 40	1,300	20,000	[illegible]-3"	17	19	21'-3"	23
147	122	121	66	18		17	9'-6"	9'-6"	26	11	12	30	78	60	60	59	26	41,500	1 to 40	1,400	22,000	24'-3"	17	19	25'-3"	23
168	140	133	72	16	118-3", 98-3½", 74-4"	21½	10'-6"	9'-10"	30½	11	12	30	72	66	60	59	30	47,500	1 to 42	1,500	25,000	20'-7"	18	20	21'-7"	24
183	165	147	72	18		21½	10'-6"	9'-10"	30½	11	12	30	84	66	60	59	30	51,000	1 to 45	1,600	27,500	22'-7"	18	20	23'-7"	24
200	180	164	72	20		21½	10'-6"	9'-10"	30½	11	12	30	90	66	60	59	30	56,000	1 to 45	1,650	29,500	24'-7"	18	20	25'-7"	24
196	173	160	78	16	148-3", 114-3½", 92-4"	21½	11'-0"	10'-8"	30½	11	12	31	72	72	61	61	30	50,000	1 to 50	1,700	27,000	20'-7"	20	22	21'-11"	26
211	185	168	78	18		21½	11'-0"	10'-8"	30½	11	12	31	78	72	61	61	30	54,000	1 to 50	1,750	29,500	22'-7"	20	22	23'-11"	26
236	205	188	78	20		21½	11'-0"	10'-8"	30½	11	12	31	84	72	61	61	30	58,000	1 to 50	1,800	31,500	24'-7"	20	22	25'-11"	26
260	230	214	84	18	166-3", 132-3½", 114-4"	21½	12'-0"	11'-0"	30½	11	14	31	84	84	61	61	30	62,500	1 to 50	2,500	31,000	22'-7"	20	22	23'-11"	26
286	258	240	84	20		21½	12'-0"	11'-0"	30½	11	14	31	90	84	61	61	30	68,000	1 to 50	3,000	33,200	24'-7"	20	22	25'-11"	26
310	284	267	90	18	210-3", 166-3½", 140-4"	21½	12'-6"	11'-4"	32	11	14	36	84	90	66	65	32	65,000	1 to 45	2,400	32,500	22'-9"	22	24	24'-3"	27
333	310	287	90	20		21½	12'-6"	11'-4"	32	11	14	36	90	90	66	65	32	70,000	1 to 50	2,250	35,000	24'-9"	22	24	26'-3"	27
346	320	302	96	18	248-3", 190-3½", 156-4"	21½	13'-0"	11'-8"	32	11	14	36	84	96	66	65	32	73,000	1 to 55	2,500	33,500	22'-9"	22	24	24'-3"	28
386	350	328	96	20		21½	13'-0"	11'-8"	32	11	14	36	90	96	66	65	32	78,000	1 to 60	2,600	36,000	24'-9"	22	24	26'-3"	28

Note.—In using this table for setting boilers, particular attention must be paid to the fact that dimensions F, J, M and N must conform to the dimensions of the front furnished with the boiler and dimensions K and L with the grates furnished. On flush fronts dimensions Q, R and S depend on dimension P, and these dimensions must be changed to conform to any changes that may be necessary in P. The column giving the number of common brick required refers to the overhanging-front style of setting, and for flush fronts these should be added [illegible] brick, depending upon the size of boiler.

foundation will cause the walls to crack and also may cause stresses on the pipe connections to the boiler that are apt to result in a serious accident.

Unloading

When the boiler arrives at its destination it should be carefully unloaded and transported to the site of erection. In handling a boiler, one should remember that it is usually made up of a number of plates riveted together and that the tightness of each tube depends upon two expanded joints; therefore, the boiler cannot be handled as if it was a chunk of pig iron. The writer has seen a boiler deliberately dropped from the side of a flat car, and the mechanic superintending the job expressed surprise that a block on which it happened to land had dented the shell. The nozzles are most likely to be damaged in handling; and pipes or bars should never be stuck in the tubes to aid in moving the boiler.

Placing the Boiler in Position

It is best to place a boiler in the correct position with the front in place before commencing the brickwork; if the boiler is to be supported on lugs resting on the brickwork it should be placed about a half inch higher than the desired final position, to allow for lowering on the brickwork when the supports are removed. When a boiler is to be hung from beams it can be placed in the correct position at once. None of the weight should be carried by the boiler front, and to insure against this ½ to ¾ inch clearance should be left between the bottom of the shell and the front. Ample clearance between the front and shell is especially important in the lug-supported type in order to allow for settling.

The front end of a boiler should be placed about 1 inch higher than the rear to aid draining through the blowoff pipe when washing out; this also allows an extra inch depth of water over the rear tube ends, which is a precaution against damage from low water. To level a boiler crosswise it is necessary to consider two points, the top line of tubes and the faces of the steam nozzles. Every boiler manufacturer endeavors to have the face of the steam nozzle parallel to a line across the tops of the tubes; but owing to the fact that the nozzle is finished in a lathe and then riveted to the boiler shell, the surface of the flange is sometimes out of true with the top line of tubes. Usually slight differences of this kind can be taken up in the packing of the joint, but if the top line of tubes and the face of the nozzle are out enough to prevent a proper joint being made, the boiler should be set so that the tubes are level crosswise and a special flange used to fit the nozzle to bring the main steam pipe vertical. Many engineers view the matter from a piping standpoint alone and endeavor to level the boiler by the face of the steam nozzle; this, however, is not correct, because the short length of surface at the top of the steam nozzle precludes accurate leveling from this point, and also because it is of more importance that the tops of the tubes be level than the flange of the nozzle. The angularity of the nozzle face can be remedied by the use of a special mating flange, but the tops of the tubes across the boiler not being level means a higher water line and consequently a reduction of steam space which cannot be remedied.

Blocking or barrels placed beneath the shell are generally used to hold a lug-supported boiler in position while the setting walls are being built; however, barrels are preferable to blocking, as they are less in the way of the brick masons. Two heavy oil barrels in good condition can be depended upon to support a 66-inch by 16-foot boiler, if the blocking below them and on top is arranged so that the load is distributed evenly over all the staves. Additional barrels should be used for larger boilers and the blocking on the top arranged so that the load will be distributed evenly between the barrels. If good barrels are not available, a cribwork of blocks placed under the front and rear ends of the shell will serve the purpose. In placing such supports care should be used in the arrangement of the blocking so that it will not interfere with the building of the setting walls.

Materials Required

Some masons still use common lime mortar in building boiler settings, but a much better and more lasting job can be obtained by adding cement to the bonding mixture. First, regular lime mortar is made, using three-quarters of a cubic yard of good, sharp sand to one barrel of lime. After this has been made up in the usual manner, a mixture of sand and cement is made, using two barrels of sand to one barrel of cement (four bags of cement); this mixture of sand and cement is added to the lime mortar and it is then ready for use. This quantity of material should make enough mortar to lay about one thousand brick. If all the mortar cannot be used at once, the sand and cement mixture should only be added to such portion of the lime mortar as will be required for immediate use, as it is difficult to keep it in proper condition for use over night after the cement has been added. Fire clay is the only bonding material that should be used in laying the firebrick and for this purpose it should be mixed with water to about the consistency of buttermilk, so that the bricks may be dipped in it and rubbed together when laying them. About two barrels of fire clay are required to lay one thousand brick.

The temperatures attained in the furnaces of return-tubular boilers are generally moderate, and it does not require a specially high grade of firebrick to withstand the heat; but there is more need of mechanical strength to withstand the wear incidental to the rubbing of the fire tools and breaking off clinkers. On this account a medium grade of firebrick, costing about $22 to $25 per thousand, will be generally found most suitable. Firebrick that are made especially with a view to resisting the very high temperatures are usually mechanically weak and soft and they are also the most costly. For arches in dutch ovens, where there is no danger of hitting the brick with the fire tools, the higher grade of brick generally gives the best service. The common brick used for setting should be well burned and selected for strength rather than beauty.

To estimate the number of common brick required for a boiler setting, figure the number of cubic feet of wall that is to be laid with this kind of brick and multiply by 23; the result will be the number of brick required. In making calculations for the number of brick, no deductions should be made for openings in the setting walls for cleaning doors, etc.; for the waste from breakage and cutting will require all of the extra brick figured in this way. Where fire lining is laid 4½ inches thick and with every sixth course a header, eight firebrick should be figured for each square foot of wall surface lined in this manner. If the lining is to be 9 inches thick and with every sixth course tied to the common brick with a header, fifteen brick should be figured for every square foot of wall surface lined.

TABLE 2. WALL THICKNESSES.

Walls All Common Brick, Inches.	Common Brick Wall Lined with Firebrick on One Side, Inches.	Common Brick Lined with Firebrick on Both Sides, Inches.
8¼	13½	18½
12¾	17¾	23
17	22¼	27¼
21½	26½	31¾
26	31	36
30½		40½
35		45
		49½

Thickness of Wall

Draftsmen usually specify a nominal thickness for the walls on a setting; and often the brick mason (who does not know how much change may be made without affecting the work) is troubled in endeavoring to meet the given dimensions without cutting the brick. For standard-sized brick, Table 2 gives about the proper wall thicknesses to specify, so that they may be laid without cutting the brick.

The sizes of common brick vary slightly with each locality; but the standard is 8¼x4x2 inches and the standard size for firebrick 9x4½x2½ inches. Although the standard sizes of firebrick are so different from the common brick, they lie together correctly because the firebrick are laid brick to brick, while the common brick have about ½ inch of mortar between them.

Design of Setting Walls

Return-tubular boilers are usually set with an air-spaced wall, as illustrated in Fig. 1. Many claims are made as to the benefits derived from such construction, one of the chief being that it lessens the radiation losses by keeping down the temperature of the exposed wall surface. The air space does reduce the temperature of the outer wall surface, but introduces other losses that probably outweigh the gain in economy due to this feature, and it is very doubtful if this form of construction, from an economical standpoint, is better than a solid wall.

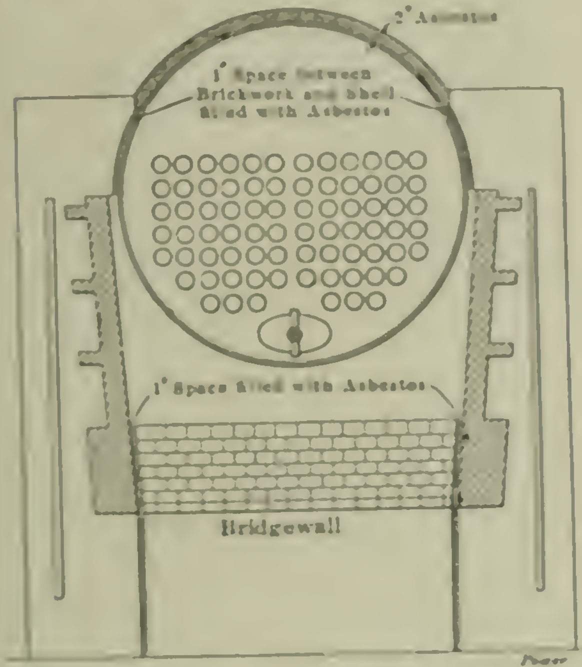


Fig. 2. Showing Clearance at Ends of Bridgewall and Around Shell

The chief advantage of the air-space construction is that when properly built it tends to prevent the cracking of the outer wall surface and, therefore, makes a better looking setting. One very important point in the design of setting walls, to prevent cracking, is the method used to join the ends of the bridgewall with the side walls. Usually a mason will build the two at the same time, and tie the bridgewall rigidly to the side walls. This method of construction is almost certain to result in cracked side walls, because the bridgewall expands when heated and pushes out the side walls. With the wall having an air space this does not necessarily show on the outer wall unless the two are tied together at this point.

There are two ways of preventing trouble from the expansion of the bridgewall. One is to leave the ends of the bridgewall about an inch away from the side walls, as shown in Fig. 2, packing the space with asbestos or mineral wool. The elasticity of the packing allows for the expansion of the bridgewall and it prevents the space from becoming clogged with ash and cinders. The other way to accomplish the same purpose is to build a recess about 4½ inches deep in the side walls having the same shape as a vertical section of the bridgewall, and build the ends of the bridgewall into this recess, leaving 1½ inches of clearance at each end for expansion; this method of construction is shown in Fig. 3.

There are many different ideas regarding the proper shape to be given to bridgewalls and the correct distance that should be left between the top of the wall and the shell of the boiler. The chief function of a bridgewall is to limit the length of the grate surface by presenting a barrier beyond which the spreading of the fuel is prevented; it also aids in mingling the unburned gases and air, so as to cause complete combustion before reaching the tubes. The exact shape or hight of the bridgewall does not greatly affect the attainment of these functions, but it may play an important part in tending to cause or prevent trouble at the girth seams due to overheating. Where girth seams are located in the vicinity of the bridgewall, the top of the wall should be so shaped and of such a distance below the shell that the products of combustion will not impinge directly against the seam. A distance of at least 10 or 12 inches should be left between the top of the bridgewall and the shell to prevent overheating of the sheets, even in the absence of seams; and the top of the bridgewall should be built straight across and not follow the contour of the shell as is sometimes done. All the bricks on top of the bridgewall should be laid as headers, as illustrated in Figs. 1 and 3, so that they may be better able to resist being dislodged by the fire tools. It is much better to rake the top of the bridgewall as shown in Figs. 1 and 3 instead of trying to cut the brick to make them present a smooth slope; for when the bricks are cut, clinker adheres more tenaciously to the cut surfaces than it does to the original surface of the brick.

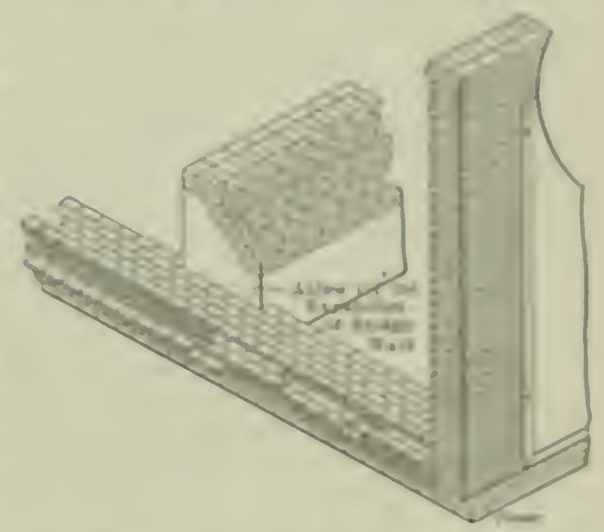


Fig. 3. Method of Allowing for Expansion of Bridgewall

The side walls of a boiler are generally battered as shown in Fig. 1, and this is good construction, especially for a lug-supported boiler; for in making repairs to the lining on the side walls of the furnace the firebrick may be removed and still leave ample support for the boiler.

Combustion Chamber

The combustion chamber at the rear of the bridgewall is a very important feature of the setting, tending to aid complete combustion, especially if bituminous coal is used. The rear slope of the bridgewall should be built vertical and the space behind it down to about the level of the floor should be left open as in Fig. 1, and not filled up and paved as in Fig. 4, which is common practice. The deep combustion chamber at the rear of the bridgewall tends to cause a whirl in the air and gases passing over it and greatly aids in their proper mixture. It also affords storage capacity for the fine ash and cinder that is carried beyond the bridgewall. The practice of filling the space behind the bridgewall to conform to the contour of the shell, as is sometimes done, cannot be too strongly condemned, for it seriously interferes with the accessibility for inspection of the most important surfaces of the boiler, and is certain to prevent complete combustion, if bituminous coal is

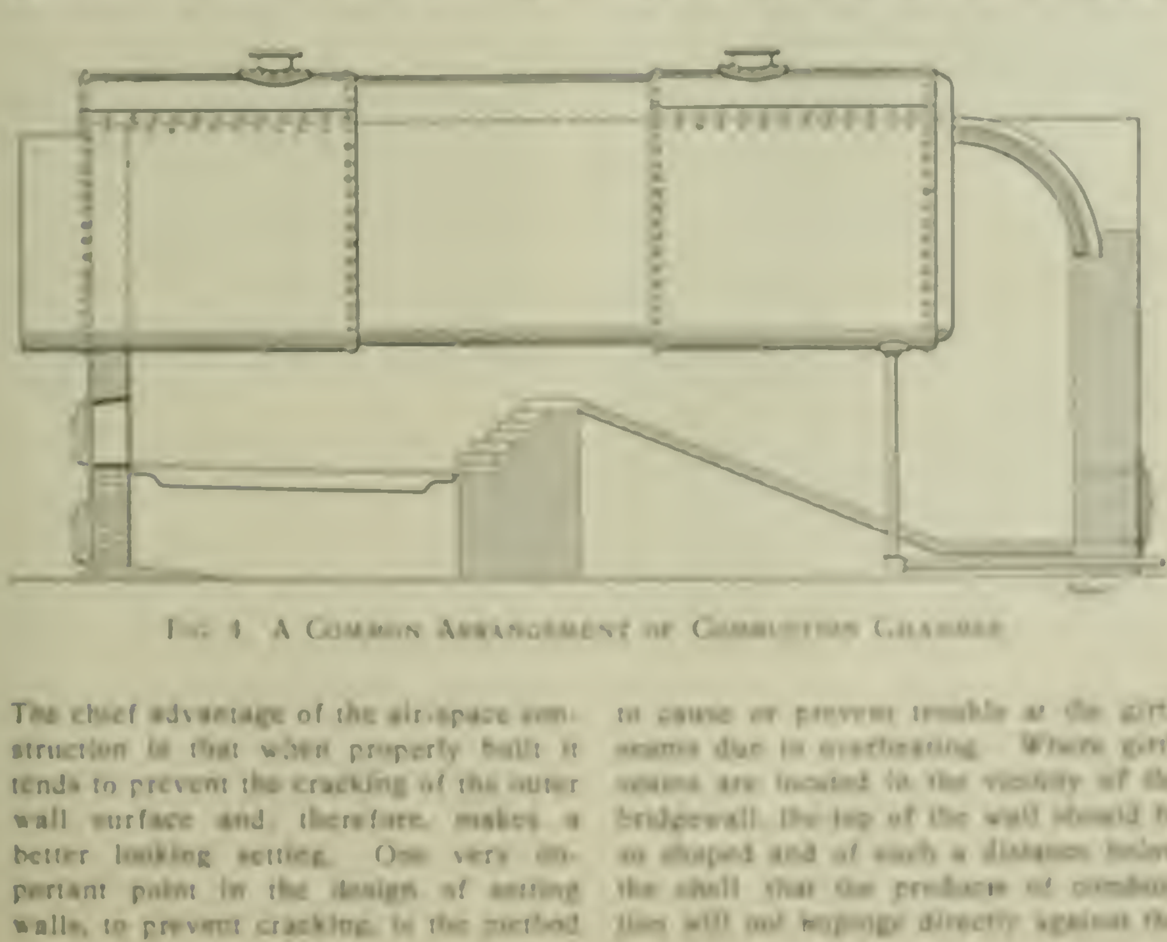


Fig. 4. A Common Arrangement of Combustion Chamber

used. Convenience in cleaning out the combustion chamber is obtained by arranging the bottom of this chamber as illustrated in Fig. 1; so that the blowoff pipe passes out below the paving, and the cleanout door, which is usually located in the rear wall, is placed on a level with the paving so that no obstacle is offered to raking out the ashes. The blowoff pipe should be placed in a brick trough, the bricks on top being arranged so that they may be readily removed for inspection. This arrangement also admits of the blowoff pipe being placed above the boiler-room floor without interfering with free access to the cleanout doors. The vertical section of the blowoff pipe should be protected from the direct impingement of the flames by slipping a pipe sleeve over it; or a form of protection which is equally as good, with the blowoff pipe accessible for inspection, may be made by laying loose firebrick in front of the pipe in the form of a V.

Firebrick Lining

The amount of wall surface that is required to be lined with firebrick is largely a matter of opinion; some engineers prefer to line all of the inner surfaces that are swept by flame and heated gases; but, although this makes a good and lasting setting, it adds considerably to the cost. If the front wall and the side walls over the space indicated by the letters *W X Y Z*, Fig. 1, are lined, together with the bridgewall, and the balance of the setting is laid with good, hard, burned red brick, a satisfactory and very durable job will result. Every fifth or sixth course of firebrick should be a header course to properly bind the lining to the main wall. In laying fire lining too much emphasis cannot be put on the necessity of using the minimum amount of bonding material. Fire clay, which is the only kind of material that should be used for this purpose, should be mixed with water to the consistency of buttermilk and the bricks dipped in it and rubbed down on each other as they are laid. When too much fire clay is used between the bricks where exposed to high temperatures, the clay will fuse and apparently acts as a flux to run out the brick material, resulting in wearing away of the bricks at the joints; a condition that may be noted with improperly laid linings.

Binder Bars

Although it has been the general custom to place binder bars on side walls of settings, it is a debatable question as to whether they are of any real benefit or not, except possibly near the front and rear ends of the setting. When a boiler is set with a dutch oven, there is absolute need of binder bars or their equivalent to carry the thrust of the arch, but no such need exists with the ordinary return-tubular setting where the boiler is hung, and probably not where the boiler is supported by lugs resting on the setting walls.

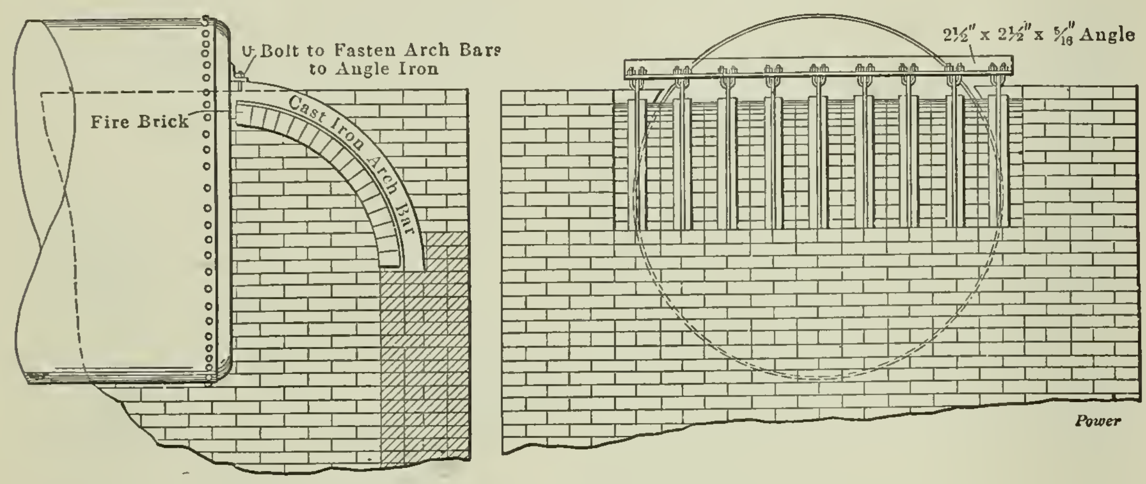


Fig. 5. Best Form of Covering for Rear Connection

Allowance for Expansion

An important point upon which depends the prevention of cracks in the walls of the setting, is the proper provision for expansion of the boiler. In supporting the boiler on lugs it is generally attempted to secure this feature, in part, by providing rollers under one pair of lugs (usually the rear lugs), as shown in Fig. 1. These rollers prevent a lengthwise thrust on the walls due to the expansion of the shell; but it is doubtful if they are of much real value because they do not provide for any movement across the setting. For instance, in a 72-inch by 16-foot boiler the longitudinal distance between the centers of the lugs is about 8 feet, while the distance between centers across the boiler is about 7 feet; hence, the movement across the setting that should be cared for is about as great as it is lengthwise, and the rollers do not aid the movement in this direction. The method of making allowance for expansion between the shell and setting is shown in Fig. 2, where a 1-inch space is left between them and the space filled with plastic asbestos or asbestos rope. The brickwork should not be allowed to touch the boiler at any point, and special care must be taken to keep it free from the rear supporting lugs, pockets usually being left in the walls for this purpose. Another point where clearance is of vital importance is around the pipe connections to the water column and the blowoff pipe, for, unless proper freedom is allowed at these points, there is danger of the pipes being broken off.

Back Connection Covering

This is one of the most difficult points about a boiler setting to keep tight. There are numerous methods of arranging the covering at this point, and one of the best ways to accomplish this, which is in common use in the West and South, is illustrated in Fig. 5. The usual arrangement of this form of covering is to have an angle-iron strap bolted to the boiler head, and the ends of the arch bars rest on the leg that extends outward; but owing to the fact that the angle is exposed to the direct heat of the gases it burns off in a short time. A better arrangement is to fasten the angle to the tops of the arch bars by means of U-bolts, so that they will all line up together. If desired the angle iron may be bolted to the boiler head, although this is not necessary. With this form of covering the arches follow the movement of the boiler head; and by covering the whole surface with plastic asbestos about 2½ inches thick, a tight job is insured. One of the desirable features of this form of covering for the back connection is that it presents a straight line across the head above the tubes, affording ample protection against overheating to the portion of the head above the water line, without interfering with the free passage of heated gases to any of the tubes.

Another method of closing in the back connection that is commonly used throughout the East, is illustrated in Fig. 6. In setting this type of arch, care must be used that the head above the water line is not exposed; and it is sometimes necessary to partially block off one or two of the outside tubes to accomplish this. In the arrangement of all types of covering for the back connection the fusible plug must be left uncovered so that it is freely exposed to the products of combustion.

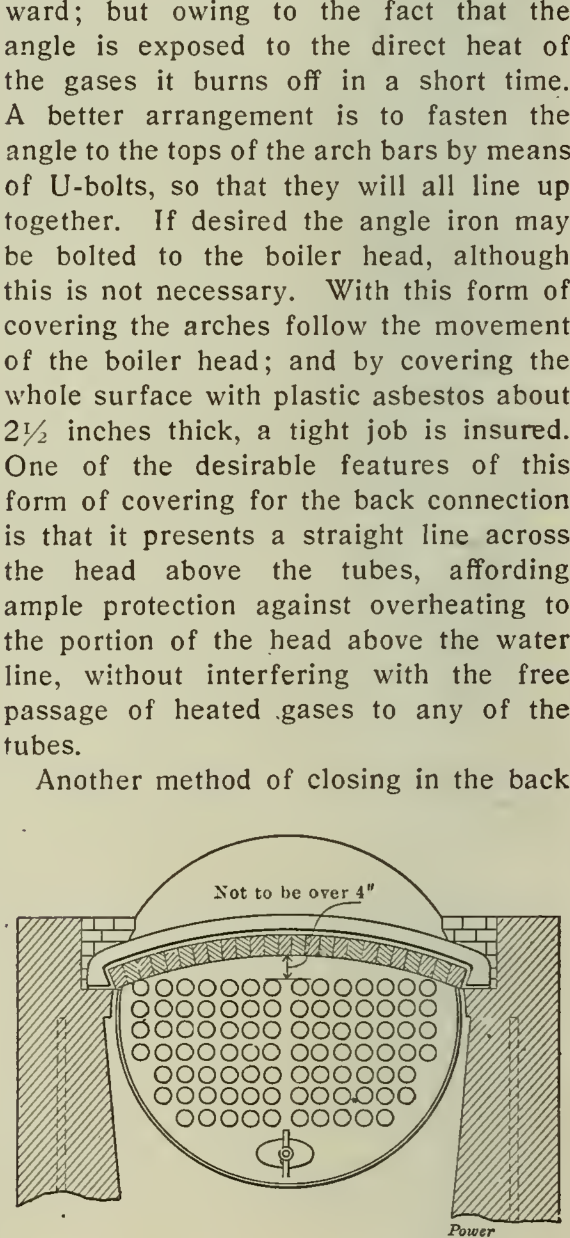


Fig. 6. Cross Arch for Covering Back Connection

Boilers Supported on Columns

Where boilers are hung from beams or channels supported on columns and more than one boiler is used, a column is often placed in the dividing wall between boilers; where this is the case too great care cannot be exercised to keep such columns from being overheated. In such cases there should be at least 13 inches of brickwork between the column and the fire and a 2-inch air space around the column, with free ventilation in this space. To accomplish this, air should be admitted near the bottom of the column through an open duct not less than 10 inches square. These requirements, where a column 8 inches in diameter is used, mean that the minimum wall thickness between the boilers at the grate level must be 38 inches.

Covering the Top of the Boiler

The best covering for the exposed surface on top of a boiler, and the one that will reduce the radiation losses to a minimum, is 85 per cent. magnesia from 2 to 3 inches thick, the outer layer being made with a hard finishing cement. A cheaper covering, but one that will resist wear better than the magnesia and still reduce the radiation losses to a low point, is made of asbestos, but it should be of good grade. The usual covering consists of a layer of bricks laid on edge; but such covering only has cheapness and durability to recommend it, as it is practically worthless as an insulator.

Cost of Setting

With common bricks at $9 per thousand and firebricks from $22 to $25 per thousand, mason's wages at 60 cents per hour and laborers at 30 cents per hour, a very accurate estimate of the cost of a boiler setting may be obtained by figuring $22 per thousand, laid, for the common brick and $45 per thousand, laid, for the firebrick. The cost, laid, will rarely exceed $25 and $50 per thousand for common and firebrick respectively.

Setting Water Columns

In setting a boiler attention should be given to the proper location of the water column; it should be placed so that the lowest gage cock is at least 3 inches above the tops of the tubes, and the lowest point of vision in the gage glass at least ½ inch above the tops of the tubes. The latter point is of great importance, for it is often a temptation for an engineer to take chances as long as he can see water in the glass, although he may realize that it is lower than safety demands and it is therefore best to prevent the water level from being seen after the lowest point for safety has been reached.

Starting Boilers

No matter how carefully a boiler setting has been built, it can be badly damaged and cracked, by carelessness in starting up. No setting which has just been completed should be operated in regular service without a thorough drying

Chimney at Queen Lane Filter Plant, Philadelphia

out, this drying is accomplished by keeping a slow fire under the boiler for at least a week, and longer if circumstances will permit. The interior of a new boiler should always be thoroughly cleaned of oil, dirt, etc., and the best way to accomplish this is to boil slowly with a strong solution of soda ash, and in this way the drying of the setting walls and the cleaning of the boiler can be accomplished simultaneously.

A Handsome Chimney

In these days when the high cost of living is a problem which baffles satisfactory solution, the industrial-plant proprietor is less than ever inclined to spend good hard cash to satisfy the artistic tastes of the members of the community where the plant is located. A chimney is bought for the amount of draft it will create and gases it will handle. The purchaser usually wants the most stack for the least money. Consequently, few chimneys are on view that have any work on them for purely ornamental purposes.

Occasionally, however, conditions may be such that the expenditure of money to produce ornamental effects in chimney and power-house design is justified. Such a set of conditions exists at the Queen Lane Filter Plant, Queen Lane and Fox street, Philadelphia. The accompanying figure is a view of the chimney at this plant. It is reputed to be the handsomest chimney in America. The plant is located in a high-class residential section of the city and any building or plant which would tend to detract from the desirability of the neighborhood would of course have a bad influence on the value of the surrounding property. For this reason it was found justifiable to go in for the esthetic in the matter of building ornamentation.

The chimney is 125 feet high and 6 feet in diameter inside. It serves six horizontal return-tubular boilers, the total rated capacity of which is 900 horsepower. The lower portion or base of the chimney is of granite and terra-cotta. The upper portion or shaft is constructed of radial brick, faced with pearl-gray blocks to match the terra-cotta ornaments of the cap and base. The round column or shaft of the chimney has a double entasis; that is, a double curvature, which is used to overcome the optical illusion which a straight shaft gives of being concaved. This is the design which was applied by the Greeks and Romans to the columns in their temples.

The general scheme of ornamentation is Italian Renaissance. The architect employed conventionalized water forms as motives of decoration, both on the chimney and the power house itself, as being indicative of the character and use of the structures. It will be noticed in the view that use is made of shells, cat tails, dolphin heads, star-fish, etc., cleverly placed as motives of decoration instead of the more commonplace garlands and flowers, etc.

In designing the ornamentation of the cap, it was necessary to give them very bold and vigorous relief, otherwise they would have been lost to view on account of the great hight; hence, the large medallions or disks, surmounted by the huge lion heads, which form so conspicuous a climax to a structure unique in the annals of chimney building.

The total cost of the chimney complete was $15,500. Under the existing circumstances it is undoubtedly true that the expenditure of this sum was justified. A radial-brick chimney of the same capacity for an industrial plant could be purchased complete for approximately $4000.

The chimney was designed by Architect William E. Groben, of Philadelphia, and erected by the M. W. Kellogg Company, contractors, New York City.

The Old Burden Water Wheel

Old overshot wheel built at Troy, N. Y., in 1851, said to be the largest in the world. It is 60 feet in diameter, 22 feet wide and at two revolutions per minute developed 600 horsepower.

One of the most interesting landmarks of Troy, N. Y., is the old Burden waterwheel. Its days of usefulness, however, are over and it is fast going to decay. The old mills for which it furnished power are in ruins and all that remains of the once busy industry are the toppled down walls, the old waterwheel and the iron penstock leading to it from a grass- and weed-covered canal. The new Burden iron works are located near the Hudson river and point to the march of progress in the steel industry; the old discarded mill indicates the primitive generation of power sixty years ago.

Henry Burden, the founder of the original Burden iron works, was the inventor of many appliances, but his greatest achievement was in designing the immense waterwheel, shown in Fig. 1, which was constructed in 1851. It is of the overshot type and was capable of developing 1200 horsepower. It is 60 feet in diameter and 22 feet wide and contains 36 buckets, each 6 feet deep. These are shown in Figs. 2 and 3.

Fig. 1. Old Burden Waterwheel Built in 1851

The axis is composed of six hollow cast-iron tubes keyed into flanges, from which diverge two hundred and sixty-four 2-inch iron rods terminating at the outer edge of the wheel.

The two axis flanges are made with bearing shafts 12 inches in diameter. The bearings in which these shafts rested are each supported by an iron frame which set on a brick foundation built between the two upright brick piers shown in Figs. 1 and 4.

Power was transmitted to jack shafts by means of small gears meshing into a toothed rim placed on the outer circumference and outside edges of the waterwheel as shown in Figs. 1 and 4. The jack shafts transmitted the power to the mill rolls by means of shaftings which extended from the flywheel and gears as shown at the left of Fig. 1.

The flow of water was governed by a rod and handwheel, the upper end of the extension rod supporting a worm which meshed with a gear, mounted on a shaft that extended from one side of the wheel to the other, on top of the flume, and supported by suitable bearings, as shown in Fig. 4.

By turning the handwheel and rod, the shaft and gear were revolved in the direction desired, and by means of gears and racks, the latter being attached to the stem of each gate in the flue, the gates were opened or shut. The water was thus regulated in flowing from the penstock to the four outlets over the buckets placed between the three metal distance pieces.

The water was brought to the wheel through an iron penstock, which extended out over the waterwheel, the water coming from the canal through the farther gate shown in Fig. 5. The second gate was for the purpose of emptying the canal.

This old waterwheel is said to be the largest in the world. When running at a speed of two revolutions a minute, between 500 and 600 horsepower was developed. A wheel of larger diameter was constructed at one time at Wales, but being of less width and depth of buckets developed less power.

Fig. 2. With the Buckets Full of Water the Wheel Revolved Toward the Foreground

The First Steam Cylinder Used in America

In a glass case in the National Museum at Washington is preserved the cylinder of the first steam engine ever run in America. The following extracts from a letter of the Hon. Joseph T. Bradley, Associate Justice of the Supreme Court of the United States, dated at Washington, September 20, 1875, to David M. Meeker, of Newark, N. J., into whose possession, we understand, the cylinder had come, contains pretty nearly all that is known in reference to this interesting relic:

"The steam engine of which this is a

portion of the cylinder was the first ever erected on this continent. It was imported from England in the year 1753 by Col. John Schuyler for the purpose of pumping the water from his copper mine opposite Belleville, near Newark, N. J. The mine was rich in ore, but had been worked as deep as hand or horse power could clear it of water.

"Colonel Schuyler having heard of the success with which steam engines—then called fire engines—were used in the mines of Cornwall, determined to have one in his mine, and accordingly requested his London correspondent to procure an engine and to send out with it an engineer capable of putting it up and in operation. This was done in the year named and Josiah Hornblower, a young man then in his twenty-fifth year, was sent out to superintend it.

"Mr. Hornblower's father, whose name was Joseph, had been engaged in the business of constructing engines in Cornwall from their first introduction in the mines there—about 1740—and had been an engineer and engine builder from the first use of steam engines in the art—about 1720.

"The engines constructed by him and his sons were the kind known as Newcomen engines, or Cornish engines. That brought to America by Josiah was of this construction. Watt had not then invented his separate condenser, nor the use of high pressure, but it is generally said that for pumping purposes the Cornish engine has still no superior.

"About 1790 the Cornish mine was worked for several years by Mr. Hornblower himself. The approach of the war in 1775 caused its operation to cease. Work was resumed, however, in 1792 and was carried on for several years by successive parties. It finally ceased altogether in this century and the old engine was broken up and the materials disposed of. The boiler, a large copper cylinder standing upright, 8 or 10 feet high and as large in diameter, with a flat bottom and dome-shaped top, was carried to Philadelphia. A portion of the cylinder was purchased by some person in Newark.

"In 1844 I met an old man named John Van Emburgh, then 100 years old, who had worked on the engine when it was in operation in 1792. He described it very minutely, and I doubt not accurately. It is from his description that I happen to know the kind of engine it was, although from the date of its construction and the use to which it was put there could have been little doubt upon the subject."

Fig. 3. Showing Design of Buckets

Fig. 5. All That Is Left of the Old Gate Control

Fig. 4. Penstock and Arrangement of Gate Control

The pumps for drawing water from the lake at Chicago to dilute the sewage of the city are to be operated by electric motors. Recently, one of the triple-expansion vertical engines was replaced by a 750-horsepower motor. This motor, though but a small machine compared to the steam engine, has the same pumping capacity, namely, 40,000 cubic feet per minute. It is operated with current supplied by the hydroelectric transmission system of the sanitary district.

Gravity Turbine Oiling System

By Hugh Hughes

Description of the design and operation of a gravity oiling system for a vertical turbine. Bypasses are extensively used so as to secure flexibility of feed and continuity of operation.

Much has been written about engine-oiling systems, and much may be written on turbine-oiling systems. The simplest form of the latter is the gravity feed which in all respects resembles that employed for engines. Its possibilities, however, when applied to turbines are not fully appreciated. By arranging a few bypasses, with valves properly placed, almost any combination of feed may be obtained. Referring to the left half of the accompanying figure, *A* is the lower receiving tank; *B* the suction to oil pumps; *C* the discharge to the upper receiving tank *D*; *E* the feed to the reservoir *F*; *G* are sight feeds on the line *H* to top bearing and the line *J* to middle bearing; *K* and *L* are the returns from the top and middle bearings respectively. The greatest head of oil that that can be brought upon the upper bearing with this system is about 3 feet. If the bearing has no tendency to heat, this is quite sufficient; but it costs but very little more to pipe in the bypass *M*, by means of which the direct pressure of upper tank *D* may be brought on this bearing. The connection *N* is a bypass that will bring this pressure on the middle bearing also. If still more pressure is required, the oil pump may be made to discharge directly into the feed line through the bypass *O*.

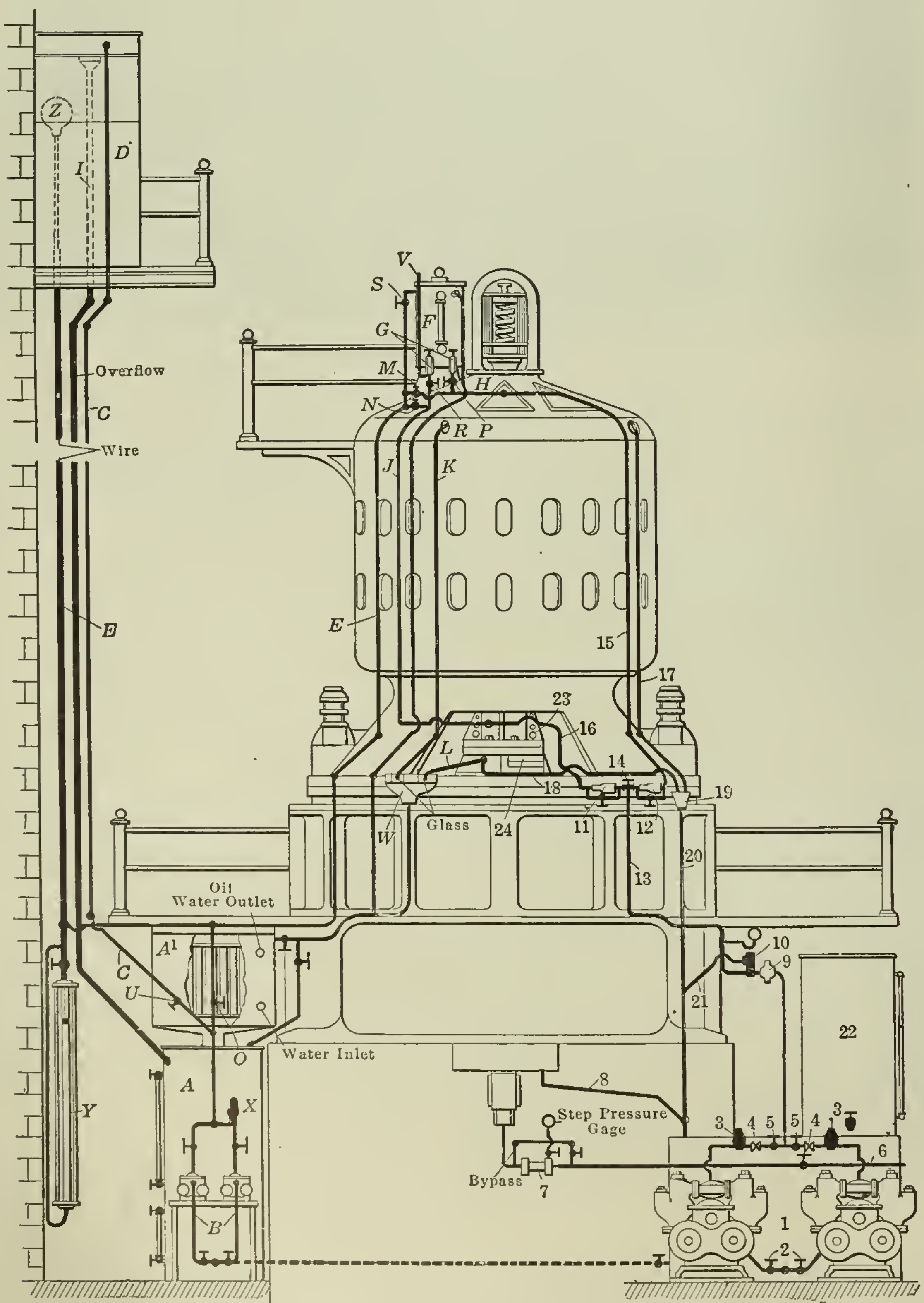


Fig. 1. Gravity Turbine-oiling System

In practice, the bypasses would be employed somewhat as follows:

To feed more oil to the top bearing, close the valve *P* and open valve *M*; to middle bearing, close the valve *R* and open *N*; to both bearings, simultaneously close the valves *P*, *R* and *S* and open *M* and *N*. If, for any reason, the upper tank *D* and the reservoir *F* are allowed to run dry, open the valve *O* and close *U*, and pump directly into the feed line, for it will take some time for the oil to reach the reservoir if allowed to follow its usual course, especially if air enters the pipe. In this dilemma, if the bypass *O* is not included in the system, draw a bucketful of oil from the tank *A*, or any other source, and empty it into the reservoir *F*; keep doing this until oil in sufficient volume is delivered to it from the top tank *D*.

Some believe that better lubrication is obtained by piping an air vent below the sight feeds as shown at *V*. Others, in cases where the flow of oil is subject to frequent stoppages, prefer to keep the reservoir *F* for emergencies only, the oil being led to a tee above the sight feeds and the reservoir outlet closed by a valve which is opened only when the regular feed stops. The returns from the bearings should be piped separately, and at some point should be open, so that the amount of oil passing through each bearing can be seen and its temperature ascertained. Some have the two returns discharge into a funnel open to the atmosphere as shown at 19. If the engine room is dusty, especially if it is subject to coal dust, it is better to have the returns discharge through oil-cup glasses with tin or brass covers as shown at *W*. It is good practice where the pump discharge is piped directly to the feed line, as through the bypass *O*, to mount a small relief valve as shown at *X*. Very often it is the case that the oil line in the glass gage of the upper tank cannot be seen from the floor below. An arrangement for indicating the quantity of oil in the tank is shown at *Y*. This is simply a glass tube piped to a continuation of the downward feed pipe. The ball *Z* floats on the surface of the oil in the tank *D*, and is guided by a short length of quarter-inch tubing. To the end of this is attached a straight piece of light wire of a length sufficient to reach the glass gage *Y*. Any dark object pendant at the end of the wire is very easily distinguished if the glass is filled with clear water. The internal piece I of the overflow pipe from tank D is screwed hand tight only, so that it can easily be removed when it becomes necessary to drain the tank. It will be noticed that the oil pumps are shown with the oil ends outward. This way of installing is preferable to the universal practice of side exposing, for one pump is as accessible for repairs as the other. With

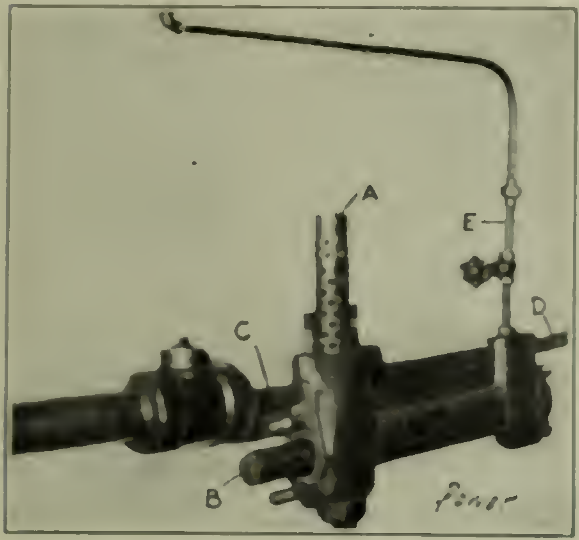


Fig. 2. The Baffler

the other arrangement, if repairs are needed to the inside pump, one must lean over the outside pump, which may be in service, and the repair man is lucky to escape without burns.

In many turbine plants oil coolers are now being installed, so that the oil is used not only to lubricate a bearing but also to cool it by carrying away the heat generated. One form of cooler is shown at A'. The water is obtained by tapping the discharge of the circulating pump. Cooling the oil condenses the vapor it may contain, which falls to the bottom of the receiving tank A. This tank should therefore be equipped with two separate sight glasses as shown, to establish clearly the true quantity of water present. When only one long glass is used the water at the bottom will be forced up in it, by the weight of the accumulating oil. I have seen a barrel of oil turned into the sewer by an attendant, who mistook the water level in the glass as indicating the water level in the tank. So far, it has been assumed that the step bearing is subject to hydraulic pressure. When oil is the balancing medium employed, it is good practice to use the same system of oiling the upper bearings as described above. The only change necessary is to substitute the larger storage tank 1 for the receiving tank A. The course of the oil to the step bearing would be from storage tank 1 through suction valves 2 to the step-bearing pump; thence under relief valve 3 through the check valve 4 and the stop valve 5 to the accumulator 6 and the baffler 7.

The oil returns from the step and guide bearings to the storage tank through the pipe 8. Valves 3, 4 and 5 are shown elevated in the figure merely to obtain space to map them. In some plants oil for the upper bearings is taken directly from the step-bearing pumps discharge, the pressure being lowered by the reducing valve 9. Tanks A and D and the pair of small oil pumps on the left-hand side are now done away with. If the top reservoir F is retained, the gravity feed is again restored on the two upper bearings; if it be removed and the feed led directly to the bearings then the relief valve 10, and the two bafflers 11 and 12, one on each feed branch, should be installed. The course of the oil now is: From the step-bearing pumps discharge through the pipe 13, to the cross valve 14, where it divides and enters the baffler 12 and the pipe 15 for the top bearing, and the baffler 11 and pipe 16 for the middle bearing. The returns 17 and 18, from the top and middle bearings respectively, enter the funnel 19, from which to the storage tank they have pipe 20 in common. The relief-valve discharge is at 21.

With such a system it is in line with good practice to have a reserve tank 22 to be used for sudden emergencies or to replenish storage tank automatically. In some plants where the turbine is run continually, and much vapor is present in the oil, the storage tank is in duplicate and each is used alternately, thus allowing time for the oil to cool and the water to settle and be drawn out from one while the other is in service. The storage tank should be placed at as great a distance below the step bearing as it is possible in order to allow for some head for the oil return. Some oil step bearings are provided with a small pipe open to the atmosphere and entering the space between the oil and the carbon packing to facilitate the flow of the return oil and prevent its intermixture with the condensed steam used to seal the vacuum. This can also be somewhat aided and air prevented from entering the return by piping it on the principle of an ejector to the common return 20 as shown in the figure. The down-flowing oil in this pipe, if the connections are properly made, will have a tendency to siphon out the waste oil from the guide bearing.

Fig. 2 shows an adjustable baffler. A is the strainer, B the baffler screw, C is the oil inlet and D the oil outlet; E is a pressure-gage connection. At the other end of the baffler screw B is an adjusting screw the head of which, when the baffler is in place, rests against the cover on the outlet side of the baffler chamber. The more this bolt is backed out of the baffler screw, the more will the oil pressure be reduced. If manipulation of this screw does not give the desired flow of oil a piece may be sawed off the end of the baffler, or one having a coarser thread may be substituted. As a rule, the baffler is designed to reduce the pressure about 25 per cent., though this depends materially on the viscosity of the oil. Altogether it is an ingenious contrivance for causing trouble if not regularly inspected.

Most readers have seen in Power sectional cuts of the upper and lower bearings of a Curtis turbine, and some have conceived the idea that they are very complicated affairs. Fig. 3 shows these members for a 2000-kilowatt turbine when stripped of all supports. A drip pan, which is generally bolted to the bearing support, and an oil deflector cast on the turbine shaft to throw the waste oil by centrifugal force into the drip pan would about complete the bearing. The part A is the top bearing, which fits tightly into the top bracket of the turbine. The governor and governor hood must be removed to get at it. Oil enters the bearing through the small holes B and leaves around the bottom or by the row of upper holes C. The parts D are the two halves of the middle bearing, which are locked together by an outer shell, also in halves and bolted together. These locking bolts are to be seen at 23 in Fig. 1, while 24 is the drip pan mentioned. The part E, Fig. 3, is the shaft lining.

A description of the newer styles of bearings will be found in back numbers of Power. If a bearing has a tendency to throw oil into the generator fields, or if steam escapes from around the high-pressure carbon packing and commingles with the oil in the drip pan of the middle bearing, felt washers held gently against the shaft by sheet-iron straps should be secured to the bottom of the oil pans or top of the bearing brackets. In some places

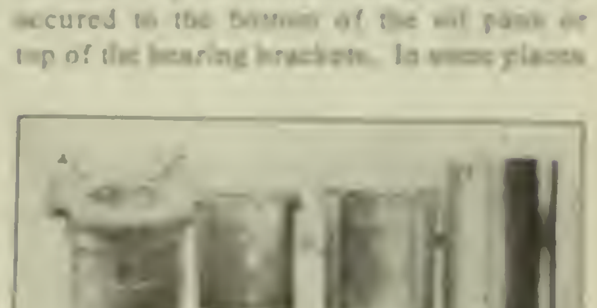


Fig. 3. Parts of Upper and Lower Bearings

a practice is made of oiling the high-pressure carbon rings upon starting the turbine. An oil cup, secured to a pipe which ends as close as possible to the shaft, is filled with freshly mixed graphite and cylinder oil. While the turbine is slowly revolving and more or less air is being drawn in around the carbon bearing, the mixture is let out of the cup. Oil feed, however, must be used sparingly as it is liable to gum the carbon packing rings and cause them to stick in their receptacles.

Modern Steam Superheaters

By Warren O. Rogers

A general description of the few successful types of American superheater, dealing with their features of design and application to various types of boiler, flooding and control of the furnace gases passing over the members.

Less than ten years ago hundreds of engineers held the opinion that, although the water consumption of a steam engine would be reduced by superheating the steam, the extra fuel required would offset the saving in the water consumption. But when the facts are fully considered there can be no doubt in the minds of those who have taken the trouble to inform themselves that, with a properly designed plant, the superheater will add to the economy.

In 1860, when the question of superheating was first taken up, the pressure carried in steam boilers ranged from 25

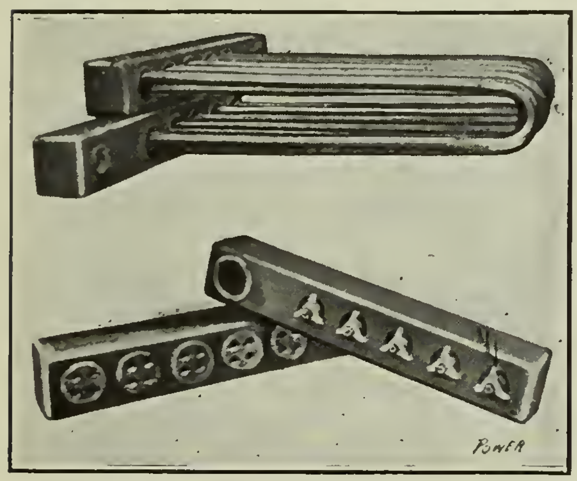


Fig. 1. Header and Tubes of Parker Superheater

to 50 pounds per square inch. With these low pressures tallow was found to answer very well for cylinder lubrication, but the use of superheated steam brought trouble to the engineer, because the high temperature of the steam dried up and decomposed this animal oil.

About this time, however, engine builders began building compound engines which demanded higher boiler pressures, and as this demand was met, the desirability of superheating the steam decreased. Furthermore, this increase in steam pressure made the use of superheated steam all the more difficult. For this reason superheating was practically abandoned for a period of thirty years.

About 1890 superheating was taken up by engineers in European countries, and was carried on successfully, especially by the Germans. The problem was solved by using a high-grade mineral oil for lubricating purposes, together with valves and cylinders of suitable design. The demand for superheated steam brought out the superheater, of which there are several types made in this country that give very satisfactory results.

There has been, and still is, a difference of opinion as to how high steam should be superheated. A common range

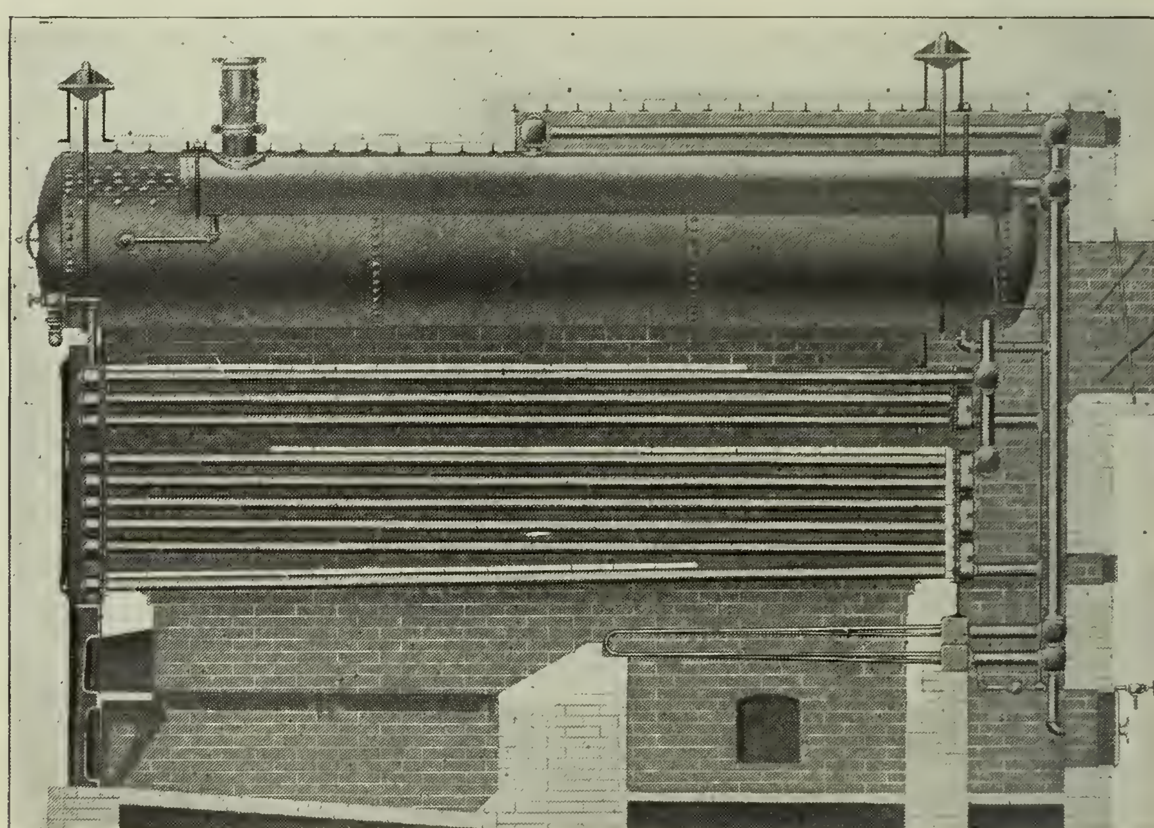


Fig. 2. Parker Superheater as Applied to a Parker Down-draft Boiler

is from 100 to 200 degrees of superheat, and 150 degrees is considered a maximum figure by many engineers.

A common objection to using superheated steam is that it has been the cause of many ills which are not encountered when using saturated steam. Packing troubles, however, have been practically eliminated; lubrication of the valves and piston can be satisfactorily maintained, and troubles from failure of pipes and fittings are being greatly reduced. As to the superheater itself, one company that has made superheaters for fifteen years has never been called upon to make a single repair due to damage from excessive temperatures.

A superheater contained within the boiler setting is perhaps the most efficient type when the steam is not to be superheated more than 200 degrees. Such superheaters require no additional space in the boiler room, unless it is an in-

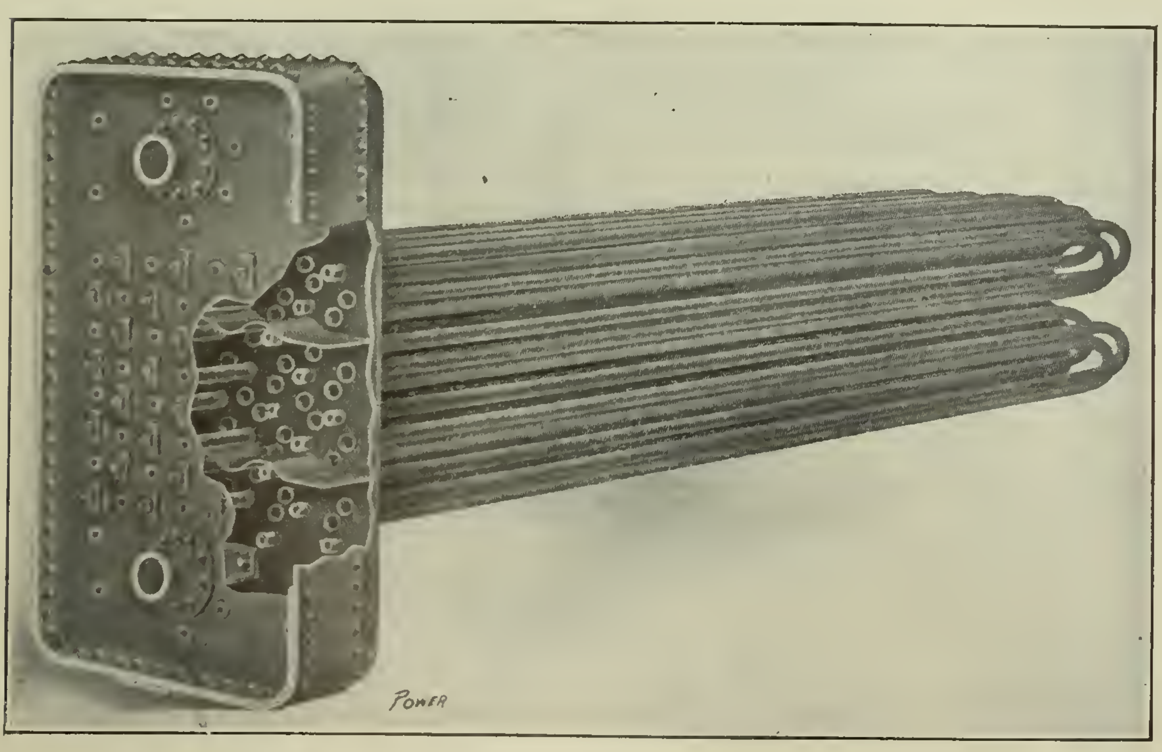


Fig. 3. Details of Tube and Header Construction in Heine Superheater

creased hight in the boiler setting, and the amount of piping required is very small. A superheater so arranged is, however, subject to the fluctuating temperatures of the furnace, for, if the boiler is forced, the superheater is correspondingly affected by the increased temperature of the furnace gases. It is also subjected to the cooling effects of air admitted through the fire doors, which naturally cools the gases passing to the uptake.

Cast iron, which was at one time largely used in the construction of superheaters, is gradually being replaced by stronger metals, especially where high steam pressures are concerned. At best it is a treacherous metal when subjected to temperature changes, and cannot compare to point of safety with forged steel, cast steel and drawn-steel sections.

In this article several types of superheaters will be taken up and attention given to their principles of design, methods of attaching to the boiler, flooding, and their general characteristics.

Fig. 4. Heine Boiler and Superheater

Parker Superheater

This superheater, which is used in connection with the Parker down-flow boiler, consists of a number of seamless drawn-steel tubes of small diameter, the number and length being proportioned to the degree of superheat desired. The tubes are bent into U forms and are expanded into steel headers. The general design of the headers and U tubes is shown in Fig. 3; front and back views of the headers are also shown.

An unique feature of this superheater is the use of the superheater drum or separator between the superheater and the steam nozzle. This prevents carrying the flooding water into the steam line, and saves the heat that would be wasted by draining the superheater.

Connection is made from the lower head of the superheater to the steam space of the steam drum of the boiler by a tube expanded into malleable-iron fittings. The top superheater header is connected to the steel superheater drum in a similar manner. At the end of the drum farthest from the superheated-steam inlet is the steam outlet from which connection to the steam main is made. This drum, which is shown in Fig. 2, acts as a separator, and has sufficient capacity to handle all of the water discharged from the superheater and connections when getting up steam in a cold boiler, or when putting a banked boiler on the line, the circulating water being returned directly to the superheater from the drum. The superheater is fitted with a drain connection for returning all excess water to the boiler drum. Thus the superheater automatically floods itself with the water of condensation when the fires are banked and requires no special attention in this regard.

Fig. 2 shows the general appearance and arrangement of this type of superheater. It is placed near the fire and thus requires only a small amount of heating surface.

All of the hot gases from the burning fuel must pass to the rear of the boiler before passing up among the boiler tubes, owing to the baffle wall placed on the upper side of the lower row of tubes for the greater portion of their lengths. This brings the superheater practically in the direct path of the heated gases.

The superheater is located near the bottom row of boiler tubes where more

Fig. 5. Sectional View, Showing Path of Gases

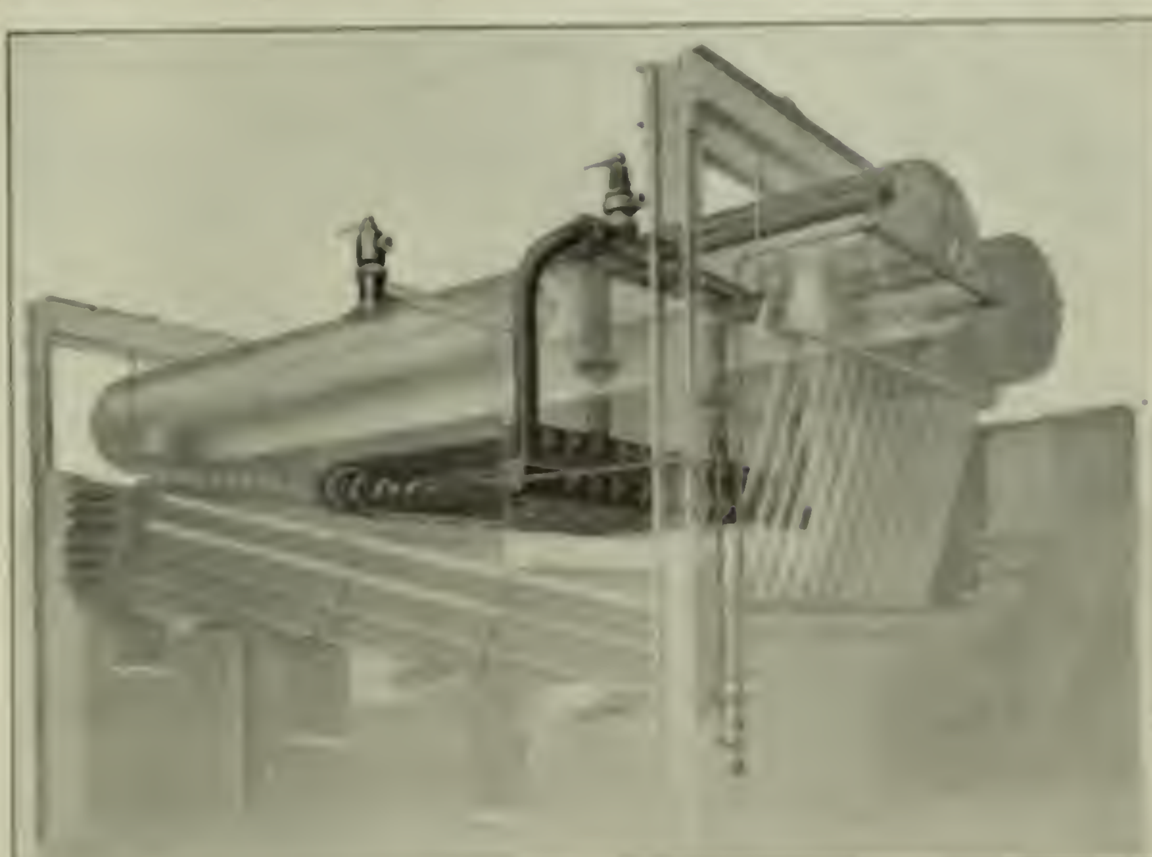


Fig. 6. Phantom View of Babcock & Wilcox Superheater Attached to a Boiler of the Same Make

of the steam is generated, and any change in the condition of the fire affects the boiler and superheater simultaneously, maintaining a remarkably uniform degree

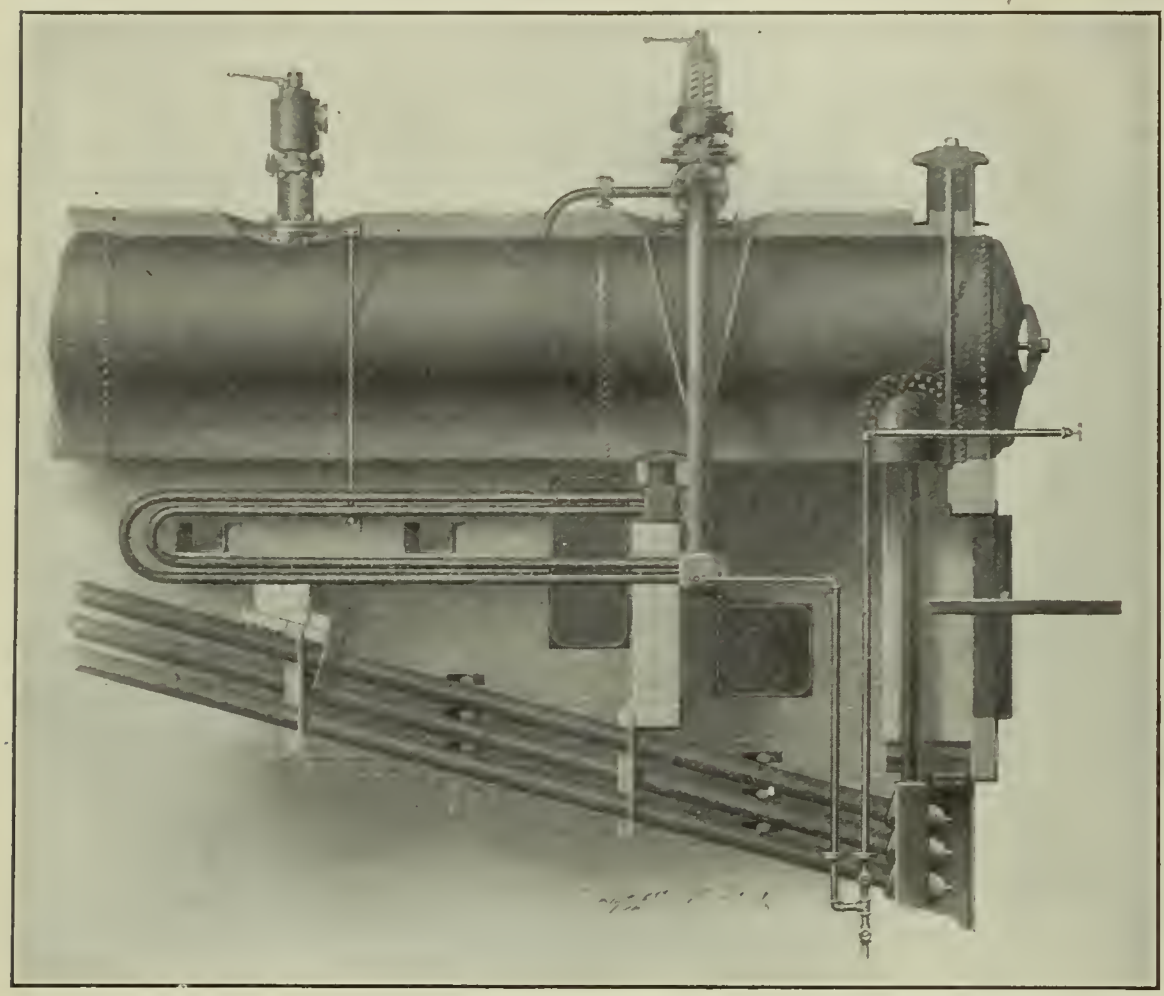


Fig. 7. Showing Position of Headers and Flooding Arrangement

of superheat. Another advantage of this location is that the size of the boiler setting is not increased, and there are no losses due to radiation and air leakage.

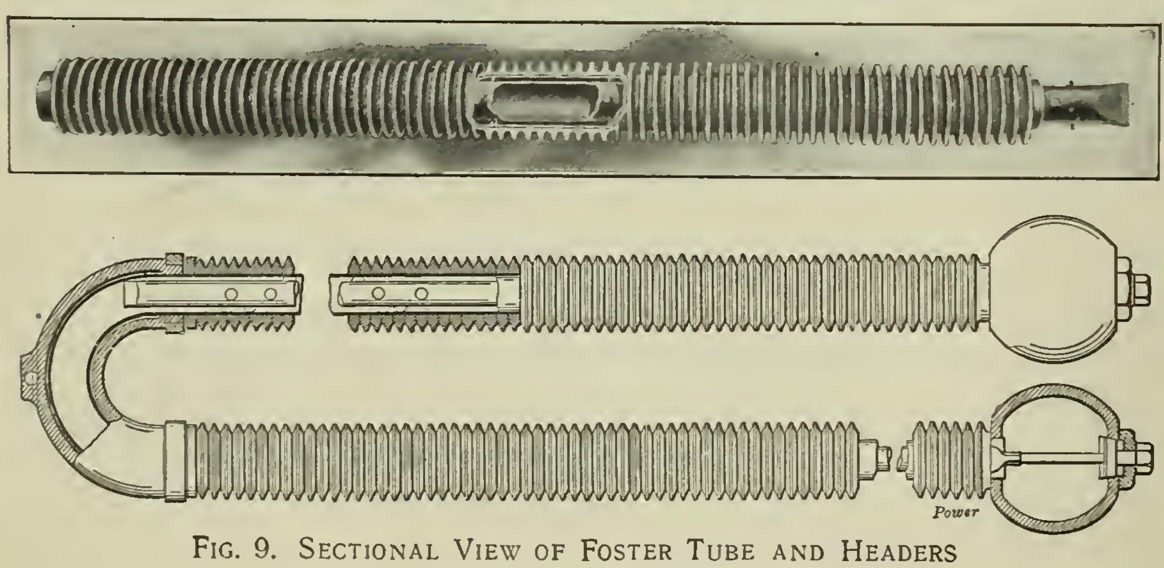


Fig. 9. Sectional View of Foster Tube and Headers

By placing the superheater in the path of the hottest gases passing from the furnace their temperature is reduced, and this results in cooler gases passing to the economizer and up the stack. If the superheater were placed in the flue it would not reduce the temperature of the gases so much on account of the smaller difference between the temperature of the steam and the escaping gases. One of the reasons for the uniformity of superheat in this superheater is that the steam and water of the Parker boiler are separated by a diaphragm and the boiler never primes.

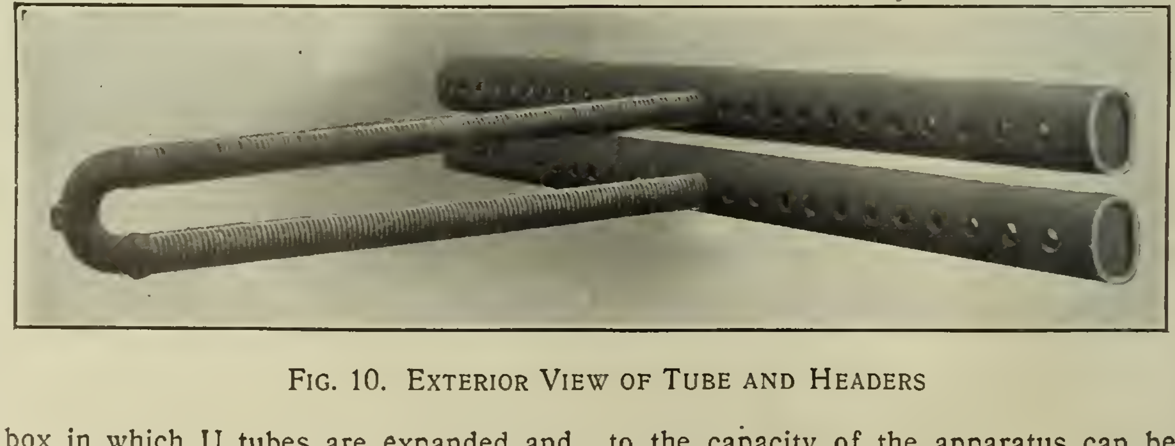


Fig. 10. Exterior View of Tube and Headers

Heine Superheater

Although the members of a superheater may be similar in construction, a difference is found in the design of the header. This is particularly noticeable in the Heine superheater, made by the Heine Safety Boiler Company.

This superheater consists of a header box in which U tubes are expanded and the flat sides of the header are strengthened by staybolts. The interior of the header box is divided into three compartments by means of sheet-iron diaphragms, as shown in Fig. 3. These diaphragms cause the steam to change its direction of travel four times in passing through the U tubes before entering the steam pipe leading to the main steam header.

This type of superheater and method of setting is shown in Fig. 4. It is located at the side of the boiler drum toward the front, and just above the last

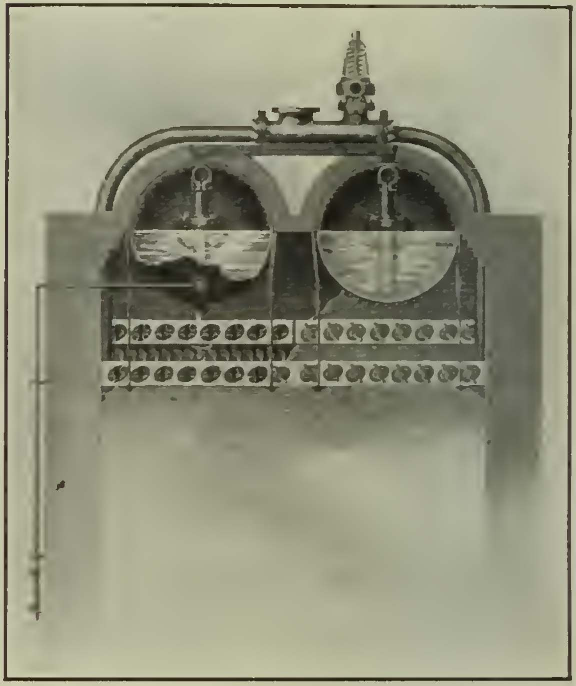


Fig. 8. End View of Manifolds in Brickwork

passage of the boiler gases. It is incased in brickwork which is lined with firebrick on the roof.

In order that the hot gases may be carried direct from the furnace to the superheater a small flue is built in the side wall of the boiler setting. In this flue the hot gases make two passes around the superheater tubes, as shown in Fig. 5. The flow of gases is controlled by a damper placed at the outlet end of the flue. When the damper is closed the circulation of the hot gases is stopped and when the heat from the gases in the flue in which the superheated is located, has been absorbed, saturated steam only is delivered to the steam main. Owing to this method of controlling the hot gases, various degrees of superheat up to the capacity of the apparatus can be obtained.

The saturated steam-outlet connection

from the boiler is made to the lower end of the superheater box, and the steam, after passing through the tubes, goes to the main steam header.

Owing to the location of the superheater above the boiler, and having no connection to it below the water line, the tubes are never flooded, nor is it necessary, on account of the complete control of the gases by the damper, which is easily operated by thermostatic control.

FIG. 12. HEADERS AND PLUGS

The exterior surfaces of the superheater tubes are smooth and such accumulations of soot as stick to them do not seriously interfere with the transmission of heat, as provision has been made by which the soot is removed by means of a blower introduced through the hollow staybolts passing from one header plate to the other. By this means the tubes of the superheater are cleaned without interfering with its operation or that of the boiler.

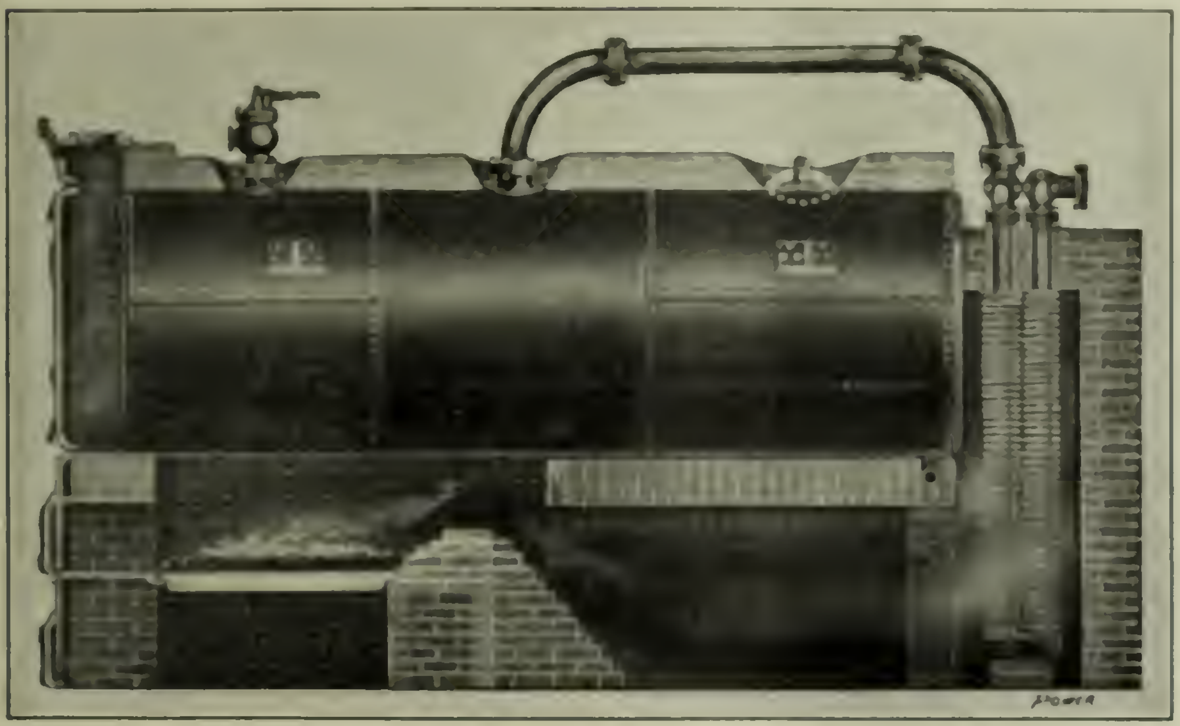


FIG. 13. FOSTER SUPERHEATER IN REAR COMBUSTION CHAMBER OF RETURN-TUBULAR BOILER

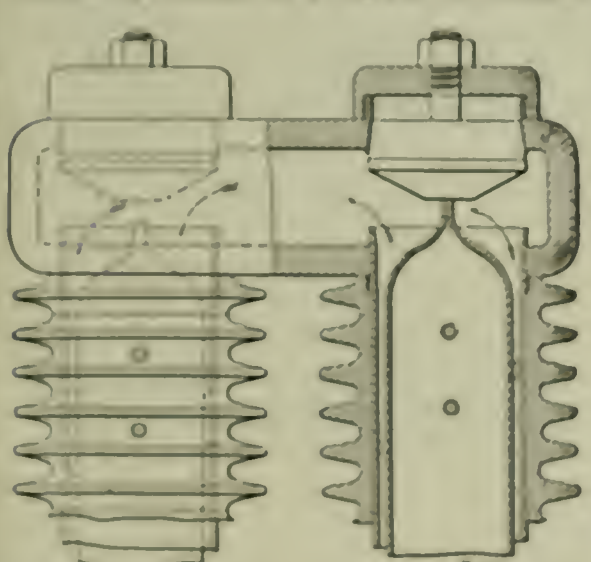


FIG. 11. SECTIONAL VIEW THROUGH RETURN HEADER

BABCOCK & WILCOX SUPERHEATER

A design of superheater that has found favor, and is extensively used, is the type made by the Babcock & Wilcox Company. It is made entirely of wrought steel and is so constructed that no joints are in the direct current of the hot gases. The superheater is made up of 2-inch No. 8 gage seamless steel tubes bent to a U form, and of square headers or manifolds of forged steel, into which the tube ends are expanded. The tubes are arranged in clusters of four, and an oval handhole opening is made in each header opposite each cluster of tube ends. A finished seat is formed on the inside of the header around each handhole, and a wrought-steel handhole cap having a fixed stud with a threaded end, is used for closing each opening; the joint is made tight by a gasket. The stud of the cap passes through a forged-steel guard, and a wrought-steel nut secures the cap in place against the gasket on the inside of the header. No cast-iron parts or screwed joints are employed in the construction of this superheater.

When used in connection with the Babcock & Wilcox boiler, the superheater is placed in the triangular space below the steam and water drums and above the inclined tubes, as shown in Figs. 6 and 7. It is supported independently of the brickwork by hangers from the drums of the boiler, in a position where it is accessible for inspection and does not in any way interfere with the cleaning or repairing of the boiler.

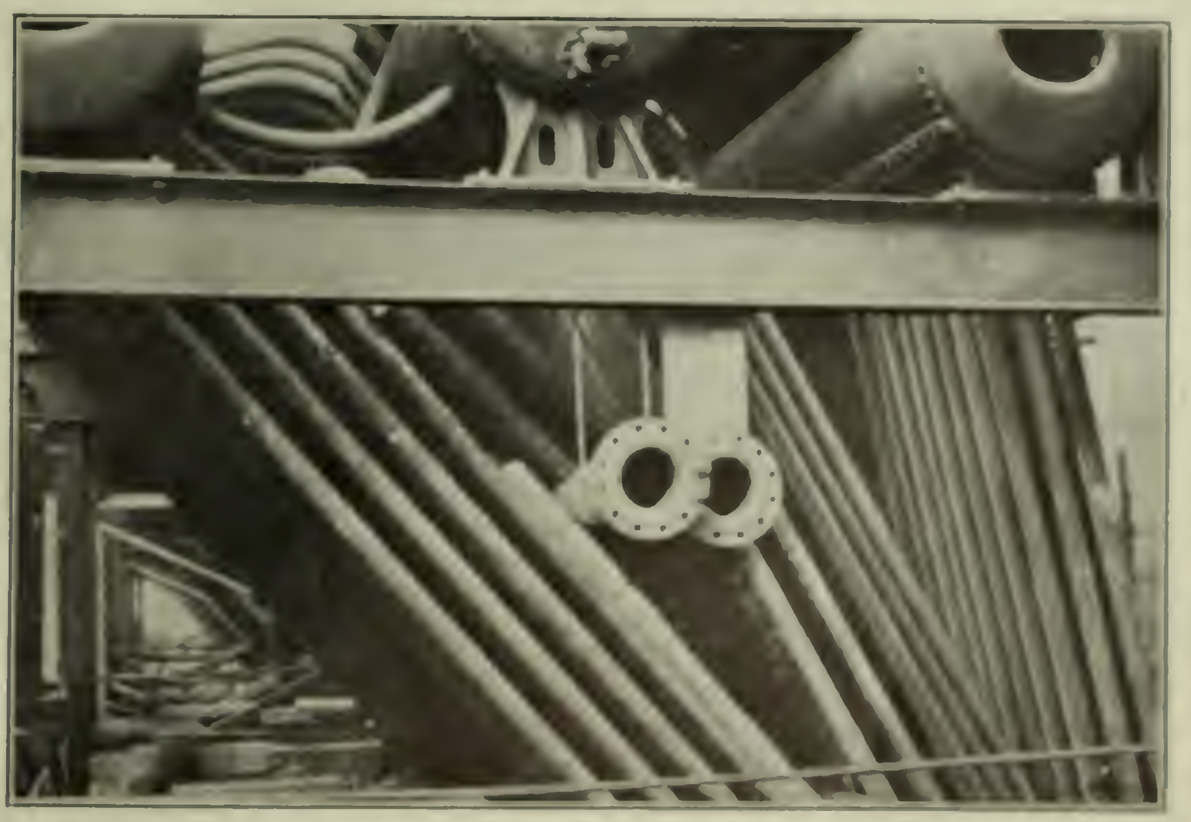


FIG. 14. SUPERHEATER ATTACHED TO STIRLING BOILER

Both manifolds are built into the brickwork of the hanging bridgewall over the second set of baffles, as shown in Fig. 8. The tube ends and handholes are thus protected, while the space back of the hanging bridgewall affords access to all handhole fittings. If necessary, the tubes can be rerolled or replaced with no more trouble than would be experienced in a like operation on the boiler. The U form of the tubes and the fact that the expanded joints are out of the path of the hot gases insure against stresses tending to cause leaky joints. As a consequence, the necessity for rerolling a superheater tube is of very rare occurrence.

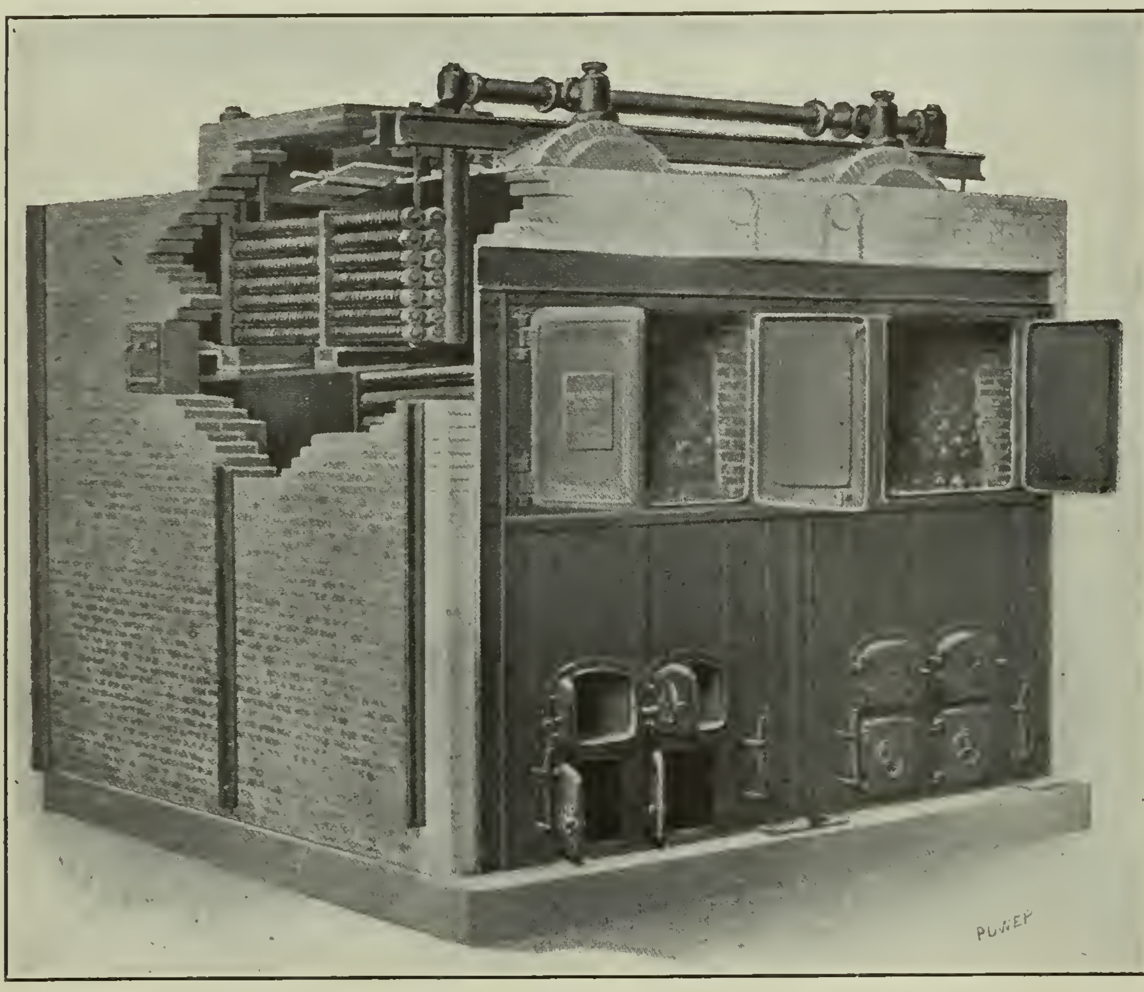


Fig. 15. Franklin Boiler and Foster Superheater

The upper box or manifold is connected to the steam space of each drum by a steel pipe passing through the bottom of the drum and fixed in position by an expanded joint in the superheater header and by a pad riveted to the drum. Outlet pipes are attached to the lower superheater header and, passing around the steam and water drums are connected over the top of the boiler by a heavy flanged fitting to the main steam outlet.

In addition to the safety valves connecting directly to the boiler drums, a special steel-body safety valve, made to withstand the action of the superheated steam, is connected to the outlet fitting. In order to give access to each expanded joint of the connecting pipes, circular handhole openings, closed by inside caps, are placed in the superheater headers. This superheater is supplied with external flooding pipes connected at one end to the rear head of a steam and water drum below the water line and to the end of the bottom superheater header, Fig. 7. These pipes are arranged so that the superheaters may be drained before cutting the boiler into the steam line. In operation, the steam is taken from the steam space in the boiler drum through dry pipes and enters the superheater through the inlet pipes. The steam is uniformly distributed through the upper manifolds and passes through the tubes to the lower manifolds. The superheater safety valve on the outlet fitting is set to open before the safety valves on the boiler drums so that when the load is suddenly thrown off the boiler the superheated safety valve opens and causes a flow of steam through the superheater until the fires can be checked, thus preventing excess superheat. By means of the external flooding piping the superheater can be flooded when steam is being raised on the boiler, thus protecting it from any possible overheating during this period.

Owing to the position the superheater occupies in the setting an even flow of heated gases over the heating surface is insured, and at the same time the area of the gas passage is not reduced so as to affect the operation of the boiler. As the external surfaces consist only of smooth, seamless tubes, there are no recesses in which ashes and soot may collect to any considerable extent, and at any time the tubes can be thoroughly cleaned with a steam jet from a lance passed through the dusting doors in the side walls of the setting.

The entire heating surface of the front pass of the boiler is between the superheater and the furnace, and wide variations of temperature are avoided in the chamber in which the superheater is located, such fluctuations of superheat that do occur being relatively unimportant.

Foster Superheater

At least four attributes should be incorporated in the design of a superheater. These are freedom from liability to burn, proper distribution of steam circulation, accessibility for inspection, both internally and externally, and provision for freedom of expansion and contraction.

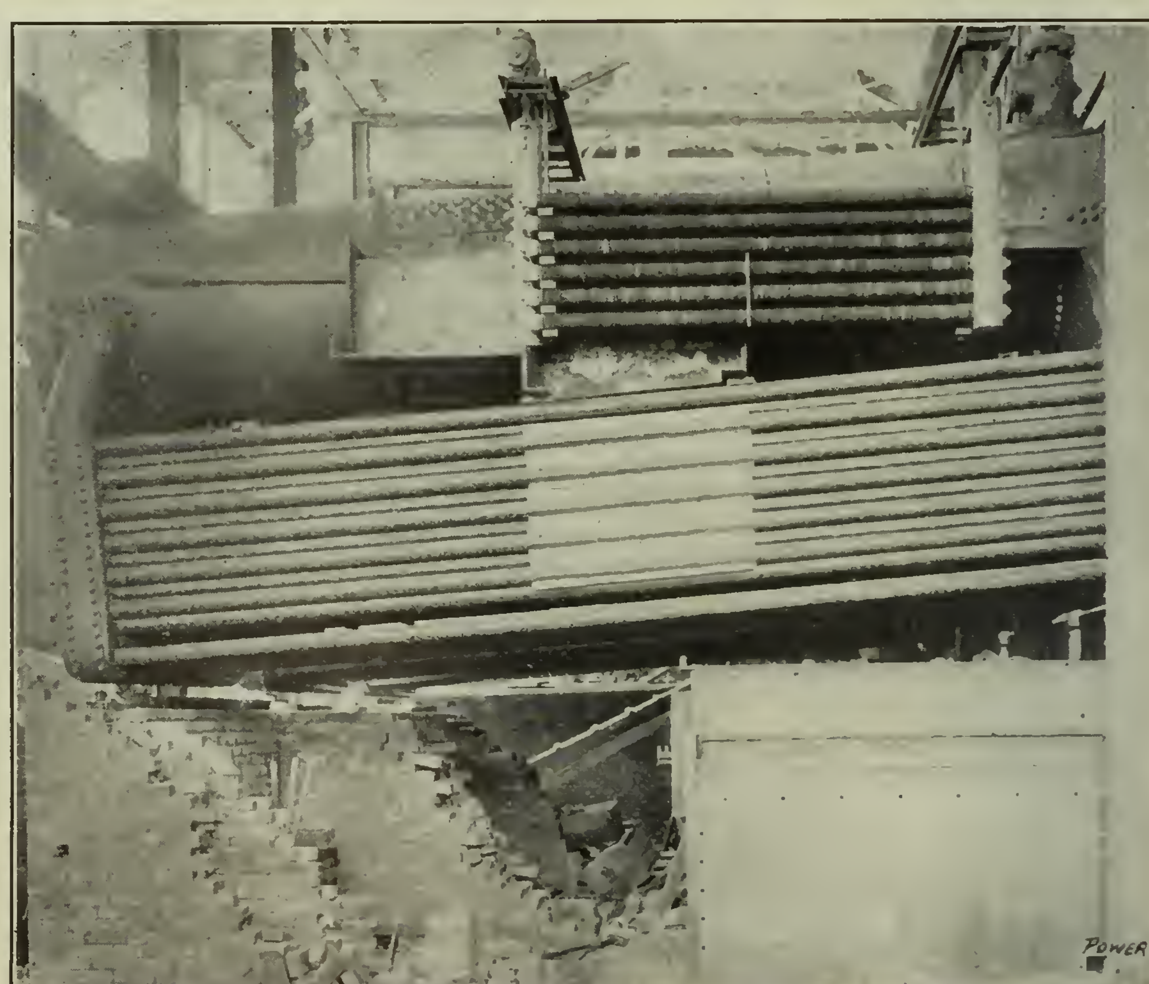


Fig. 16. Heine Boiler and Foster Superheater

The various designs of superheater have characteristics distinctly their own. One design that differs materially from all others is the Foster. It is a combination of annular cast-iron flanges and seamless-steel tubes. The elements or tubes are straight and are generally placed parallel to each other. A manifold joins the elements at one end and the other end of each element is joined to a return header, as shown in Figs. 9 and 10.

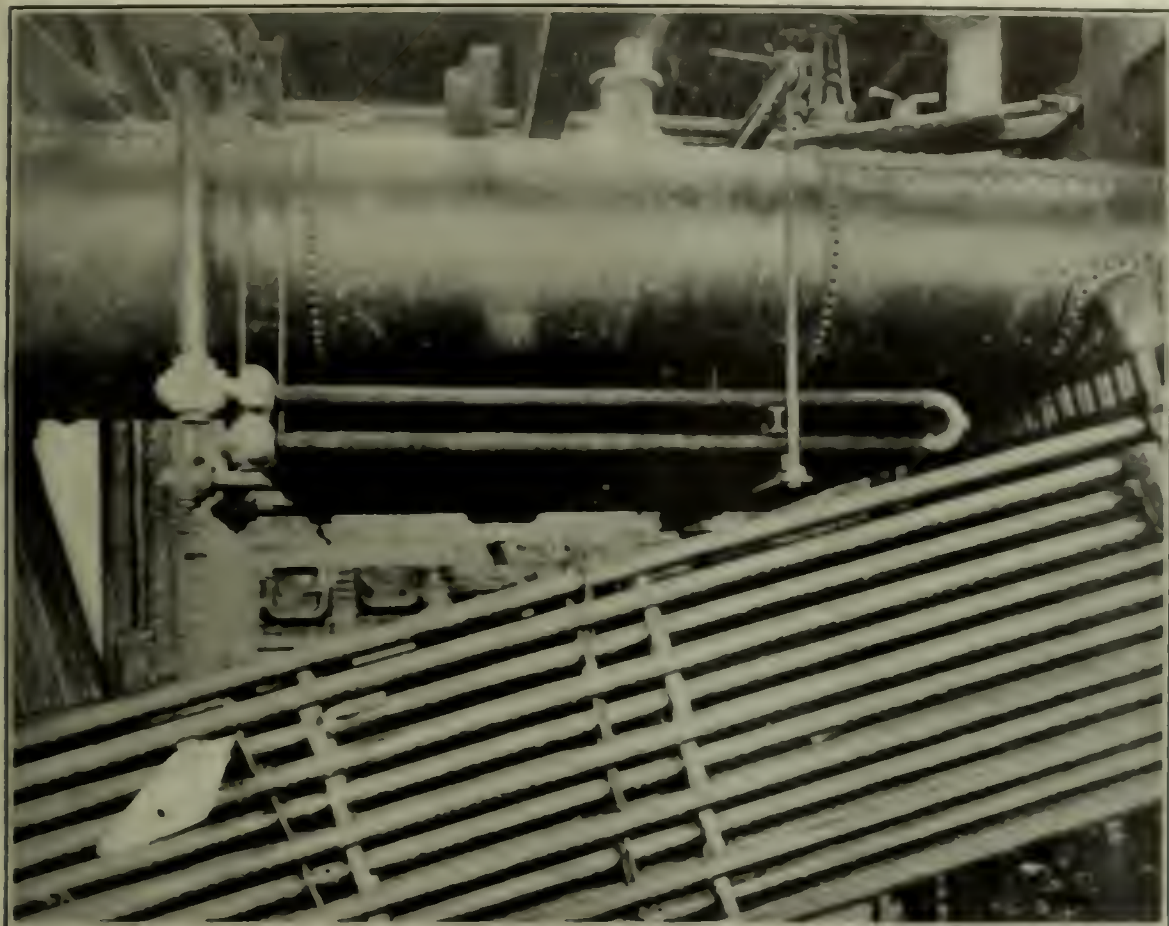


FIG. 17. BABCOCK & WILCOX BOILER AND FOSTER SUPERHEATER

The construction of the combination casting and steel tubing is shown in Fig. 9. The cast-iron flanges fit over the steel tube and are used to protect the tubes from the high temperature of the furnace gases. As the cast-iron rings are shrunk on the tubes, the rings and tubes practically act as a unit. An additional benefit derived from using cast-iron rings is that they act as a reservoir of heat, and are therefore capable of continuously imparting practically the same amount of heat to the superheater, thus maintaining a constant temperature of steam regardless of the ordinary fluctuation in the temperature of the hot gases.

Inside of the steel tubes of each element is a wrought-iron tube. It is kept central in the outer tube by knobs spaced through the length of the inner tube. This feature is shown in Fig. 9. Steam, however, does not enter this inner tube, as it is closed at both ends, as shown in Fig. 11, which is a cross-section through a return header. An exterior view of the same header and handhole plugs is shown in Fig. 12. The purpose of this inner tube is to force the steam as it passes the superheater to go between the inner and outer tubes in a thin sheet. This causes the steam to cling to the heating surface of the outer tube in its passage through each element.

No provision is made for flooding this superheater, and all the protection necessary to guard against burning the elements when getting up steam is found in the covering of cast iron.

This design of superheater is adaptable for use with any type of boiler. In Fig. 13 it is shown attached to a return-tubular boiler. The elements are set on end, and the steam connections are made at the top. The number of elements are determined by the size of boiler and the degree of superheat desired. The superheater is placed in the chamber at the rear end of the boiler, and in order that the greatest amount of heat may be imparted to the superheater, a firebrick arch is constructed in the combustion chamber, as shown. The path of the gases is over the bridgewall, under the arch and through and around the superheater member before entering the tubes of the boiler. This arrangement is not only suitable for new return-tubular boilers, but also for boilers of the same type that have been in service for some years and cannot carry with safety the necessary steam pressure demanded by the engine. As the temperature of superheated steam does not change the pressure, a boiler generating saturated steam can be made to deliver steam to an engine at a high temperature, but low pressure, by using a superheater.

Where this superheater is used in connection with a water-tube boiler, its shape will vary as the design of the boiler dictates. When used with a Stirling boiler the superheater is suspended by means of suitable U-bolts to the I-beams of the boiler support. The members are placed between the first and second banks of tubes in an inverted position. That is, the return bend is placed at the top and the header at the bottom. The general arrangement is shown in Fig. 14. This brings the superheater in the direct path of the hot gases as they pass from the first to the second bank of tubes. The steam connection from the steam drum to the superheater is placed outside of the setting, likewise the pipe running

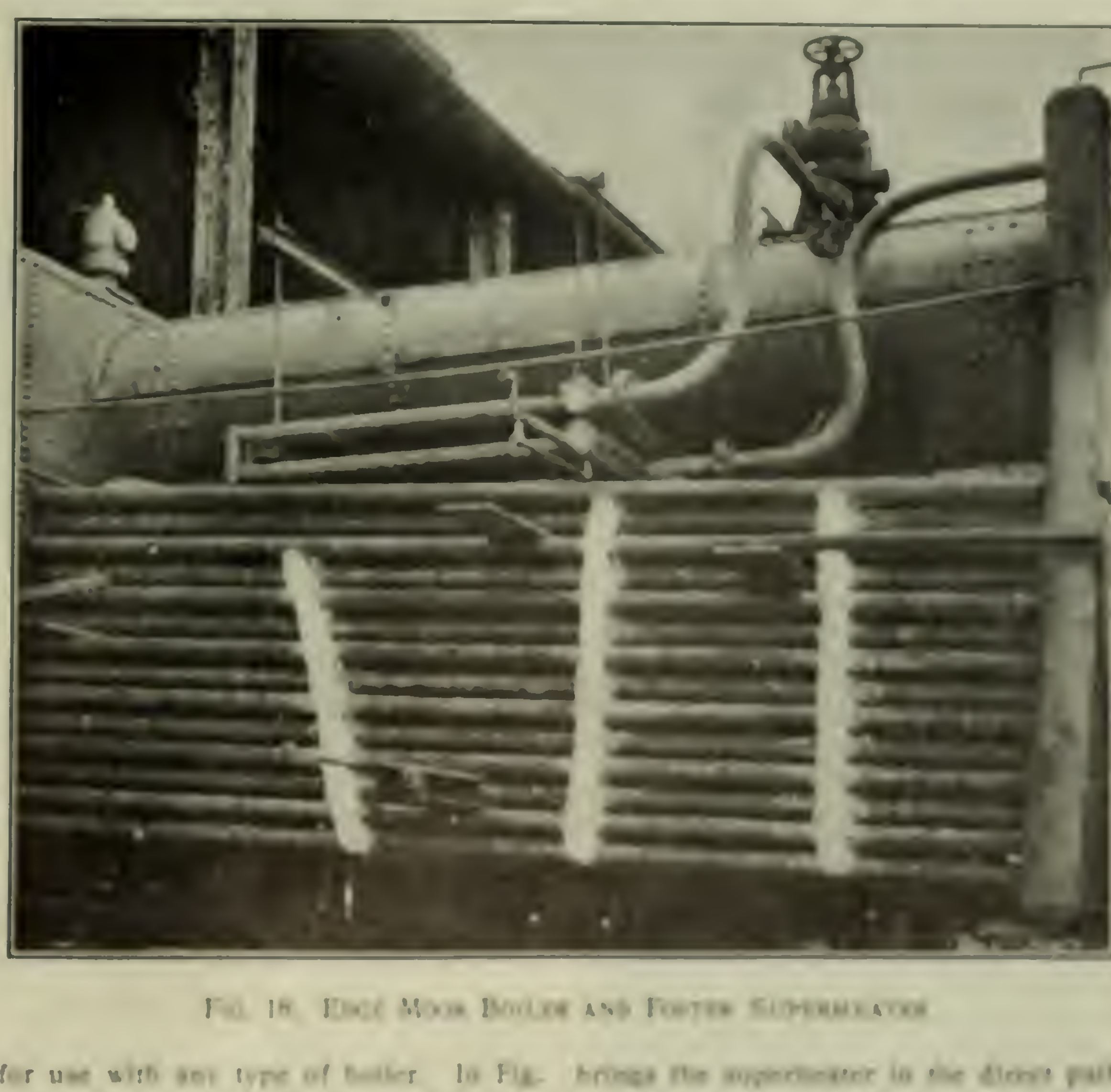


FIG. 18. EDGE MOOR BOILER AND FOSTER SUPERHEATER

from the superheater to the steam main.

This type of superheater is not always made with return bends. What is termed a return header, Figs. 11 and 12, is used with some types of boiler, the design having much to do with the type of header used in connecting the elements.

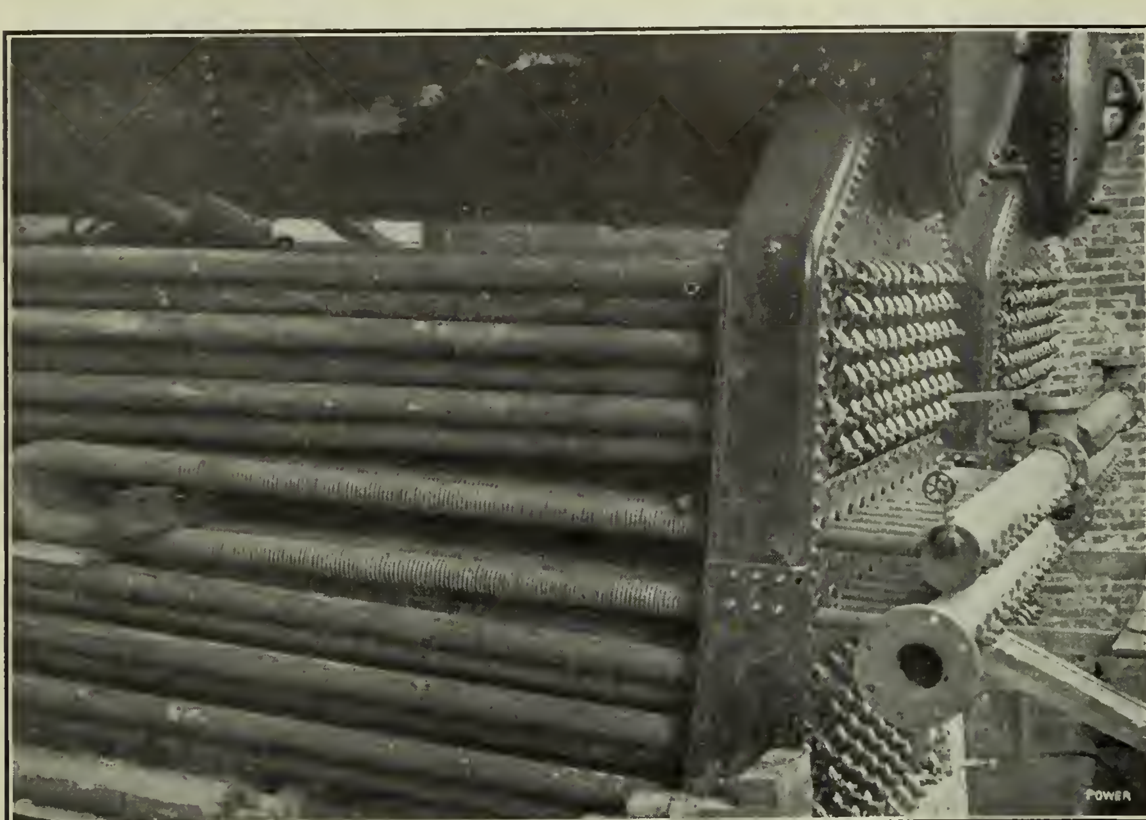


Fig. 19. Casey-Hedges Boiler and Foster Superheater

A Franklin water-tube boiler, Fig. 15, is equipped with this same design of superheater header, as shown in Figs. 11 and 12. Owing to the close proximity of the drum to the tubes it is necessary to place the superheater at the front end and along the side of the drum. The superheater is arranged in a separate chamber, which is divided into two compartments by means of a vertical baffle running transversely across the superheater tubes. The bottom of the rear compartment of the superheater chamber is connected by means of a flue in the side walls of the setting directly with the combustion chamber a little to the rear of the bridgewall. The bottom of the forward compartment of the superheater chamber is in direct communication with the area provided for the passage of the gases passing through the boiler underneath the boiler drums. The circulation of the gases through the superheater chamber is then into the chamber by way of the flue in the side walls, upward among the superheater tubes in the rear compartment, and downward among the superheater tubes in the front compartment of the superheater chamber, from which they issue and join the gases passing through the boiler on their way to the stack. A damper arranged above the vertical baffle in the superheater chamber controls the amount of gases passing through, and consequently the degree of superheat. The amount of hot gas made to pass directly past the superheater is controlled by a damper placed above the top member of the superheater.

Practically the same arrangement of the superheater is made with the Heine boiler, Fig. 16, and other similar designs of boilers, where the superheater is generally suspended from the I-beams by means of suitable bolts.

Fig. 17 shows the method of attaching the superheater to a Babcock & Wilcox boiler. As it is placed central to the longitudinal length of the boiler between the tubes and the drum it lies in the direct path of the hot gases as they leave the first section of tubes and enter the second nest of tubes between the first and steam drums of the boiler is made with second baffle walls. A connection from the the lower header of the superheater on one side of the drum. The steam, after passing through the coils, escapes through a pipe leading from the top header, and on the opposite side of the boiler from the inlet pipe to the main steam header. It is connected to similar types of boilers in practically the same manner. Figs. 18 and 19 show the superheater applied to an Edge Moor and Casey-Hedges boiler, respectively.

Fig. 20. Wickes Vertical Boiler and Foster Superheater

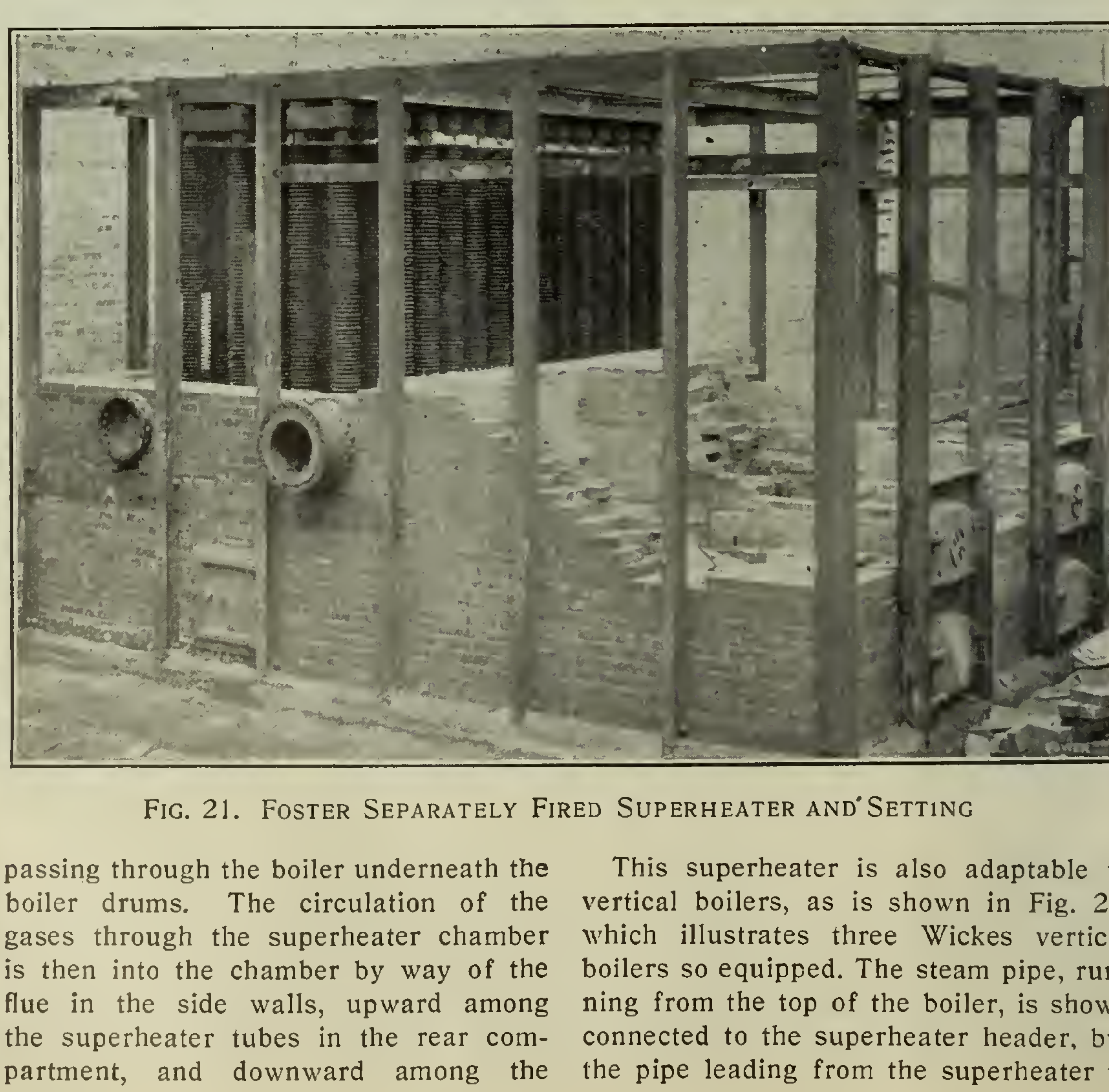


Fig. 21. Foster Separately Fired Superheater and Setting

This superheater is also adaptable to vertical boilers, as is shown in Fig. 20, which illustrates three Wickes vertical boilers so equipped. The steam pipe, running from the top of the boiler, is shown connected to the superheater header, but the pipe leading from the superheater to the steam main is not indicated, the connection being shown flanged. The members of the superheater are arranged vertically. The return headers serve as a means of support, which is accomplished by rods being bolted to a cross piece under each return header. The upper end of the bolts pass through holes in an angle piece that is riveted to the boiler.

This superheater is adaptable to separate firing, that is, obtaining the heat for superheating the steam from a furnace separate from the boiler furnace. This design is illustrated in Fig. 21, which shows the method of constructing the framework and the arrangement of the superheating members in relation to the furnace. In steel mills this type of superheater can be operated by waste heat from the various furnaces.

The Steam Turbine in Germany

By F. E. Junge and E. Heinrich

A study of the losses which occur in turbines of the Curtis and Rateau types, with an example from practice on a combination turbine.

Special Discussion of Curtis and Rateau Principles

After having given a general idea in the article in the December 20 number of the methods of investigation we proceed now to the special discussion of the economic qualities of the Curtis and Rateau systems, respectively, by determining, as far as this is possible today by calculating, the losses occurring in each.

Calculation of Losses

(1) By far the largest part of all losses is caused by friction, shock and eddy currents in nozzles and blades. This loss was determined in equation 2 as

$$R = (1 - \eta_i) h_a \qquad (2)$$

wherein R = loss in heat units per pound of steam, η_i indicated efficiency and h_a available energy of the stage.

(2) *Work absorbed by friction and windage of the rotating wheels.* By the friction between the wheel disks and the surrounding medium a certain amount of work is consumed. Moreover, those blades upon which the live steam does not impinge act as a fan, causing a circular motion of the steam whereby work is again absorbed. Of course, it is not possible to determine the exact amount of this loss by calculation. We profit, therefore, by the results of experimental research, so far as they have been condensed in formulas. For our purpose here we employ the formula of Lasche (Stodola, fourth edition, page 129), which is applicable for admission diameters of from 900 to 1200 millimeters, or 2.95 to 3.94 feet, with length of blades ranging from 10 to 50 millimeters, or 0.394 to 1.97 inches. In this formula the friction and windage expressed in kilowatts for a wheel not inclosed in a casing, and working without admission of steam but in the medium steam, is

$$N_{kw} = \beta \cdot 10^{-6} D_m n^3 L_m \gamma \qquad (5)$$

wherein D_m is admission diameter; L_m mean length of blades; n, number of revolutions per minute; γ, specific weight of steam.

If metric units are employed (D and L in meters, γ in kilograms per cubic meter) the coefficient β becomes

17. [illegible] for wheels with one row of buckets,
29. [illegible] for wheels with two rows of buckets,
[illegible] for wheels with three rows of buckets,
[illegible] for wheels with four rows of buckets.

If British units are employed (D and L in feet, γ in pounds per cubic foot) the coefficient β becomes

26.1 for wheels with one row of buckets,
30.5 for wheels with two rows of buckets,
41.7 for wheels with three rows of buckets,
63.2 for wheels with four rows of buckets.

Recalculated in B.t.u. per second and considering that 1 kilowatt = 737.3 foot-pounds per second and 1 B.t.u. = 78 foot-pounds, this equation reads:

$$V = \frac{737.3}{778} \beta \cdot 10^{-6} D_m n^3 L_m \gamma =$$
$$0.948 \beta \cdot 10^{-6} D_m n^3 L_m \gamma \qquad (6)$$

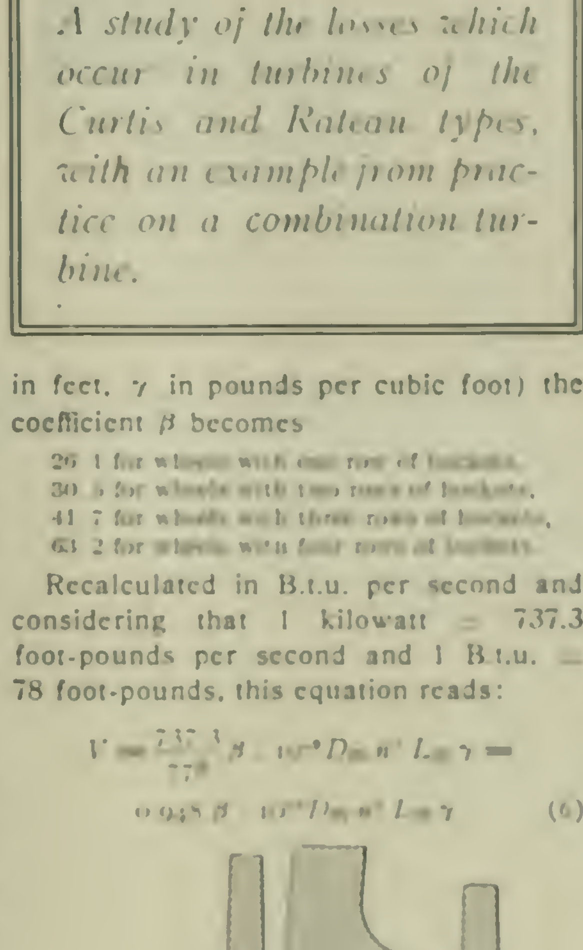


Fig. 11. Stuffing Box of a Rateau Stage

(3) *Losses through leakage at the wheel hubs.* Between the hubs of the wheel disks and the hubs of the rotating wheels there is, of course, a certain clearance through which steam can escape from one stage into the next without performing any useful work; see Fig. 11. If no resistance were opposed to the flow of steam through these clearances the actual passage velocity of the steam would be equal to the theoretical velocity c_{th}, which corresponds to the theoretical drop of heat. In order to get small losses one must take care, therefore, that this passage velocity remains as low as is practically possible, or, in other words, the resistance offered to the flow must be as high as possible. This is attained by a labyrinth packing, as shown in Fig. 11. This construction affords a reduction of the actual passage velocity down to 0.6 c_{th}. If $f = \pi d_s s$ is the cross-section of the orifice of loss and γ the specific weight of the steam leaving, the lost steam weight is:

$$g_s = 0.6 \pi d_s s c_{th} \gamma \qquad (7)$$

If further h_a equals the available energy in the stage in heat units per kilogram of steam, the loss through leakage may be expressed in heat units as follows:

$$s = g_s h_a \qquad (8)$$

In the first stage of an impulse turbine there is no leakage loss on account of the fact that there is no clearance through which steam could escape.

Energy to Be Regained

Part of the velocity of issue c_2 (Fig. 7, December 20), may be regained by catching the steam jet, emanating from the rotating wheel, in the following guide blades in such a manner that as little as possible of the inherent velocity of the steam is destroyed. It is customary to assume that with average quality of design and shop work, about 80 per cent. of the residual energy $\frac{c_2^2}{2g}$ of the steam is utilized in the following guide blades. Thus the energy regained per kilogram of steam passing through the blades is in heat units:

$$U = 0.8 \frac{c_2^2}{[illegible]} \qquad (9)$$

Combination of Losses

After having determined the various losses and the energy to be regained we combine the results in the following formulas: If g pounds is the weight of steam flowing through the turbine per second, we must bear in mind that not the whole of it passes through the guides and moving blades, but that the amount g_s passing through the clearance at the hubs must be subtracted, so that $g - g_s$ pounds per second pass through the blades rendering useful work. It must be further considered that the loss R

and the amount M of the regainable energy refer to the unit of steam weight which flows through the guiding and moving blades, while the calculated amount for windage V and for leakage losses U refers to the total steam weight flowing through the turbine. If we designate by L the sum of losses per pound of steam,

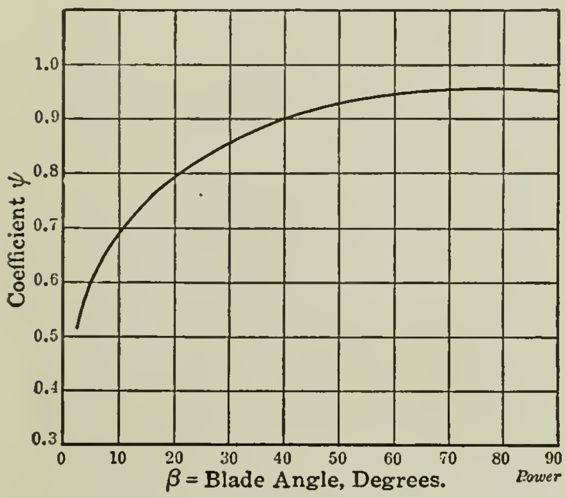


Fig. 12. Coefficient of Resistance of Rotating Blades

the total loss in the turbine is: $L \times g$, and we get the following equations:

$$L g = (g - g_o) R + U + V - (g - g_o) M = (g - g_o)(1 - \eta_i) h_o + g_o h_o + V - (g - g_o) M = g(1 - \eta_i) h_o + g_o h_o \eta_i + V - (g - g_o) M \qquad (10)$$

Hence the loss per pound of steam is found to be:

$$L = (1 - \eta_i) h_o + \frac{g_o}{g} \eta_i h_o + \frac{V}{g} - M \qquad (11)$$

of a turbine, where leakage losses do not occur, we get:

$$L_1 = (1 - \eta_i) h_o + \frac{V}{g} - M \qquad (12)$$

With Curtis wheels the residual exit velocity is, as a rule, not utilized for reasons of design and because it is very small. Hence, we have for Curtis wheels:

$$L_c = (1 - \eta_i) h_o + \frac{V}{g} \qquad (13)$$

researches, especially of Stodola. As to coefficients it is to be noted that the value depends essentially on the state of the surface of the nozzles or blades, which is to say, it depends preëminently on shop work. Further, it is to be noted that the nozzles and blades may vary the state of their surface even during operation, as a result of corrosion of the blades and of sediment of impurities of the steam. Hence, the coefficients of resistance of

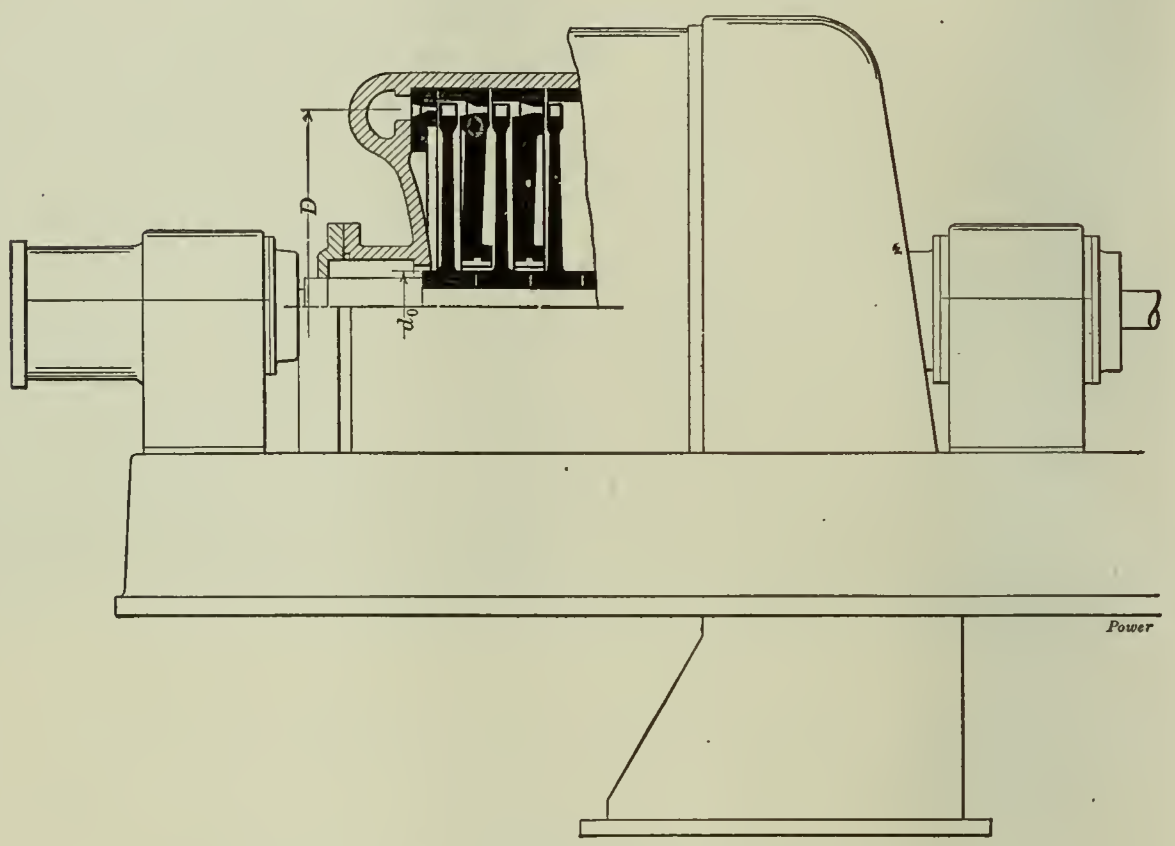


Fig. 14. Three Rateau Stages

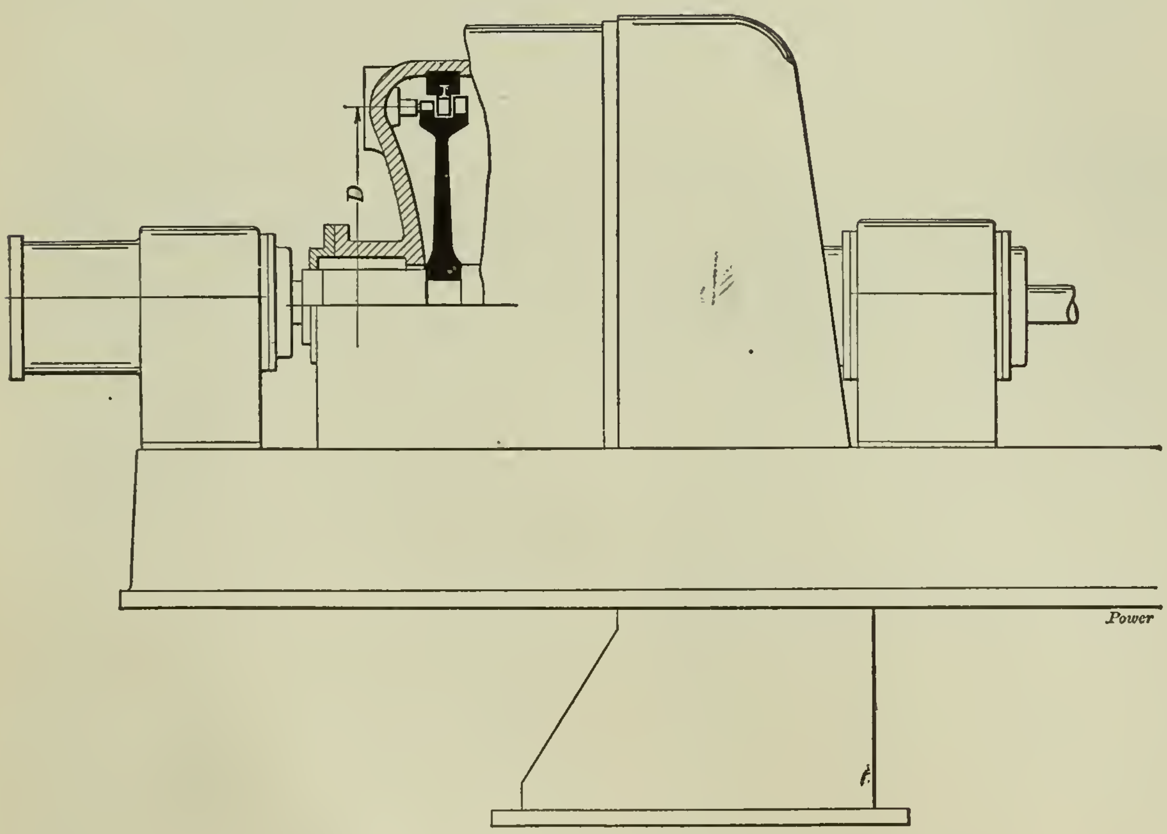


Fig. 13. Single-stage Curtis

In the above expression we have assumed the factor of M, $\frac{g - g_o}{g}$, to be equals 1 for the sake of simplicity, because the total amount of M is comparatively small and because g_o is a small amount compared to g. For the first stage

The Coefficients of Losses

Before attempting to carry through a calculation of an example on the basis of these reflections it appears necessary to determine the amount of the coefficients of loss, ϕ, ψ, ξ, wherefore we profit again by the latest experimental

one and the same turbine are far from constant.

The coefficient ϕ is usually assumed to be 0.95 for first-class shop work. As to the coefficient ψ the results of the experiments of various investigators differ essentially. Thus, for instance, Briling and Rateau found that the coefficient ψ increases with the relative velocity w_1, hence the loss of energy decreases, while Stodola and Huguenin found, in contradistinction, that ψ decreases with w_1. On the other hand, all experimenters have established the fact that ψ decreases with increasing curve of blade, that is to say, with decreasing blade angles. With this consideration in mind we assume according to Stodola that the coefficient of resistance is independent of the steam velocity w_1 and depends only upon the curve or angle of the blades, as shown in Fig. 12.

The number ξ in equation 4, representing the loss in the first row of blades, in percentage of the energy of issue $\frac{w_2^2}{2\,g}$, is assumed to be 25. This value was determined from an analysis of a Curtis turbine made by Stodola.

Example from Practice

In a turbine of 1000 kilowatts at 3000 revolutions per minute, consisting of eight simple-pressure stages (Zoelly system), the high-pressure part is to be replaced by one Curtis wheel. Figs. 13 and 14 show the two devices. In order to utilize by means of the original Rateau principle the same drop of energy as in one Curtis wheel we must assume at least three Rateau stages as its equivalent. Furthermore, the mean wheel diameter and therefore the circumferential velocity shall remain the same. In our example which is taken from actual practice the admission diameter is 1 meter = 3.28 feet. The operating conditions of the turbine are:

Admission pressure = 180 lb. per sq.in. absolute.
Steam temperature = 525 deg. F.
Superheating = 177 deg. F.
Vacuum = 94 per cent.
Steam consumption = 15 lb. per kilowatt-hour
Steam weight per sec. = 4.17 lb.

In the high-pressure part the steam expands down to 33.5 pounds per square inch. From the Mollier diagram is obtained a theoretical heat drop of 146 B.t.u. The clearly defined conditions of the comparison of the two systems are, therefore, one Curtis wheel as against three Rateau stages; equal circumferential velocity in both cases; equal heat drop to be utilized in both cases; coefficients of losses determined by same laws.

The theoretical exit velocity is $c_0 = 223.8\sqrt{146} = 2705$ feet per second.

The circumferential velocity is $u = \frac{3.28 \times \pi \times 3000}{60} = 515$ *feet.*

Curtis Wheel

Fig. 15 shows the Mollier diagram, Fig. 16 the velocity diagram. In the latter such angles have been used as obtain in practice.

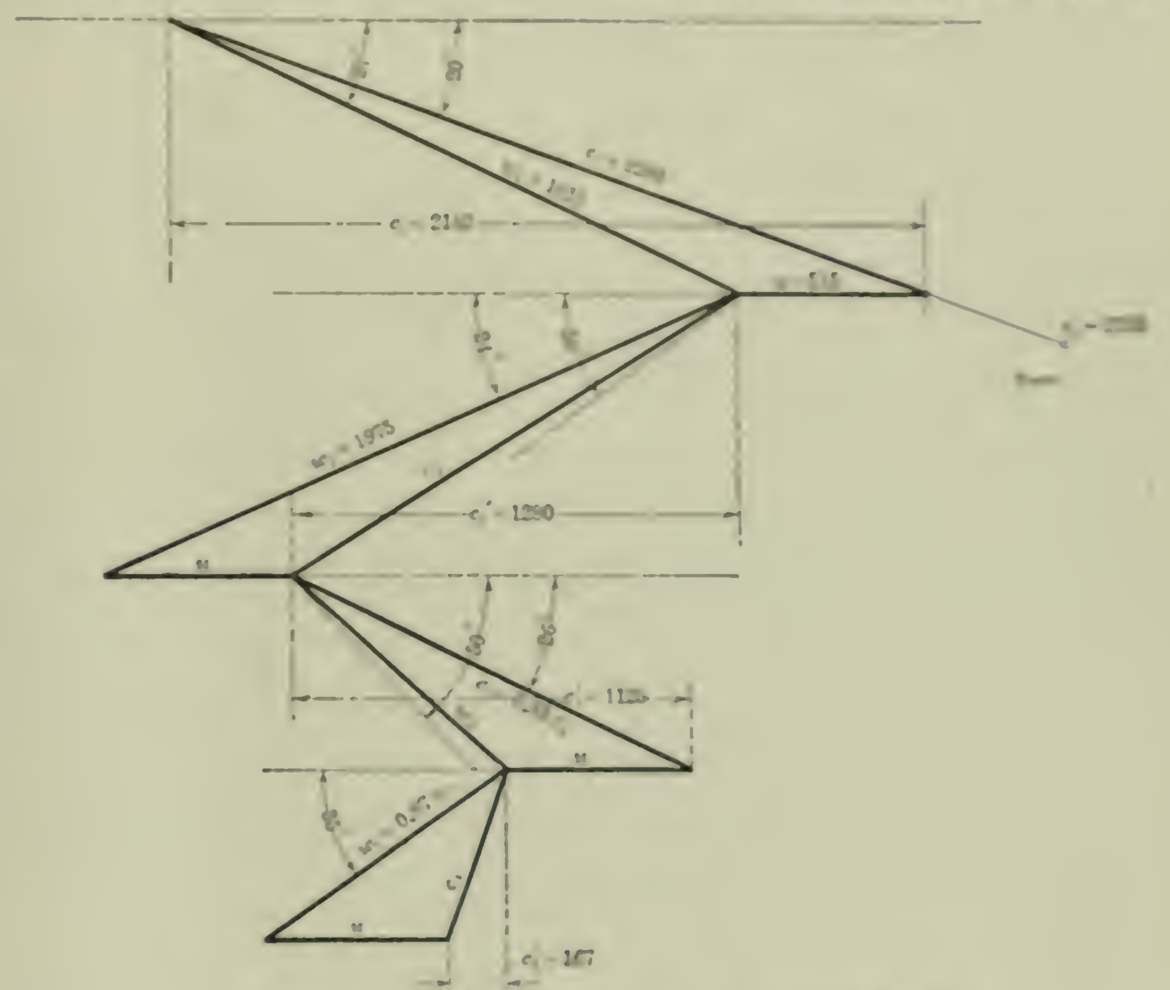


Fig. 16. Velocity Diagram of the Curtis Wheel

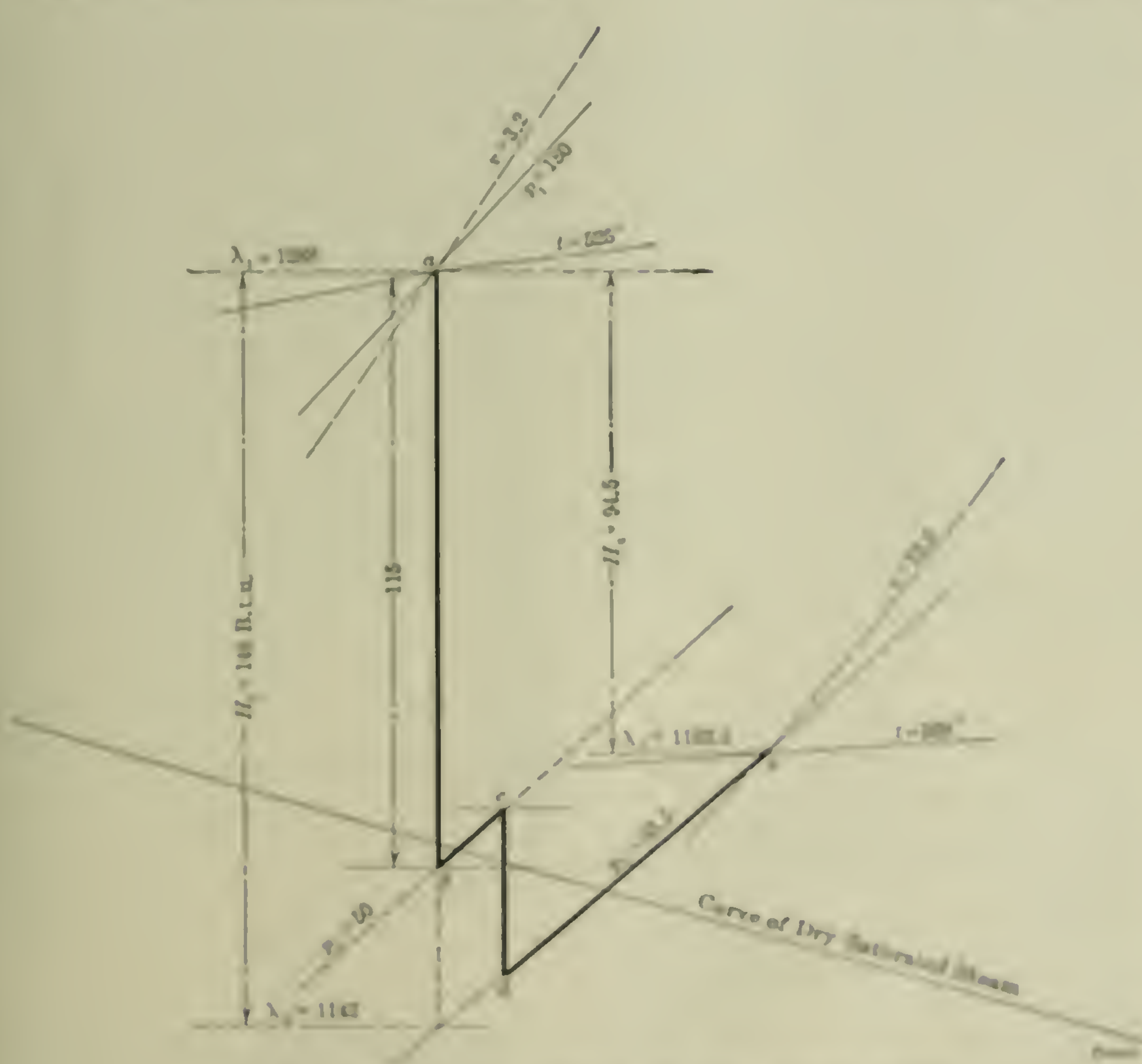


Fig. 15. Mollier Diagram of the Curtis Wheel

In accordance with the above we do not expand in the nozzle down to the counterpressure 33.5 pounds per square inch, but to the pressure 80 pounds per square inch. Then we find from the Mollier diagram that in the nozzle 115 B.t.u. are converted corresponding to a theoretical velocity of $223.8\sqrt{115} = 2400$ feet per second and an actual velocity of $0.95 \times 2400 = 2280$ *feet per second,* as shown in the diagram. In the nozzle we expand theoretically down to point *b*, but owing to the losses occurring the end point of the expansion is shifted to *a*. [Loss $115 (1 - 0.95^2) = 11.5$ B.t.u. per pound.]

In the first row of revolving blades we expand further down to *d*, realizing a drop of heat of $h_1 = 32$ B.t.u. From the velocity diagram is found $w_1' = 1810$ feet per second, and w_1 from equation 4 in the December 20 number

$$w_1 = \sqrt{\frac{w_1'^2 + 2g \times 778 h_1}{1 + \xi}} = \sqrt{\frac{1810^2 + 2 \times 32.2 \times 778 \times 32}{1 + 0.25}} = 1975$$

feet per second

Having w_1, we get from the velocity diagram c_1. This is the velocity with which the steam enters the deviating blades. For the latter we obtain for the smallest blade angle (20 degrees) the coefficient from Fig. 12, $\psi = 0.83$. And the velocity of the steam leaving the deviating blades, being equal to the entrance velocity of the steam into the second row of revolving blades, becomes $c_1' = 0.83\,c_1$.

The velocity conditions in the second row are normal and need not be further explained. It may be mentioned that as the smallest angle of the second row of revolving blades, 35 degrees, corresponds a coefficient $\psi = 0.87$. The respective projections of the absolute entrance and exit velocities upon the direction of travel are obtained directly from the velocity diagram.

The indicated efficiency, according to equation 4, is

$$\eta_i = \frac{2 \times 515 \times (2140 + 1280 + 1125 + 167)}{2705^2} = 0.663$$

Therefore the friction loss per pound of steam is

$$R = (1 - \eta_i)\, h_o = (1 - 0.663)\, 146 = 49.2 \text{ B.t.u.}$$

It remains to determine the windage from equation 6. The mean length of blades has been assumed as ⅝ inch = 0.052 feet. The mean diameter d = 3.28 feet, the specific weight from the Mollier diagram $\gamma = \frac{1}{13.6} = 0.0735$ pound per cubic foot, the coefficient $\beta = 30.5$. Thus we get the following formula:

$$V = 0.948 \times 30.5 \times 10^{-9} \times 3.28 \times 3000^2 \times 0.052 \times 0.0735 = 9.8 \text{ B.t.u.}$$

and per pound of steam per second $\frac{V}{g} = \frac{9.8}{4.17} = 2.3$ pounds of steam per second.

Hence the total loss according to equation 13:

$$L_c = 49.2 + 2.3 = 51.5 \text{ B.t.u. per lb. of steam}$$

and the interior efficiency of the Curtis wheel is:

$$\eta = \frac{146 - 51.5}{146} = 0.647$$

Uncle Pegleg's Philosophy

The old man explains the difference between force and work, shows how the resultant of two forces may be obtained, and incidentally works out some problems in proportion.

"I started in the other day to explain something to you and you led me off," said Uncle Pegleg, another day.

"So?" I said. "What was it?"

"When I asked you about the pull of that bag of gravel they were hoisting, we got off onto the pull on the rope. I wanted to get at the stress on the strut."

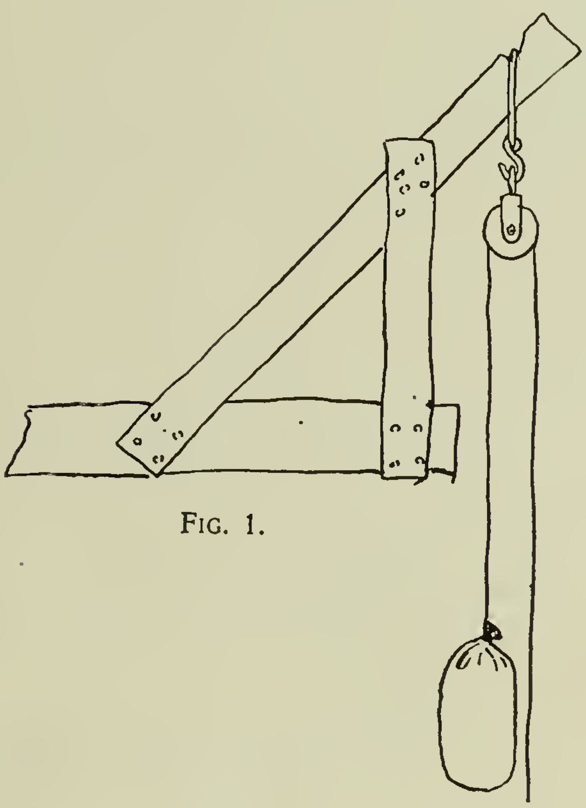


Fig. 1.

"What do you mean—the stress on the strut?"

"They had a board stuck up like this (Fig. 1) with a pulley on the end of it to hoist the gravel with. Well, I want to know what is the stress on that strut. How hard does it push on the nails that hold it? Take this case," and he drew Fig. 2. "Suppose the weight is 100 pounds. How would you go to work to find the force with which the boom was pushing down into the corner A?"

"Two hundred pounds, isn't it?" I said on a guess.

"No, because the pull in the part of the rope between B and C is 100 pounds, but it isn't pulling in the direction of the strut; and the pull on the piece of rope between C and D is 100 pounds, but that isn't pulling in the direction of the strut either. A pull that don't pull in the right direction may help some, but not its full amount."

"Well, what's the answer?"

"Suppose a boat was going across a river and the man in it rowed straight for the opposite bank all the time. If he went with a steady, uniform speed of 200 feet a minute, he would be here (indicating a in Fig. 3) at the end of the first minute, here (indicating b) at the end of the second minute, here (c) at the end of the third minute, etc."

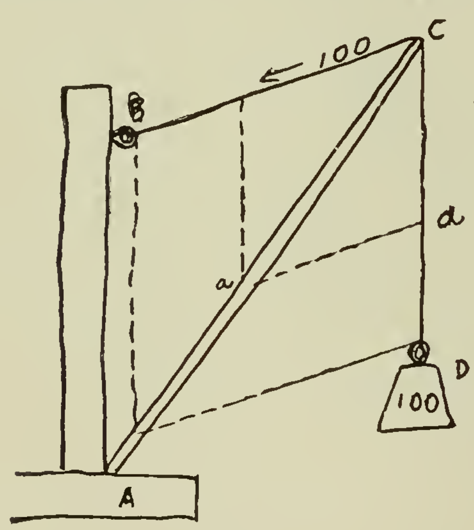


Fig. 2.

"If the current didn't carry him down," I said.

"Exactly. That's just what I was coming at. If the current carried him downward at the rate of 100 feet a minute, he would be at d instead of at a at the end of the first minute, just as though he had gone straight to a by reason of his rowing and then to d by reason of the current. At the end of the second minute he would be at e instead of at b and at the end of the third minute at f instead of at c; and always supposing that the velocities were uniform, the path that would have actually followed would be $o\,d\,e\,f$. Is that plain?"

I admitted that it was.

"Well, then, if $o\,a$ is proportional to his velocity in the direction $o\,a$, i.e., across the river, and $a\,d$ is proportional to his velocity in the direction $a\,d$, i.e., down the river, $o\,d$ must be proportional to his actual velocity, because he actually goes from o to d in the same time that the other velocities would have taken him from o to a or from a to d."

"What has that got to do with the force on the strut?" I asked.

"Everything. We will come to that. I am showing you now how, if you have two velocities and their direction, you can find the actual velocity and direction which they, acting together, will produce. The same thing applies to forces. Here (Fig. 2) you have two forces; one acting in the vertical direction $C\,D$ and the other acting in the direction $B\,C$. You want to find what their resultant in the direction $C\,A$ is. You do it the same way as with velocities. Now let us see what we do.

"Starting from the starting point o, lay off a line $o\,a$, Fig. 4, two inches long for the 200-foot velocity across the river, and from the same point a line $o\,g$, one inch long, for the velocity down the river. Complete the parallelogram of which these are two sides by drawing in the sides $g\,f$ and $a\,f$; then the diagonal $o\,f$, *drawn from the starting point o*, will be the actual or resultant direction and velocity."

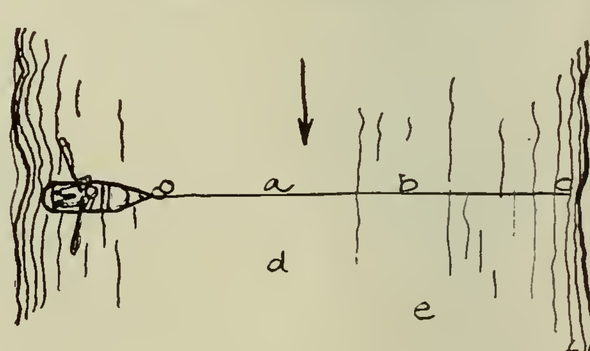


Fig. 3

"Wouldn't it be just the same if you took the diagonal $a\,g$?" I asked.

"No, because the corners may not be right angles. It only happened so in this case because the man was rowing at right angles to the current. Let's see what would happen if he started up the river at an angle of 30 degrees."

With the 30-degree angle of his drawing set he drew Fig. 5. The line *o a* points 30 degrees up stream. The line *o g*, one-half as long, because the velocity is one-half as great, points down stream, representing the direction in which the boat is carried by the current. Complete the parallelogram. Then the diagonal *o f* from the starting point is proportional in length and represents by its direction the actual velocity and direction which the boat would take. You can see that the other diagonal *a g* would be away off. Always start at the starting point to draw your diagonal. You could have done it just as well by drawing the line *o a* and then *a f* and connecting *o* to *f*, using only the triangle *o a f* instead of the parallelogram. They call this the triangle of forces or velocities, but if you ever get confused, go back to the starting point, put in both velocities or forces from that point, make your parallelogram and use the diagonal from the starting point and you will be all right.

"Now, then, let's see about the force. Here (Fig. 2) you have equal forces acting in the directions *C B* and *C D*. Lay off equal distances, since the forces are equal on these lines and complete the parallelogram drawing in the dotted lines. Then the force acting in the direction *A C* will be as much greater than 100 pounds as *C a* is longer than *C b*. If you make *C b* 1 inch long to equal 100 pounds and *C a* is 1.25 inches, then the force acting in the direction *C a* will be 125 pounds. If the force was any other number, 140 for instance, you would have to do it by proportion. Know how to do proportion?"

'I didn't.'

"Well, it's easy. The old rule of three. Come up to the house and I will give you an arithmetic. You can learn the whole section on proportions in an evening and they are always coming up. You know

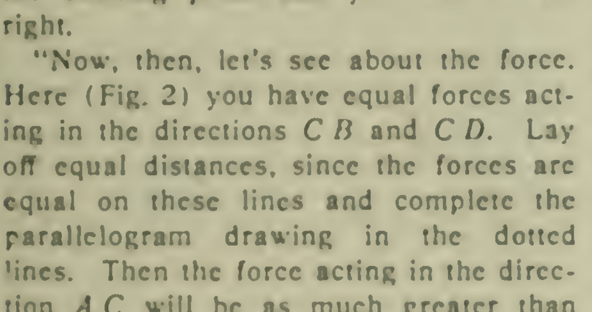


Fig. 4

three things and you want to know a fourth. For instance, in this case we know the length of the line *C b* and of the line *C a* and we know the force acting in the direction *C D*, say 140 pounds. We know that this force bears the same relation to the force acting in the direction *C A* that the length of the line *C d* does to the length of the line *C a*.

Set down the two similar terms that

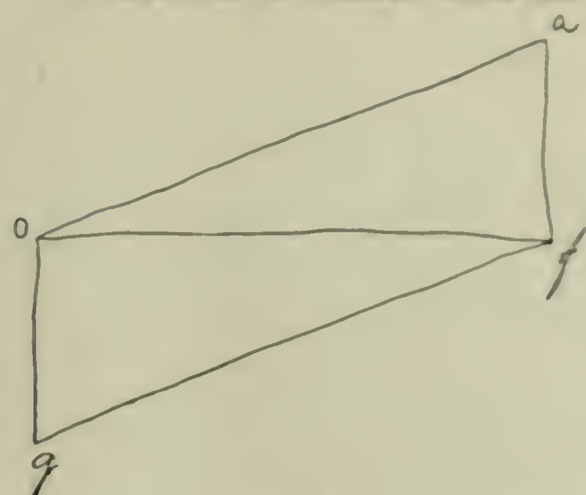


Fig. 5.

you know; in this case the two lengths of the lines, 1 inch and 1.25 inches, putting the one that agrees with the odd term that you know first

$$1 : 1.25 :: 140 : x$$

This reads, as one is to 1.25 so is 140 to the quantity you want to know.

"The thing to look out for is to get them so that the two quantities to the left of the double colon will bear the same relation to each other as those to the right and in the same order. Thus,

$$2 : 4 :: 3 : 6$$

You know that 2 is one-half of 4 and 3 is one-half of 6. If you get them in this order it will be true that the product of the two inside figures will be the same as that of the two outside. Try it."

I saw that $2 \times 6 = 12$ was the same as 4×3.

"If you have any three of them you can find the other," continued my instructor. "If one of the end ones is missing, multiply the two middle ones together and divide by the end one which you have. If one of the middle ones is missing, multiply the end ones together and divide by the inside one which you have. Simple enough, isn't it? In the case of the strut we have the two middle terms given, 1.25 and 1.40, and one end term, 1.

$$\frac{1.25 \times 140}{1} = 175 \text{ lb.}$$

"That proportion rule is one of the handiest things in the trade," continued the old man. "All you've got to do is to look out and get them set down right.

"If you put the smaller of the pair of known terms first, fix it so that the smaller of the pair of unknown terms will come inside, i.e., will come first on that side. For instance, you know that the horsepower of an engine is proportional to the piston speed. If it runs twice as fast, other things being equal it will develop twice as much horsepower. Well, suppose an engine develops 360 horsepower at 120 revolutions, how much will it develop at 125?

Here your pair of similar terms are the revolutions 120 and 125; if you put them down in that order, you must put the 360 first in the next pair because the 360 goes with the 120 of the first pair.

$$120 : 125 :: 360 : hp$$

$$\frac{125 \times 360}{120} = 375 \text{ hp}$$

"But sometimes it happens that a proportion is 'inverse' or backward. You know that the smaller pulley you put onto a driven shaft the faster it will run. The speeds of the shafts are inversely proportional to the diameters of the pulleys. A shaft running at 180 revolutions per minute carries a pulley 36 inches in diameter which is belted to a pulley 24 inches in diameter on another shaft. How fast will the other shaft run? Here your known pair are the diameters 24 and 36; the known term of the unknown pair is the 180 revolutions. Well, you put it down so

$$24 : 36 :: 180 : rev$$

or so

$$24 : 36 :: rev. : 180$$

You know that the revolutions will be greater than 180 with the 24-inch pulley, as much greater than 180 as 36 is greater than 24, so that you can see that the first way is right and that whereas with a direct proportion you put the known term of the incomplete pair first if its corresponding term was first in the other pair (120 revolutions for 300 horsepower both first in the other example). You now put them just the other way.

$$\begin{matrix} rev & rev & hp & hp \\ 120 & 125 & 360 & 375 \end{matrix}$$

$$\begin{matrix} diam & diam & rev & rev \\ 24 & 36 & 180 & 270 \end{matrix}$$

$$\frac{36 \times 180}{24} = 270 \text{ rev}$$

"How much do you suppose that crosshead bears on the guide," asked the old man, coming back to the main question, after this little lesson in arithmetic, "when the crank is at an angle of 45 degrees?"

It was too deep for me even with the explanation which I had heard, so I let him figure it.

"Let's lay it out," said he. "Give me that little drawing board and the tools."

I tacked a clean sheet of paper on his small board and he laid the T-square on it and drew the center line *A B*, Fig.

6. On this he drew a circle for the path of the crank pin, put in the crank *O C* at an angle of 45 degrees with the line of centers, and drew the connecting rod *C D*, twice the diameter of the crank-pin

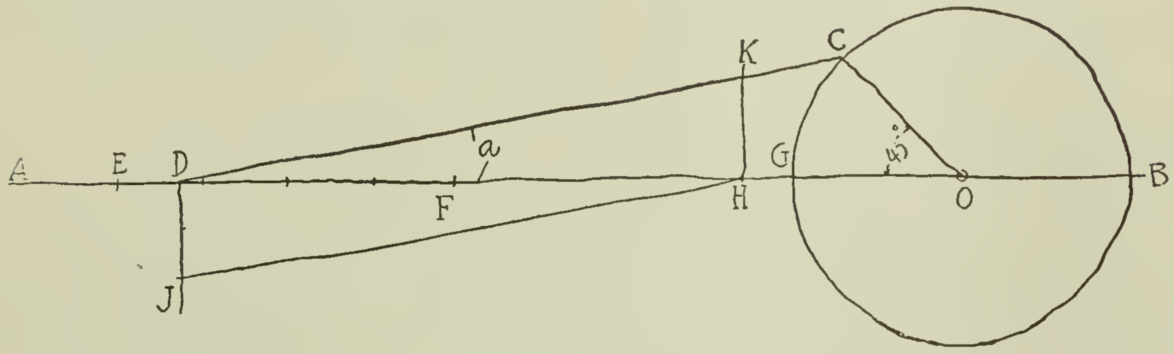


FIG. 6.

circle, for in our engine the connecting rod was twice the length of the stroke. Setting off the same distance from *G*, he determined the point *E* where the wristpin would be when the crank was at *G*, and from *B* the point *F* where the wristpin would be when the crank was on the farther center. He then showed me that the crosshead would travel from *E* to *F* and that it would be at *D* when the crank was at 45 degrees.

"There's another example in proportion for you," he said. "I've made the stroke here *E F* = 3 inches. The piston has traveled *E D* = about 9/16 inch. Our indicator takes a diagram 3¾ inches long. As the distance *E D* is to the distance *E F* so is the distance of the point on the diagram which represents the position of the piston at that point of the stroke to the length of the diagram.

$$ED : EF :: X : \text{length of diagram}$$

$$\tfrac{9}{16} : 3 :: X : 3\tfrac{3}{4}$$

Multiply the two outside terms together.

$$3\tfrac{3}{4} = \frac{15}{4}$$

$$\frac{15}{4} \times \frac{9}{16} = \frac{135}{64}$$

Now divide this by the inside term.

$$\frac{135}{64} \div 3 = \frac{45}{64}$$

"Good. Now measure out on one of your diagrams 45/64 of an inch and see how much pressure you have between the forward and back-pressure lines at that point."

I measured one of the diagrams and found about 72 pounds.

"That," went on the old man, "is the difference between the pressures on both sides of the piston when the crank is at *C*—on each square inch of it. How many square inches are there?"

It was an 18-inch cylinder and I found in the table of areas that it had 254 square inches. Multiplying this by 72 I found that the unbalanced push on the piston was

$$72 \times 254 = 18{,}288 \text{ lb.}$$

"Yes, over nine tons," said the old man. "Pretty good shove, eh? Now, this push acts on the wristpin *D* in the direction *D B*. Let's lay off *D H*, say 5 inches, to represent it. This force is split up into two forces, one that acts through the connecting rod in the direction *D C*, and one that pushes the crosshead down onto the guide in the direction *D J*. Now, if we draw *H J* and *H K* parallel to *D K* and *D J*, we shall have a parallelogram of forces of which *D H* = 18,288 pounds is the diagonal, and the downward force on the guides will be the same part of 18,288 pounds that *D J* is of *D H*, and the shove on the rod will be as much greater than 18,288 pounds as *D K* is greater than *D H*. You can scale it off. For instance, *D H* is 5 inches and represents 18,288 pounds. *D J* is about ⅞ of an inch.

$$DH : DJ :: 18{,}288 : X$$

$$5 : \tfrac{7}{8} :: 18{,}288 : X$$

$$\frac{\tfrac{7}{8} \times 18{,}288}{5} = \frac{7 \times \overset{2286}{\cancel{18{,}288}}}{8 \times 5} = 3200 \text{ lbs}$$

or over a ton and a half.

"If you want to get it more accurate than you can draw and scale it, you can calculate it."

"How?" I asked.

"You have a triangle *O C D* of which you know the length of two sides and one of the angles. A triangle has three sides and three angles. If you know any three of these six properties you can find the rest, but one of the known properties must be a side if you want to get actual lengths. You can get the proportions of the sides if you know only the three angles but not the actual lengths, for a triangle of the same shape may be so small you would need a microscope to see it or as big as all outdoors. Opposite each side of a triangle is an angle. The angle opposite the side *C O* is the angle at *D* which we don't know. The angle opposite the side *C D* is that at *O*, 45 degrees.

"The sides of triangles are proportionate to the sines of their opposite angles. Then, calling the unknown angle at the sharp point of the triangle *a*,

$$CD : \sin 45° :: CO : \sin a$$

Look up a table of sines in that handbook."

I passed him the book open to the table of sines and he showed me that the sine of 45 degrees is 0.70711.

"Now we know that the connecting rod *C D* is 4 times the length of the crank *C O*. Call *C D* 4 and *C O* 1; then

$$4 : 0.70711 :: 1 : \sin a$$

Multiply the two middle terms together and divide by the known end one.

$$\frac{0.70711 \times 1}{4} = 0.17678$$

This is the sine of the angle *a*. Hunt it up in the column of sines."

The nearest that I could find to it was 0.17794.

"That's all right. This table goes by quarter degrees or 15 minutes. That's near enough for our purpose. If we were working astronomy we should have to use finer tables. The sine value 0.17794 corresponds to 10 degrees and 15 minutes. See?"

That was as easy as looking up areas or circumferences.

"Now," continued the old man, "while your've got that angle there see what its tangent is."

I looked in the tangent column on the same line and found 0.18083.

"You don't know what a tangent is, do you?" he asked.

I had heard of things "going off at a tangent" and had a shady idea that it was a straight line hitched onto a circle.

The old man drew Fig. 7. "Here is a piece of a circle," he said, "drawn with a certain radius *O A*. Draw a line as *O B* from the same center and it will include a certain angle. Draw a line perpendicular to the end of the radius up to the line *O B*, bounding the angle, and it will

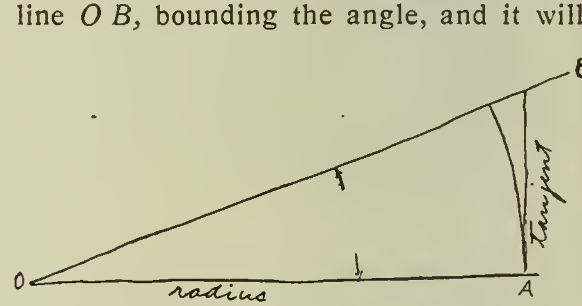


FIG. 7.

be the tangent of that angle. The table tells you what the length of the tangent would be if the length of the radius were unity or 1.

"Well, *H K* (Fig. 6) is the tangent of the angle *a* with a radius of *D H*; that is to say, for an angle of 10 degrees 15 minutes *K H* is 0.18083 of *D H*. Then, since *D H* represents 18,288 pounds, *K H* represents

$$18{,}288 \times 0.18083 = 3292 \text{ lbs.}$$

The Influence of the Cylinder Wall

By Prof. V. Dwelshauvers-Dery

> *In which it is demonstrated that the thermal influence of the cylinder walls depends very little upon the size of the machine and very much on the conditions of operation.*

The theory expounded by Professor Heck in the issue of September 13 last of POWER, under the title "Some Points Favoring Compression," is a complete abstraction of the disturbances brought about in the evolution of the steam by the thermal action of the metallic walls, which, during all the cycle, exchange heat with the steam. It seems that according to his idea this disturbing action will not be of importance except in small machines such as that with which I have operated at the laboratory of the University of Liège—diameter 12 inches, stroke 24 inches, 30 horsepower—but will be negligible for the larger machines, such as are met with in industrial use.

I do not know on what duly established facts he rests this hypothesis. I would like to believe that it is upon experiments made with the same precision as those made at the laboratory of Liège, and I should like to be assured upon this point. Meanwhile, I will try to demonstrate, contrary to his assertion, that the extent of the thermal influence of the cylinder walls depends very little upon the size of the machine and, on the contrary, very much on the conditions of operation. It is only the efficacy of the steam jackets which is reduced in large cylinders, but the evil or beneficial effects of the degree of admission of superheat and of high speed are as marked in the large as in the small machines.

It is this that I shall show, depending upon tests made with the greatest care, by different experimenters, and recorded in various periodicals, notably:

A. Bulletin de la Société Industrielle de Mulhouse Alsace. 1. 1876. Report of Hallauer on eight experiments made in 1873 and 1875 on the famous engine of Logelbach under the direction of G. A. Hirn, by Hallauer, Grosseteste and V. Dwelshauvers-Dery. 2. 1888. V. Dwelshauvers-Dery. New method for representing the exchanges of heat between the metal and steam. 3. 1889. V. Dwelshauvers-Dery. Exposition of the experimental theory of Hirn for single-cylinder machines.

B. Act of the International Congress of Applied Mechanics, held at Paris, September 16 to 21, 1889. 4. V. Dwelshauvers-Dery. Note on various methods of economizing steam in single-cylinder machines.

C. Excerpt from the minutes of the proceedings of the Institution of Civil Engineers, London, Volume XCVIII, Session 1888-1889. 5. Bryan Donkin and V. Dwelshauvers-Dery. Heat expenditure in steam engines.

Of the experiments with which these memoirs deal, seven have been made by Bryan Donkin on a small experimental machine of six indicated horsepower; diameter, 8.4 inches; stroke, 14 inches; revolutions per minute, 90; real degree of expansion, 0.684; clearance, 0.10 of the piston displacement. This engine was provided with a gas-flame jacket, and the object of the test was to compare the performance of the engine with and without the jacket. Of these seven tests we will retain in that which follows only the two carrying the numbers two and four respectively, made without jackets, the first condensing and the second noncondensing; the first on August 9, 1888; the second, July 26 of the same year.

Twelve have been made by Willans, the celebrated English engine builder, in order to determine the effects of differences in speed. They are classed in four series of three tests each: the first with the point of cutoff at 0.437, the second at 0.339, the third at 0.264 and the fourth at 0.216; and in each series the first test at about 400 turns per minute, the second at 200, the third at 100, all noncondensing. The engine is single acting; diameter, 13 inches; stroke, 6 inches; indicated horsepower varying between 35 and 6; clearance, 0.07 of the piston displacement. We will consider here only the three tests of the fourth series, Nos. X, XI and XII, for which the real degree of expansion was 0.28.

Eight tests were made by Hirn on the celebrated engine of Logelbach, operating ordinarily with superheated steam: two in 1873, one November 18 with superheated steam, the other November 28 with saturated steam; six in 1875, all with superheated steam and all condensing save one, that of October 28, which was noncondensing, with degrees of expansion varying between 0.102 and 0.457. Of these eight tests we will retain only three under the respective numbers II, V and VI: No. II, of November 28, 1873, condensing and with saturated steam with an actual degree of expansion of 0.227; No. V, of September 7, 1875, condensing, superheated steam, real degree of expansion 0.162; No. VI, September 9, 1875, condensing, saturated steam, real degree of expansion 0.162.

The dimensions are: Diameter, 24 inches; stroke, 70 inches; clearance, 0.01. The number of revolutions did not vary widely from 30 per minute, and the output was 150 horsepower. The object of the test was multiple. It bore principally on the effect of superheating, of condensation, of the ratio of expansion and the economy of the engine.

We hope that this last machine of 150 indicated horsepower will find grace in the eyes of Professor Heck and will not be, like the two others and that of the laboratory of Liège, considered as too small. In any case it differs sufficiently from those of Donkin and of Willans that one can deduce by experiment the certitude that the size of the machine has not a sensible effect on the disturbances brought about by the exchange of heat between the metal of the cylinder and the working vapor.

Since I have indicated my sources of information it is possible for the reader to verify the conclusions of the tests in question, and of which a table will be found at the end of this article. I have abstained from presenting the data of the tests and have given simply the calculated results, on the subject of which a little preliminary explanation is due.

Contrary to the ordinary theory of the steam engine, the only one which Professor Heck apparently sees, is what experiment has revealed on the action of the heat carried by the steam into the cylinders of our engines.

During admission a part of the inflowing steam condenses against the walls, chilled on the preceding stroke by communication with the condenser.

During the expansion a part of this water condensed on the surface of the walls during admission is revaporated usefully, contributing to increase the exterior work. But ordinarily the water is not entirely evaporated, and there remains at the end of the expansion and at the moment when communication with the condenser is established some still unevaporated.

During exhaust the rest of the water which was on the walls is evaporated simply to pass through the condenser, which constitutes a complete loss so far as work is concerned. For one readily sees that this water thus coming to the condenser has come in the form of steam from the boiler, has passed through the cylinder by the favor of the metal, and has entered the condenser anew under the form of vapor, without having in any fashion contributed to the work done.

We will not talk of the phase of compression in the clearance space in order not to unnecessarily complicate the argument, and in the same spirit, we will neglect the heads and exhaust leads, as well as the small quantity of steam which fills the clearance at the end of the exhaust.

Therefore, during the admission there comes from the boiler into the cylinder a weight M_a pounds of steam, which separates itself into two distinct parts: the one in the gaseous state occupying a volume V_o corresponding to the pressure p_o indicated upon the diagram, of which we will call m_o the weight; the other, in the liquid state, is spread over the surface of the walls, and its weight is $M - m_o$.

The difference $M_a - m_o$ has received the name of missing quantity at the end of admission, and for this reason: In order to estimate m_o, the weight of the saturated steam present in the cylinder at the end of admission, and occupying the volume V_o corresponding to the pressure p_o, one finds in the steam tables the weight d_o pounds per cubic foot of saturated steam, and the product $v_o\ d_o$ is equal to m_o. As to M_a, it is a quantity determined directly by experiment. The ratio

$$\frac{m_o}{M_a} = x_o$$

is called in French *"titre du mélange,"* and in English "quality of the steam."

It is this which it is necessary to know for the discussion of engine economy. This is also true of the ratio

$$\frac{M_a - m_o}{M_a} = 1 - x_o$$

It should not be concluded that the missing quantity is of small importance. In the tests recorded in the final table this quantity $1 - x_o$ varies between 20 and 44 per cent.

In the same way at the end of the expansion there remains in the cylinder a volume v_1 corresponding to saturated steam of the pressure p_1 of which the weight is $V_1\ d_1 = m_1$ pounds. Its quality is, therefore, $x_1 = \frac{m_1}{M_a}$ and the missing quantity equals

$$1 - x_1.$$

Generally during the expansion a part of the $(M_a - m_o)$ pounds of water is evaporated, with the result that one has

$$x_1 > x_o \text{ and } 1 - x_1 < 1 - x_o$$

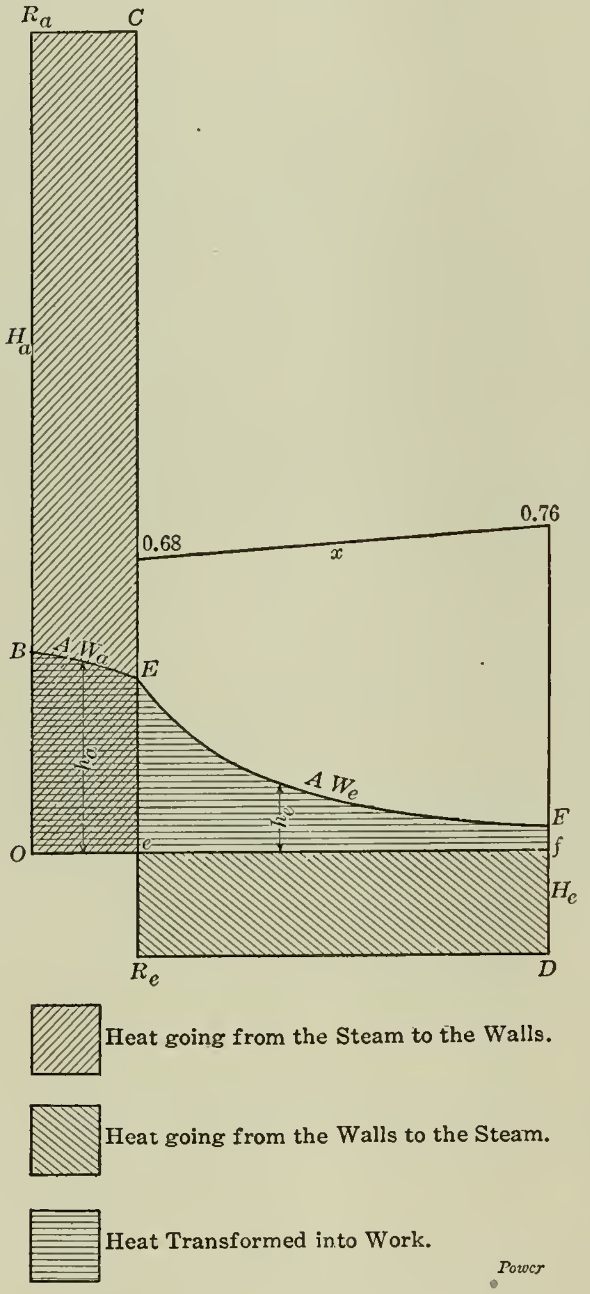
For the eight tests of engines recorded in the final table the values of $1 - x_o$ and of $1 - x_1$ are given. Let us now pass to the valuation of the quantities of heat in play.

The M_a pounds of steam coming into the cylinder for one stroke of the piston bring in Q thermal units, of which a part disappear to produce the work W_a foot-pounds. This part equals $\frac{W_a}{778}$ B.t.u., which we will call $A\ W_a$, representing the reciprocal of 778 by A. A second part, R_a thermal units, represents the heat given up to the metal of the cylinder walls. The rest

$$V_o = Q - A\ W_a - R_a$$

is present in the steam at the commencement of expansion. The experimental theory gives the means to calculate R_a by this equation, in furnishing experimentally the value of V_o, of Q and of $A\ W_a$.

During the expansion the steam which had V_o thermal units at first loses $A\ W_e$ thermal units to produce the work of expansion. It gains the heat R_e thermal units that the walls restore in vaporizing a part of the water which covers them and finishes by still containing U_1 thermal units from now on completely lost, so that



$$U_o - A\ W_e + R_e = U_1$$

Experiments giving the values of U, $A\ W_e$ and U_1 make it possible to deduce the value of R_e from this last equation.

To recapitulate, for the entire stroke of the piston, the heat utilized in work is

$$A\ W_a + A\ W_e = A\ W_f$$

The loss to the cylinder walls,

$$R_a - R_e = R_f$$

Loss by heat of exhaust steam, U_1.

The Diagram of Heat Exchange

Whatever the length of the stroke of the piston in the engine in question, that stroke is represented invariably upon the diagram by a length of two inches $= O\ f$ in the accompanying figure. The fraction of the stroke passed through during admission is represented by $O\ e$, and that during expansion by $e\ f$. The steam line $B\ E$ and the expansion line $E\ F$ of the indicator diagram are traced in upon a convenient scale. Then the area $O\ B\ E\ e\ O$ represents upon a certain scale the heat equivalent of the work performed by W pounds of steam during admission; that is to say, $\frac{W_a}{778}$ B.t.u., that we call $A\ W_a$ in making $A = \frac{1}{778}$.

In the same way and to the same scale the surface $e\ E\ F\ f\ e$ represents the heat equivalent of the work furnished by the steam during expansion. In order to distinguish these areas I have covered them with horizontal rulings.

We will call h_a and h_e respectively the hights of two rectangles, of which the bases will be $O\ e$ and $e\ f$, and of which the surfaces are $A\ W_a$ and $A\ W_e$.

Now, knowing by experiment the quantities of heat R_a furnished by the steam to the metal during admission, and R_e restored by the metal to the steam during expansion, these may be represented by surfaces on the same scale as those proportional to the work effected. In order to represent R_a thermal units a rectangle is drawn, of which the base is $O\ e$ and the hight H_a, calculated from the equation

$$O\ e \times H_a = R_a$$

that is, the rectangle $O\ B\ R_a\ C\ E\ e\ O$. In the same way we proceed to represent R_e, which gives a rectangle having $e\ f$ for the base and H_e for hight, calculated by the equation

$$e\ f \times H_e = R_e$$

The sign for R_a is, however, the contrary of the sign for R_e, the one representing the heat ceded by the steam to the metal, and the other by the metal to the steam. For this reason we place the first rectangle R_a above the axis $O\ f$ and the second below, distinguishing the surfaces besides by different inclinations of the cross-hatching.

The diagram of heat exchange is, therefore, $O\ B\ R_a\ C\ E\ e\ R_e\ D\ f\ O$. It is easy to trace it if one knows the ratio of R_a to $A\ W_a$ and that of R_e to $A\ W_e$, ratios equal to $\frac{x\ H_a}{h_a}$ and $\frac{H_e}{h_e}$ respectively.

We add to the figure a line of which the ordinates represent the quality x of the steam during the expansion, and of which the values are $x_o = 0.68$ at the commencement and $x_1 = 0.76$ at the end. We suppose, although this will not be exact, that the diagram of this quality will be a straight line. The diagram is drawn upon the scale of two inches equals unity. Under the conditions assumed, the heat R_a lost during admission is 4.47 times greater than the heat $A\ W_a$ utilized for the work, and it is greater than the heat R_e restored by the metal during exhaust, with the result that there is a positive loss equal to

$$R_a - R_e = R_f$$

which we will call the final loss R_f. It is important to consider also the ratio of the final loss R_f to the heat equivalent of the final work

$$A W_f = A W_a + A W_e$$

In the accompanying table we give these ratios

$$\frac{R_a}{A W_a}, \quad \frac{R_e}{A W_e}, \quad \frac{R_f}{A W_f}$$

which permit diagrams of the heat exchange for the eight tests of Donkins, Willans and Hirn to be traced. One who has not studied in actual operation the evolutions of steam in the cylinder will perhaps with difficulty believe that the quantity of heat ceded to the metal during the admission can amount to 4.47 times that which represents the work effected during the same period. He will believe without doubt that our diagram is exaggerated, but if he will cast his eyes over our table of experimental data he will see that the figure 4.47 was obtained in text X of the Willans engine at 400 revolutions per minute, and that at 138 the same ratio has increased to 9.20, that in the VI test of the Hirn engine of 150 horsepower this ratio amounted to 6.6, while in the two tests II and IV on the Donkin engine of six horsepower the ratios were 3.55 and 2.67 respectively. In fact, our diagram is very approximately that of test X of Willans as to degree of expansion, as to work diagram, diagrams of exchanges and to qualities x_0 and x_1. Our diagram makes very apparent the relative importance of the heat exchanges between the metal and the steam comparatively to the heat converted into work. It presents this advantage over the entropy diagram, which conceals rather than illustrates the real phenomena and which is plotted only with great difficulty and by graphic calculations impossible to control, while our diagram is based on figures obtained by arithmetical calculations. But let us return to the principal object of our discussion and commence by giving the table of tests chosen as enumerated above.

Is Professor Heck justified in believing that the disturbance brought about by the thermal action of the walls are sensible in small engines and negligible in the larger machines, such as one finds in practice? The accompanying table gives the results obtained on three machines, one large of 150 horsepower, another small of 6 horsepower, the third intermediate of 35 horsepower. It seems to me that the differences are sufficient to show themselves. Well, the examination of the table leads to the following conclusion. The loss by the walls during admission varies according to circumstances from 4.33 to 6.59 in the large machine, 2.67 to 3.55 in the small machine, 4.47 to 9.20 in the intermediate machine.

The restitution by the walls during expansion from 0.80 to 1.22 in the large engine, 1.90 to 2.50 in the small engine, 1.20 to 1.90 in the intermediate engine.

The positive loss by the walls from 0.97 to 1.94 in the large engine, 1.51 to 1.70 in the small engine, 1.08 to 2.30 in the intermediate engine.

The proportion of steam condensed during admission varies from 25 to 37 per cent. in the large engine, 20 to 23 per cent. in the small engine, 32 to 44 per cent. in the intermediate engine.

The proportion of water reëvaporated during expansion varies from 2 to 8 per cent. in the large engine, 3 to 4 per cent. in the small engine, 8 to 10 per cent. in the intermediate engine.

To sum up, the action of the cylinder walls does not vary with the size of the engine, but considerably with the conditions of operation. If this action is more intense in the intermediate machine, it is that this was single-acting, and its walls exposed for one-half of the time to free and cool air.

DATA FROM TESTS OF DONKIN, WILLANS AND HIRN

Object of the Tests	Number	Condensation	Degree of Expansion	Revolutions per Minute	Experimental H.P. Absolute	Experimental H.P. Indicated	Pounds of Steam per Hour Per Absolute H.P.	Pounds of Steam per Hour Per Indicated H.P.	Moisture Quantity At Beginning of Expansion $1 - x_0$	Moisture Quantity At End of Expansion $1 - x_1$	Ratio of the Exchange of Heat R to the Heat Equivalent of the Work: $\frac{R_a}{AW_a}$ During Admission	$\frac{R_e}{AW_e}$ During Expansion	$\frac{R_f}{AW_f}$ During both Admission and Expansion
DONKIN 6 H.P.													
Effects of condensation	II	Condens.	0.681	92.27	8.03	5.61	20.14	27.11	[illegible]	0.18	3.55	2.5	1.70
	IV	No Cond.	0.681	92.66	11.74	6.20	22.74	42.85	[illegible]	0.17	2.67	1.9	1.51
WILLANS 35 H.P.													
Effects of speed	X	No Cond.	0.28	400.16	[illegible]	[illegible]	17.00	24.7	0.32	0.21	4.47	1.2	[illegible]
	XI	No Cond.	0.28	223.7	28.27	[illegible]	[illegible]	[illegible]	0.41	0.32	[illegible]	1.8	[illegible]
	XII	No Cond.	0.28	138.0	17.97	[illegible]	[illegible]	[illegible]	0.44	0.34	9.20	1.9	2.30
HIRN 150 H.P.													
Effects of superheat and of ratio of expansion	II	Complete	0.257	30	160.64	[illegible]	18.27	21.51	[illegible]	[illegible]	4.33	1.2	[illegible]
	V	Condens.	0.162	30	125.20	[illegible]	14.50	16.15	[illegible]	[illegible]	[illegible]	[illegible]	0.97
	VI	Complete	0.162	30	121.73	107.31	17.18	19.41	[illegible]	[illegible]	[illegible]	[illegible]	1.94

REJOINDER BY PROF. R. C. HECK

In so far as the foregoing is controversial in form, it is to a large degree based upon misconception, as has been already pointed out. Assumptions and "theories" are attributed without any real foundation in my article of September 13. It is regrettable that the tone of personality should be so strongly injected into a presentation of scientific information, and so much space wasted on the demolition of theories which are now held by no intelligent thinker.

The thesis still stands that in its combination of small size and low speed the engine in the laboratory at Liége is not representative of commercial practice, and that deductions from the results of experiments upon it cannot be directly applied to large or fast-running engines. The same actions exist in large engines, but their relative magnitude is less.

In the foregoing paper the discussion which follows the presentation of references and data, describing the general action of the cylinder walls in causing condensation and reëvaporation and in wasting heat on the exhaust steam, is all common knowledge; no one questions it or is ignorant of it. The scheme of graphical representation of thermal action is one of the recognized methods, although it is doubtful whether engineers in this country ever use it. For most purposes, and especially when considering such an involved and uncertain matter as the way in which the action of the cylinder walls varies in different engines and under different conditions, the mere percentages of steam initially condensed and then reëvaporated constitute a close enough measure of the wall effect.

The Hirn engine which is quoted certainly had a large cylinder, but was of slow speed. However, in the sense of output it was not a large engine; an engine, excluding pumping engines, only begins to be considered large at 500 horsepower. That the Donkin engine shows less condensation than the Hirn engine is accounted for by higher speed and late cutoff, which factors overbalance the smallness of the cylinder. The Willans engine has its marked peculiarities, and besides is no bigger (in piston displacement) than the Donkin engine; as a minor correction, the size is 14x6 inches, not 13x6 inches. Altogether, the data presented are too few and too discordant to give a clear idea of the influence which any of the controlling conditions exert upon cylinder action. These governing conditions are, speed in revolutions per minute (not piston speed), size (with which the type of cylinder design must be included), ratio of cutoff or of expansion, and range of pressure and steam temperature within the cylinder.

Reciprocating Engine and Low Pressure Turbine*

Some interesting figures in support of the low-pressure turbine as used in connection with the reciprocating engine were shown by the tests of the steam yacht "Vanadis." This vessel, which is of 1300 tons displacement and 279 feet length overall, was built in 1908 and fitted with three Parsons turbines, one high-pressure and two low-pressure. The builders guaranteed a coal consumption of 26 tons per 24 hours when cruising at 13 knots, but it was found that in actual service this figure was greatly exceeded, in fact, so much so that the steaming radius with the limited bunker capacity was cut unconveniently short.

To remedy this, it was decided to remove the high-pressure turbine and replace it by a triple-expansion reciprocating engine, leaving the low-pressure turbines connected to the outboard shafts. After the completion of these changes a set of standardization trials were made. First, the propellers were removed from the turbine shaft and the vessel run at 13 knots with the reciprocating engine alone, during which the steam consumption was approximately 17 pounds per indicated horsepower-hour. Next, the propellers were replaced and the reciprocating engine run in connection with the two turbines—a speed of 13 knots being maintained—in which case a water consumption of 14½ pounds per indicated horsepower-hour was attained, as against 20½ pounds before the change was made.

*Abstracted from a paper read by C. H. Crane before the Society of Naval Architects and Marine Engineers.

A Rule of Thumb for Horsepower

By F. R. Low

The horsepower of an engine is the product of the piston area, the piston speed and the mean effective pressure divided by 33,000.

The piston area is 0.7854 times the square of the diameter.

The complete formula then is;

$$H.P. = \frac{0.7854\ D^2 \times \textit{piston speed} \times M.E.P.}{33{,}000}$$

Dividing the 33,000 by the 0.7854 this becomes,

$$H.P. = D^2 \times \frac{\textit{piston speed} \times M.E.P.}{42{,}017}$$

The quantity by which the square of the diameter is to be multiplied will be for the usual case somewhere between 0.5 and unity. When it is unity, i.e., when the product of the piston speed and the mean effective pressure is 42,017, the formula becomes delightfully simple

$$H.P. = D^2.$$

This would be true of any of the combinations of piston speed and mean effective pressure given in the first double column of the accompanying table. A condensing engine might easily have a mean effective pressure of 52.5 pounds and run at 800 feet piston speed, and for such an engine this simple formula would give out of hand an excellent idea of its capacity.

The remaining double columns of the table give the combinations of piston speed and mean effective pressure which would justify the use of the single-place numbers 0.9, 0.8, 0.7, etc., at the heads of the column. The common assumption of 600 feet of piston speed and 40 pounds mean effective pressure would call for 0.57 to which a column is devoted, but 0.6 D^2 would give a close approximation to this condition.

The idea is that the horsepower will usually lie between

$$H.P. = D^2$$

and

$$H.P. = 0.5\ D^2\ or\ \frac{D^2}{2}$$

For simple condensing engines at high piston speeds the first and simpler formula will give a close approximation. With lower piston speeds and mean effective pressures the square of the diameter may have to be multiplied by a factor running down to 0.5 for the conditions given in the last column of the table.

$H.P. = D^2$ $P. \times S. = 42{,}017$		$H.P. = 0.9\ D^2$ $P. \times S. = 37{,}815$		$H.P. = 0.8\ D^2$ $P. \times S. = 33{,}614$		$H.P. = 0.7\ D^2$ $P. \times S. = 29{,}412$		$H.P. = 0.6\ D^2$ $P. \times S. = 25{,}210$		$H.P. = 0.57\ D \approx \frac{D^2}{1.75}$ $P. \times S. = 24{,}000$		$H.P. = 0.5\ D^2 = \frac{D^2}{2}$ $P. \times S. = 21{,}008$	
Piston Speed.	M. E. P.	Piston Speed.	M. E. P.	Piston Speed.	M. E. P.	Piston Speed.	M. E. P.	Piston Speed.	M. E. P.	Piston Speed.	M. E. P.	Piston Speed.	M. E. P.
300	140.1	300	126.0	300	112.0	300	98.0	300	84.0	300	80.0	300	70.0
350	120.0	350	108.0	350	96.0	350	84.0	350	72.0	350	68.6	350	60.0
400	105.0	400	94.5	400	84.0	400	73.5	400	63.0	400	60.0	400	52.5
450	93.4	450	84.0	450	74.7	450	65.4	450	56.0	450	53.3	450	46.7
500	84.0	500	75.6	500	67.2	500	58.8	500	50.4	500	48.0	500	42.0
550	76.3	550	68.7	550	61.1	550	53.5	550	45.8	550	43.6	550	38.2
600	68.7	600	63.0	600	56.0	600	49.0	600	42.0	600	40.0	600	35.0
650	64.6	650	58.2	650	51.6	650	45.2	650	38.8	650	36.9	650	32.3
700	60.0	700	54.0	700	48.0	700	42.0	700	36.0	700	34.2	700	30.0
750	56.0	750	50.4	750	44.8	750	39.2	750	33.6	750	32.0	750	28.0
800	52.5	800	47.3	800	42.0	800	36.8	800	31.5	800	30.0	800	26.2
850	49.4	850	44.4	850	39.5	850	34.6	850	29.6	850	28.2	850	24.7
900	46.7	900	42.0	900	37.3	900	32.7	900	28.0	900	26.6	900	23.3
950	44.2	950	39.8	950	35.4	950	31.0	950	26.5	950	25.3	950	22.1
1000	42.0	1000	37.8	1000	33.6	1000	29.4	1000	25.2	1000	24.0	1000	21.0
1050	40.0	1050	36.0	1050	32.0	1050	28.0	1050	24.0	1050	22.8	1050	20.0
1100	38.2	1100	34.4	1100	30.5	1100	26.7	1100	22.9	1100	21.8	1100	19.0
1150	36.5	1150	32.9	1150	29.2	1150	25.6	1150	21.9	1150	20.9	1150	18.3
1200	35.0	1200	31.5	1200	28.0	1200	24.5	1200	21.0	1200	20.0	1200	17.5

On account of numerous cases of cholera, which it is thought may be traced to that source, the Minister of the Interior of Hungary has forbidden the cutting of ice from ponds and rivers. This would seem to open an unusual opportunity for builders of ice and refrigerating machinery in that country.

A good telltale that will show when a bucket trap is not working or is getting more water than it has capacity to handle can be made by connecting a brass-tube air valve to the top of the trap, which will blow whenever the trap is full of water.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

The Gas Cleansing Plant at the Lackawanna Steel Works*

By E. P. Coleman

At the Buffalo works of the Lackawanna Steel Company is located the first gas-engine power plant to be operated in this country with blast-furnace gas. As far as can be learned, the selection of the type of engine was made in 1900, based on extended observation by a committee of the working of blast-furnace gas-power plants in Europe. The types observed were the Cockerill, Otto, Oechelhaeuser and Koerting. The Oechelhaeuser engine was disregarded on account of the crank-shaft design and the four-stroke cycle engines were not favorably considered on account of exhaust-valve troubles which did not seem to have been mastered at that time. The engines were built by the De La Vergne Machine Company, New York, after designs by the firm of Koerting Brothers, Hanover, Germany.

At this plant 12,000 to 15,000 net horsepower is normally developed by gas engines operated with blast-furnace gas, the greater portion for blowing the furnaces. There are sixteen blowing engines, each rated at 2000 indicated horsepower, and eight electric power units, each consisting of a gas engine rated at 1000 indicated horsepower, direct connected to a 500-kilowatt generator. Four of the latter units generate direct current at 250 volts and the other four generate three-phase 25-cycle alternating currents at 440 volts. All of the engines are of the two-stroke cycle type, equipped with twin cylinders and cranks spaced 90 degrees apart.†

The general arrangement is shown in Fig. 2. There are six blast furnaces in a line extending approximately north and south. These furnaces are grouped in pairs, each pair forming a unit with reference to the arrangement of its stoves, ore bins, gas plant and various auxiliaries. The engines in blowing-engine house No. 2 furnish air for furnaces 3 and 4. Furnaces 5 and 6 are supplied with air by the engines in blowing-engine house No. 3. The air for furnaces 1 and 2 is usually supplied by steam engines located in the north end of blowing-engine house No. 2. The gas-driven electric generator units are located in the south end of power house No. 1.

The general process of preparing the gas for use in the engine cylinders is as follows: The gas leaving the furnace top passes through large downcomer pipes to the dust catcher, where the heavier portion of the dirt is deposited under the action of gravity. From the dust catcher, portions of the gas pass through pipe mains respectively to the hot stoves, the boilers and the gas engines. That portion used by the gas engines is cooled and partially cleaned by means of water sprays in the pipes and chambers through which the gas passes, after which it is further cleaned by passing through centrifugal fans into which water is also sprayed. From the fans the gas passes through separators which remove the entrained moisture and its entrained dirt, and thence under a few ounces of pressure (above atmospheric) to the engine houses.

The six blast furnaces under consideration produce about 2000 long tons of iron per 24 hours, or about 108 tons per hour. The gas amounts to about 150,000 cubic feet per ton of iron, or, say, about 16,000,000 cubic feet per hour or more from the six furnaces. Approximately 2,500,000 cubic feet per hour is used for the gas-engine plant, the remainder being burned in the hot-blast stoves and under the boilers.

All of the dust catchers are provided with a suspended partition or baffle wall of firebrick cutting off direct passage of gas from inlet to outlet; the gas having to pass under this wall and up to the outlet.

Piping

The general arrangement and main dimensions of the piping for washed gas are shown in Fig. 1. Each group of eight blowing engines is served with washed gas through a 60-inch overhead main of riveted steel plate delivering gas to a main header of 96 inches diameter alongside the wall of the engine house near the yard level. The eight 1000-horsepower engines at power house No. 1 are supplied with gas from furnaces 1 and 2 through a 30-inch underground pipe of cast iron. This pipe is cross-connected with the 96-inch header near the south end of blowing-engine house No. 2 by means of a 42-inch overhead pipe. Gas washers 3 and 4 are connected with gas washers 5 and 6 through a 36-inch equalizing pipe, as shown. Low points in the piping are provided with drains. The general arrangement of this piping deserves adverse criticism, as will be shown.

No gas holders are installed or required. The length of the 30-inch main supplying the power house is about 1190 feet. The 60-inch main supplying engine house No. 2 is about 525 feet long, and the 96-inch header at blowing-engine house No. 3 is supplied through about 415 feet of 60-inch pipe. In this main

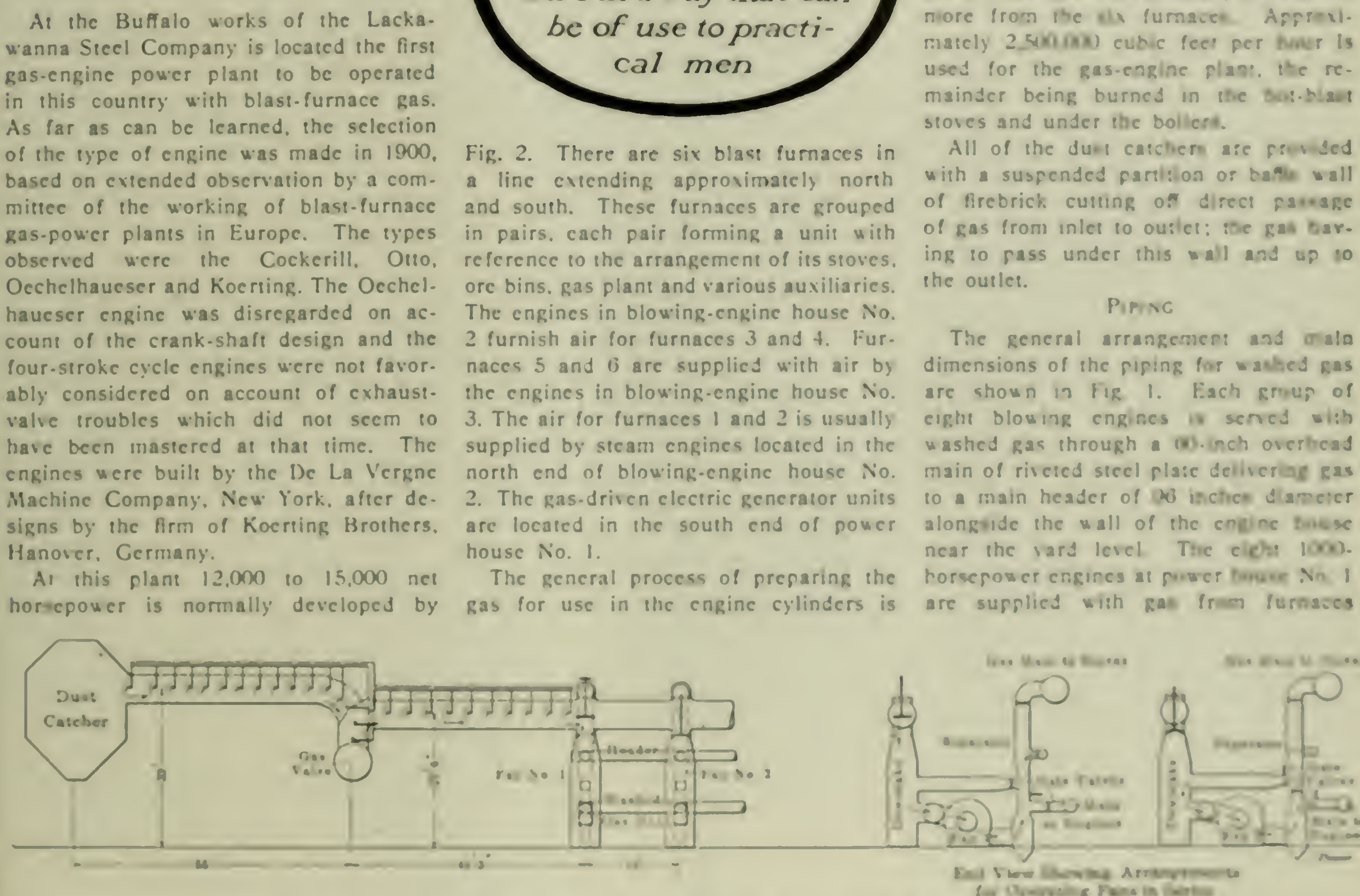


Fig. 1. Schematic Diagram of Gas-washing Plant for Furnaces 1 and 2

*Partial abstract of a paper read before the American Society of Mechanical Engineers, December, 1910.

†These engines were described in Power several years ago; hence a detailed description of them is omitted here.

at the south end of the engine house is a 60-inch venturi meter. The blowing-engine house header lies along the east side of the building. It is supported on the concrete work of the exhaust tunnel and is about 400 feet long. The 8-foot section is 255 feet long and is of riveted ⅜-inch plate. The plates of the 6-foot portion are 5/16 inch thick. A 24-inch connection is taken off for each engine on the side nearest the building. Water is drained from the header by means of an inverted siphon. The total length of piping from the washers to the engine houses is about 3800 feet.

Nos. 1 and 2 Gas Washers

There is a gas-cleaning plant at each pair of furnaces consisting of chambers equipped with water sprays for cooling the gas and washing out a portion of the dirt, centrifugal fans also provided with water sprays, separators for removing the entrained water, and the necessary valves and piping. Schematic diagrams, Figs. 1 and 3, show the general arrangement of the washing plants, the former illustrating the washery first installed at furnaces 1 and 2, and Fig. 3 the arrangement of apparatus at furnaces 3 and 4. The general arrangement of washers at furnaces 5 and 6 is similar to that at furnaces 3 and 4. In the plant represented in Fig. 1 the gas is taken from the dust catchers through horizontal pipes where it is given an initial cooling and washing by means of water sprays. The cool gas then passes to four fan washers located between the two furnaces. These fans are normally operated in pairs, each pair forming a unit consisting of the two fans operating in series with each other; the first fan draws cool gas from the main supply and discharges it to a first-washed main, and the second fan takes its gas from this main and discharges it to the second-washed main, from which the gas passes to the 30-inch gas line and to the power house.

The pipe leading from the dust catcher to the fans is 70 inches in diameter. At a point about midway between the fans and the dust catcher a water-seal valve is located, consisting of a horizontal steel tank 8 feet in diameter, through which the gas passes on its way to the fans. By filling with water it acts as a shut-off valve and by partly filling with water the gas flow may be reduced to any desired extent, these functions being useful when a furnace is working badly and giving a poor quality of gas. The 8-foot tank also serves as a receptacle to which the water is drained from the cooling sprays.

The 70-inch pipe connecting the dust catchers to the fans is about 236 feet long, the total travel of the gas from dust catcher to fan being about 123 feet. Located in this piping are 99 water sprays for cooling the gas on its way to the fan washers. These spray nozzles are located at the axis of the pipe, about 3 feet 6 inches apart, and discharge a cone-shaped spray into and against the stream of gas. The sprays are supplied from a 3-inch header through 1-inch pipe connections and each spray consumes about 8 gallons of water per minute. The water drains first into the 8-foot tanks and from thence through a seal into tank cars beneath, where the dirt is deposited and the water passes off from an overflow into the general drainage system.

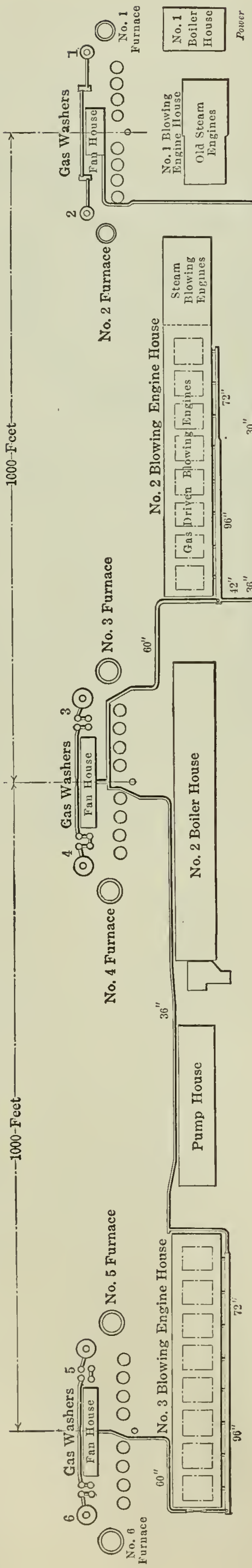


Fig. 2. Plan Diagram of Furnaces, Washers and Power Houses of Lackawanna Steel Works

The connections to the fans are taken from the bottom of the 70-inch main, the connection being 48 inches in diameter, enlarging to 70 inches diameter. Each connection can be shut off from the gas pipe by means of a disk valve operated by a chain drum and handwheel located on top of the gas pipe, and each connection is provided with a hopper bottom, valve and drain, forming a pocket for the mud and water brought down with the gas. The drain pipe extends downward into a well, forming a seal.

The fans are very similar in general features to ordinary centrifugal ventilating fans. The wheels are 6 feet 11 inches in diameter. There are 8 blades, each 15½ inches wide at the inner end and 13 inches wide at the tip, carried on tee-iron arms set in a cast-iron hub. The cast-iron suction connections are rectangular. The main is 20¼x52 inches. A branch 21x48 inches leads to each side of the fan, the opening to the fan casing being 36 inches in diameter. These connections are provided with cleaning holes to facilitate removal of mud. Water connections are provided for four nozzles on each side carried through the casing and discharging through the circular inlet to the fan. Waste water from the furnace tuyeres and bosh plates flows from the furnace troughs into a stand pipe equipped with an overflow located at the proper level, and a portion of the water in the stand pipe passes through pipes to the fans.

Each fan is driven by a 75-horsepower electric motor direct connected to the fan by means of a flexible coupling, and each one discharges horizontally at the bottom through a 21½x45-inch connection into a water separator. The separator is a steel box 4 feet square by 9 feet high, containing a set of baffles consisting of three rows of 3-inch steel channels, the flanges of the channel bars facing the stream. The openings between channels are about 1 inch wide, and the spacing is alternate or staggered, such that the streams of gas are broken and turned. The separated water and mud drop to the bottom of the separator and pass out through a seal. The gas leaves the separator at the top through a 24-inch pipe connection.

First-washed gas which has passed through one fan passes back into one of the 70-inch vertical connections on the cool gas main, and is isolated from it by means of the disk valve at the top, previously mentioned. The gas then flows through the second-wash fan to the second-washed gas main; and thence through the 30-inch line to the power house. The piping and valves are so arranged that any fan may be used for either first or second washing. The valves in the fan connections are 24-inch gates, with seats and disks of cast iron.

Nos. 3 and 4 Gas Washers

In the washing plant shown in Fig. 3, the gas passes from the dry-dust catcher through a 96-inch connection leading to a set of four cooling towers 12 feet in diameter and 72 feet high. The cooling water is sprayed into these towers through numerous nozzles set in the sides. The first-washed gas passes from the fans through a water separator into a 78-inch header called the first-wash main, from which it is passed back to the suction side of the fans working on second washing, these being shut off from the cooled-gas main. From these fans the gas passes through the separators and into the second-washed main of 60 inches diameter. The 60-inch main supplying the engines is connected to the middle point of this header.

The four cooling towers are carried on a structural platform which is located 18¼ feet above yard level to provide clearance for mud cars which receive the drainage from the bottom connections. The connections between the towers are 8 feet in diameter and the travel of the gas is up and down in alternate towers. Each tower is provided with a hopper bottom and pipe seal having connection with a common drain pipe which delivers the discharge of all four towers to the tank cars beneath. Towers *A* and *B* are further provided with emergency seal drains at a higher level. These emergency seals are normally idle, but should the bottom drain become clogged the tower will then drain through the emergency seal. Tower *A* is also provided with a steel plate baffle in front of the inlet opening. When the tower is filled with water to the required hight the water and baffle serve as a valve to shut off communication between the towers and the dry-dust catcher, a sealed overflow maintaining the proper water level when desired.

The first tower is equipped with about 30 sprays, the second has 35, and the third and fourth about 20 to 25 sprays each. The sprays are placed in five circular rows, 6 feet apart vertically; the lower row is about 20 feet from base of tower. The nozzles are of brass throughout, and made as shown in Fig. 4. The shell has a 2½-inch external pipe thread which screws into a flange riveted to the shell of the tower. The helical passage produces a whirling cone-shaped spray of about 90 degrees "spread" and 6 to 10 feet maximum diameter. The 1½-inch plug permits access to the spindle for cleaning. These sprays use about 7 gallons per minute at the average pressure carried.

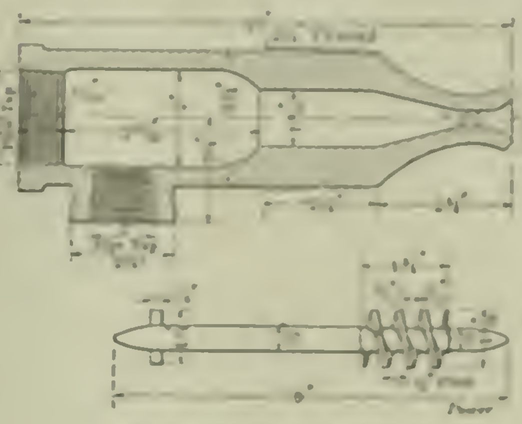


Fig. 4. Spray Nozzle

From the towers the gas passes through a 7-foot pipe to the fans. This pipe also is provided with nozzles which spray water into and against the stream of gas, the nozzles being located at the center of pipe. The gas leaves the cooled-gas main at the bottom and passes to the fans through vertical suction connections. The latter have hoppers and water-sealed drains at the lower end and may be shut off from the cooled-gas main by means of bell valves operated by a winch and handwheels located on top of the horizontal main. These valves seat in a water seal. The opening is of 45 inches diameter. At the midpoint of the cooled-gas main connecting the two sets of towers is located a shut-off valve consisting of an inverted siphon which may be partly or wholly filled with water to regulate the amount of gas coming from either furnace.

There are eight fan washers housed in a steel-frame building and set with their shaft centers 9 feet 8 inches above the yard level, this elevation being necessary for drainage. The wheels are of ¼-inch steel plate, 7 feet 1 inch in diameter, having eight blades each 29½ inches wide at the inner end, and 27½ inches wide at the tip. The central opening of wheel is 40 inches in diameter. The casing is of cast iron and of the double-suction type; each branch of the suction connection is rectangular, 20x50 inches, opening into the fan through a 36-inch diameter inlet. The bottom-discharge connection is 40x36 inches. The wheel shaft is direct connected through a flexible coupling to a 100-horsepower motor running at 480 revolutions per minute. Six of these motors utilize alternating current and two direct current. The two types are used so that should there be an accident to either circuit, the motors on the remaining circuit will continue to operate and keep a part of the engines running until the necessary corrections can be made.

Water is thrown into each fan through 16 spray nozzles. Eight of these discharge into the central inlet openings, four on each side; the other eight discharge into the fan through the upper half of its periphery. The sprays are fed by four 1½-inch lines connected to a 6-inch header extending the full length of the building, over the fans. Each spray connection is a ¾-inch pipe. The water for the fan sprays is taken from the waste of bosh-cooling water from the furnace, which overflows from a stand-pipe, a portion under the necessary head going to the fans.

From the fan washers the gas passes to water separators constructed as follows

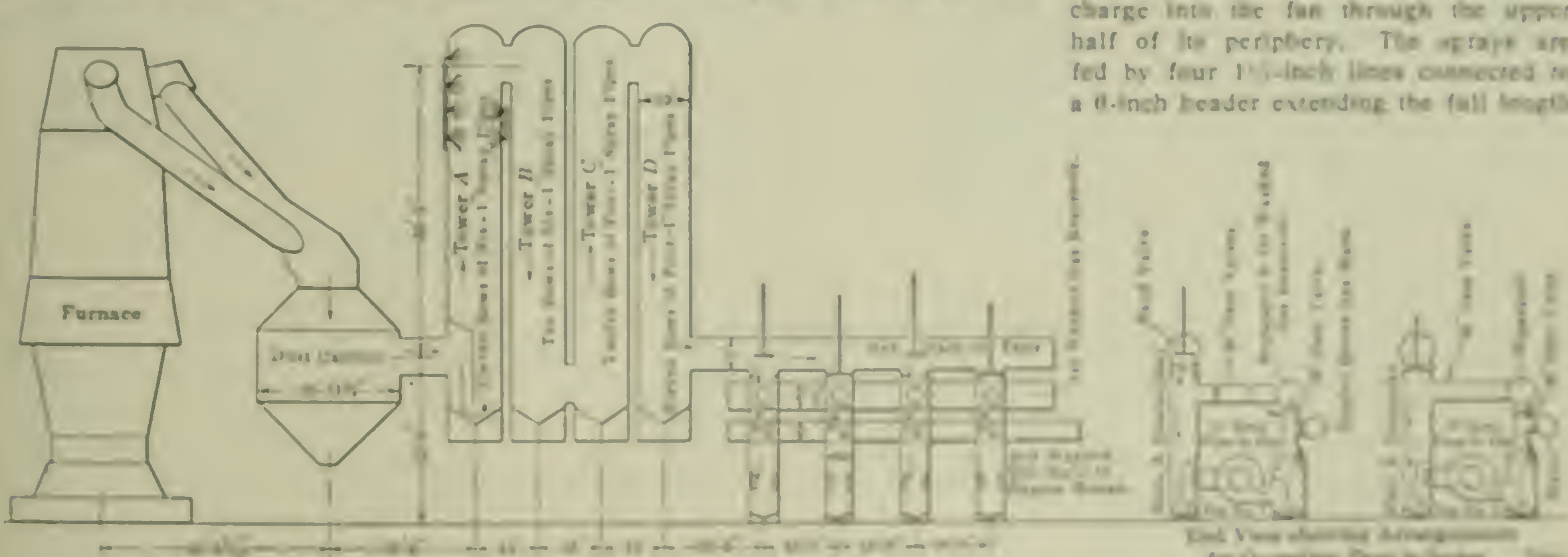


Fig. 3. Schematic Diagram of Gas-washing Plant for Furnaces 3 and 4

in Fig. 5. The gas passes first through a set of baffles consisting of four rows of 4-inch channels set vertically, the openings between the channels being 1½ inches wide, with staggered spacing so that the streams of gas are broken and turned. The separated water falls down the vertical channels, carrying with it the dirt, and passes out at the bottom through a seal to the drainage system. After passing through the channel baffle, the gas rises through annular disk baffles and passes from the separator through a 36-inch top connection.

Each separator is equipped at the top with a cast-iron tee providing outlets through 36-inch gate valves to the first-washed and second-washed mains. Fans working on first washing discharge their gas into the first-washed main. This gas is then taken by the fans working on second washing and by them discharged into the second-washed main. The diameters of the first- and second-washed mains are 78 inches and 60 inches. The first-washed main extends the full length of the fan house, and is connected to the vertical suction connection of each fan through a 42-inch gate valve. The valves and piping are so arranged that any fan may be operated on either first or second washing.

The gas-washing plant at furnaces 5 and 6 is substantially the same as that described for furnaces 3 and 4, but the water separators have a different style of baffling. One of these separators is shown in Fig. 6. The gas circulates through zigzag passages formed by narrow plates assembled as shown. The projecting edges of plates are formed to catch the water and lead it to the bottom of the chamber, where it passes out through a seal. There are two sets of baffles through which the gas passes in succession, one at the bottom and one at the top.

General

The delivery mains from the three gas-cleaning plants are interconnected by two pressure-equalizing pipes. These mains for hot gas, cooled gas and washed gas are locally interconnected in parallel relation at each pair of furnaces. It is therefore possible to control the amount of gas taken from each furnace and the gases from the two furnaces are thoroughly mixed by discharging into a common washed-gas delivery main. In order to promote in the best manner uniformity in the composition of the gas, the joint delivery from the several washeries should then discharge into a common distributing main or holder. The locations of the three delivery mains, however, and the relative locations of the two equalizing pipes are such that it is impossible for such mixing to occur even locally or approximately, as reference to Fig.1 will make clear.

A partial solution constituting a great improvement would consist in relocating the 30-inch delivery pipe from washers Nos. 1 and 2 along the west wall of blowing house No. 2, to form a junction at the southwest corner of that building with the 60-inch delivery main from washers Nos. 3 and 4. Also the 36-inch equalizing main should deliver gas into the 60-inch delivery main from washers Nos. 5 and 6, instead of into the north end of the 96-inch header at blowing house No. 3. Power house No. 1 and blowing house No. 2 would then receive the average of gas from four furnaces, whereas at present blowing house No. 2 receives gas only from furnaces 3 and 4, and at power house No. 1, the four north engines may receive gas from furnaces 1 and 2, and the four south engines from furnaces 3 and 4. Under these conditions of piping, the gas supply at any point is but an average of that from two furnaces, and at times the irregularity is considerable, the heat value occasionally varying between the limits of 105 and 80 B.t.u. per cubic foot, within a period of a few seconds.

Both the gas-cleaning apparatus and the gas engines were installed at an early stage in the history of the art and are necessarily imperfect when compared with modern examples to which have been applied those refinements that can be gained only through experience. The average dust content of the gas delivered to the second-washed main amounts to about 0.022 to 0.035 grain per cubic foot, which would rightly be considered bad practice in modern gas-cleaning plants.

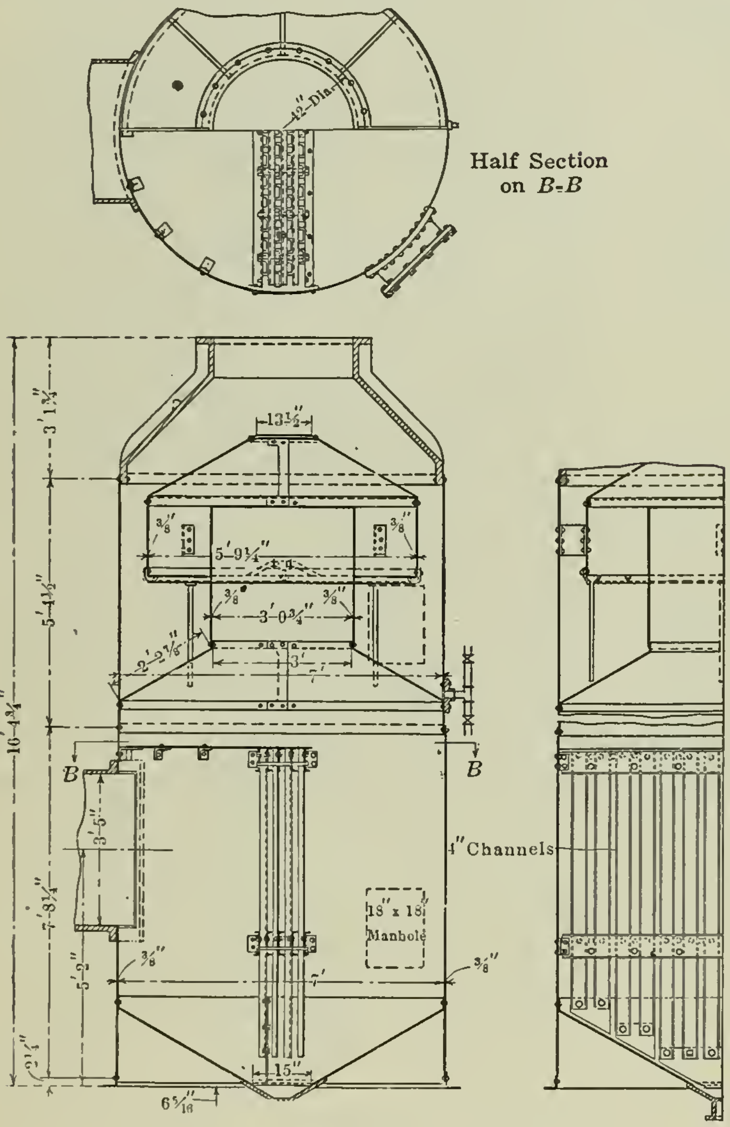


Fig. 5. Water Separator at Gas Washers of Furnaces 3 and 4

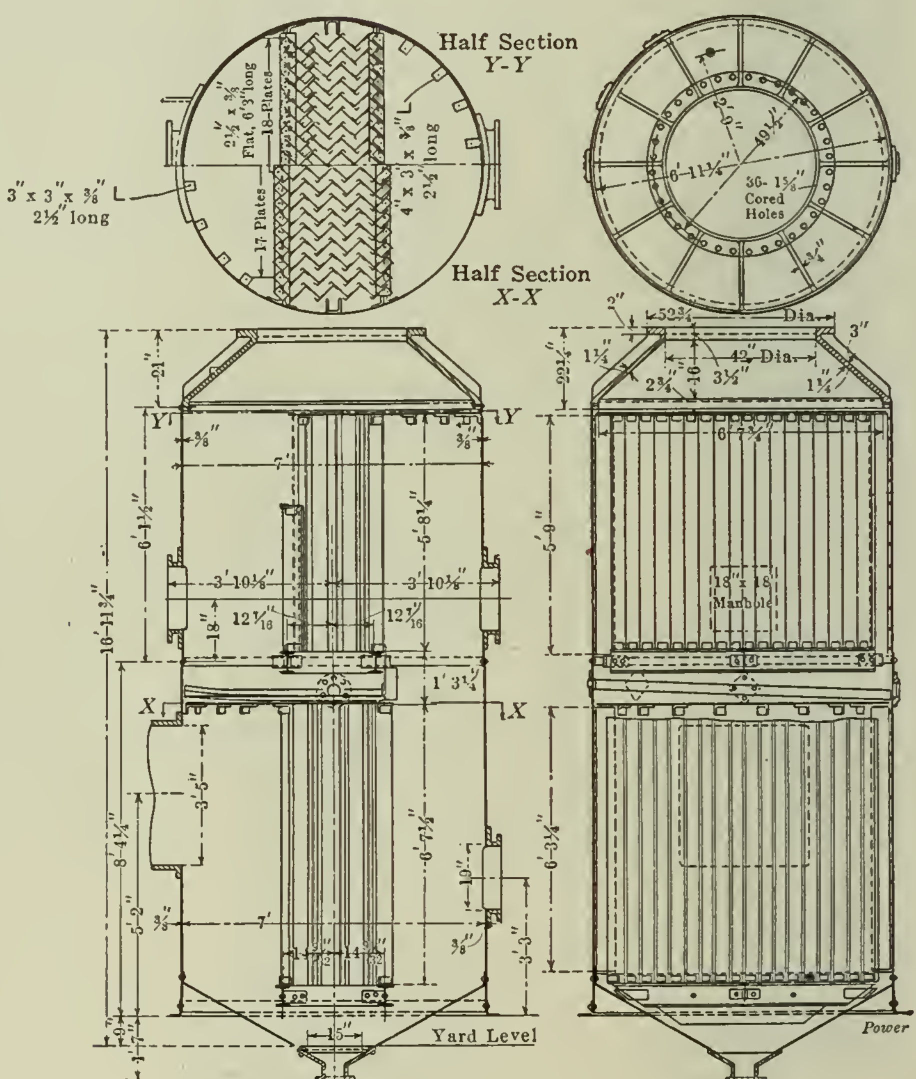


Fig. 6. Water Separator at Gas Washers of Furnaces 5 and 6

The cleaning of the gas at washers Nos. 1 and 2 is less complete than that at washers Nos. 3 to 6. At the two former the dust content in second-washed gas as delivered averages about 0.035 grain per cubic foot. At gas washers Nos. 3 and 4 the average dust content is about 0.328 grain per cubic foot of cooled gas, 0.061 grain in first-washed, and 0.022 grain per cubic foot in second-washed gas.

The gas supplied through the 30-inch main to power house No. 1, therefore, contains more dirt and moisture than that delivered from washers Nos. 3 to 6, in consequence of which there is more trouble with dirt at the power house than at the blowing-engine houses. Moreover, the long 8-foot gas headers at the blowing-engine houses are of probable value in taking moisture out of the gas.

Discussion

In the discussion of Mr. Coleman's paper, George D. Conlee paid tribute to the painstaking thoroughness with which the tests described in the paper had been made and brought out some interesting points regarding some indicator diagrams which were shown in an appendix to the paper.

Louis Doelling, vice-president of the De La Vergne Machine Company, said that the troubles that had been experienced with these engines were due partly to errors in design but largely to dirty gas. The dust in the gas now runs from 30 to 80 milligrams per cubic meter and four years ago it was often as high as 200, whereas good practice puts the limit at 20 milligrams. In the early days, too, the gas was unstable; there were sudden rises of hydrogen due to water getting into the furnaces, and these produced premature ignitions, causing excessive wear and repairs. With clean gas a cylinder ought to run five years before requiring reboring.

The high gas consumption (18,500 B.t.u. per blowing cylinder horsepower-hour) of the Lackawanna engines, Mr. Doelling explained, was due largely to the excessive power consumed by the gas and air pumps and the loss of gas during the final half of the scavenging period. In later engines the pump loss is much smaller by reason of the use of poppet valves and the reduction of the maximum pump pressure from 10 to 4 pounds per square inch. The later engines regulate much more closely also, due to the control of the air and gas taken in by the pumps instead of bypassing the pumps; this gives sufficiently close regulation even for cotton-mill work.

George A. Orrok explained that the Lackawanna power houses are situated unfortunately in that they are between a row of blast furnaces and a row of Bessemer converters, each row being about 60 feet from the power houses. The result is that coke and ore dust from the furnaces and steel dust from the converters are constantly blown into the engine rooms and settle all over the engines. He expressed wonder that the engines would run at all under the existing conditions.

Fan Dynamometer for Testing Stationary Engines

The fan dynamometer designed by Joseph Tracy, the well known automobile expert, for testing small gasolene engines* has been adapted by Mr. Tracy to the testing of stationary gas and oil engines of moderate output. The accompanying picture shows the machine as made for this purpose. It is equipped with a pulley of a diameter which is a submultiple of the diameter of the engine pulley and the fan arm and vanes are made so that the vanes can be adjusted toward and away from the shaft by small increments, according to the amount of power to be absorbed. The arm bears a scale for each fan vane, and the dial of the indicator is graduated

Tracy Fan Dynamometer

with a power scale corresponding to each position of the vanes on their scales. Consequently, the power absorbed at any setting of the vanes can be read directly from the indicator dial.

Because of the difference between the diameters of the engine and dynamometer pulleys, the engine speed cannot be read directly from the speed scale, but by using a convenient diameter ratio, such as 2, 3 or 4, the engine speed is, of course, calculated instantly from the dial indication.

It is evident that there must be a slight loss in both speed and power by reason of the belt slippage. For this reason Mr. Tracy does not recommend the dynamometer for making close efficiency tests or fuel-economy tests. It is intended for determining approximately the maximum ability of an engine and for supplying an artificial load while "running in" an engine or testing its endurance.

*Described in Power, January 25, 1910.

Gas Power Progress during the Past Decade*

By J. R. Bibbins

Since the beginning of the present century there has been considerable progress in the field of gas power. In size, engines have developed from single-acting units of 100 horsepower or so to double-acting tandem units of 4000 to 5000 horsepower designed for and operating under the same conditions as the steam engine. Producer units have developed from a diminutive 50-horsepower size up to 1000 horsepower or more and the problem of gasifying bituminous fuels is well along toward solution; the practice is tending in the direction of the induced-draft type for both large and small units with the self-contained vaporizer. Opinion is somewhat divided on the tar question but all efforts are directed toward the elimination of this undesirable byproduct by gasifying it.

In its varied applications the direct-combustion principle has indeed achieved success. The gas engine has made possible the submarine, the motor boat, the automobile and the aeroplane. The aeroplane motor affords an object lesson in the results of high relative speeds. The motor of the "Antoinette" weighs only 3½ pounds per horsepower and the "Gnome" aeroplane motor weighs still less.

The gas-electric motor car is another interesting development in railroad practice for service on extensions or suburban branches where steam locomotives are not warranted. The car is propelled by standard railway motors supplied from a generator driven by a compact 8-cylinder gasolene engine located in the cab. Sixty-seat coaches usually make a schedule speed of 25 miles an hour, including stops, and demonstration runs have shown a fuel economy of 0.30 to 0.48 gallon of gasolene per car-mile.

In the way of conservation, there is the utilization of blast-furnace gas, coke-oven gas and byproduct oil gas from refineries, as well as the use of low-grade fuels unsuitable for steam making. A power plant is now being built for utilizing waste cupola gas, which has a heat value of about 90 B.t.u. and requires about 200 pounds compression in the engine.

By reason of its high efficiency the gas-driven pump has been adopted for water-works service, sewage disposal, hydraulic excavation and long-distance gas transmission. The absence of standby losses makes it equally desirable in emergency service such as fire protection, auxiliary power supply and canal-lock operation.

*Abstract of preliminary address [illegible] Gas Power Section, A. S. M. E., at the annual meeting, December, 1910.

Gas-engine Details

The development of the heavy-duty double-acting gas engine has been accompanied by certain interesting features. The side-crank type has been generally preferred to the foreign center-crank construction. Dry metallic-rod packing has been substituted for the elaborately water-cooled kind. Valve mechanism has been simplified by using a single cam to open both the inlet and the exhaust valves. Mixing is now done only at the inlet valves, minimizing the results of a back-fire and contributing to uniform mixture quality at all valves by eliminating fluid-inertia effects.

The electromagnetic igniter has found much favor by reason of its simplicity and the feasibility of using several igniters in each combustion chamber without entailing complex mechanism.

The series system of water circulation has reduced water consumption and also the troubles from the sweating of rods working in high-sulphur gas. The foreign practice of cambering piston rods is not followed here. With light pistons the rod flexure is not greater than is desirable to keep the sectional packing free.

Desired Features

A serious handicap in industrial work is the inability of the gas engine to supply enough exhaust heat to warm a factory. Some progress has been made with the exhaust heater but the 5000 or 6000 B.t.u. per brake horsepower-hour available from an engine is not sufficient to do the work. Some system including an auxiliary gas-burning heater must be worked out.

More convenient and practical methods of measuring the volume and heat value of gases should be provided. Some large plants have adopted the venturi meter, but even this simple apparatus is sensitive to deposits in the throat. A continuously recording calorimeter is greatly needed, and some progress is being made in this direction.

There is a disposition to discount the demand for large engine and producer units. With steam-turbine units increasing rapidly in size the gas-power industry must respond in kind or have the gas engine remain an auxiliary for special conditions.

Education of the operator, the salesman and the manufacturer is essential. The great mistake is made in partial education—an incomplete understanding of the conditions, a make-shift equipment and a jealous guarding of knowledge of defects. The results are loss of confidence, dissatisfaction and failure.

Power from Crude Oil

Development of the oil engine has made great progress abroad since the expiration of the basic Diesel patents. Two of the principal builders have turned out 250,000 horsepower in engines, some of which rated as high as 1000 horsepower per cylinder. The smaller engines mostly work on the four-stroke cycle, but above 1000 horsepower the two-stroke cycle prevails.

In the various experiments with oil-gas producers the small progress has been discouraging. Two systems have been used, the retort and the partial combustion. In the former, difficulties with carbon deposition in the retorts are encountered; in the latter, excessive production of lamp black. Both are hopelessly low in efficiency as compared with the oil-burning steam plant. A large oil-gas plant in California, operating gas engines as water-power auxiliaries, endeavors to apply to power purposes mixed gas, consisting of part retort and part carbureted water gas, utilizing the carbon deposits of the former as briquets in the latter process. In this mixed gas, the hydrogen content is kept down to about 30 per cent., but in the oil gas it is very much higher, 40 to 60 per cent. For straight power purposes the combustion producer seems more promising both in simplicity and efficiency.

Peat

We have looked to Canada for important developments in the use of peat, but private experiments have failed so signally that the Government has started a peat-manufacturing and power plant to demonstrate the process on a commercial scale and reëstablish confidence in this industry. Director Haanel, of the Bureau of Mines, thus summarizes his investigations: Artifical drying processes have failed commercially and a machine process must be substituted for the manual labor. The department is, therefore, proceeding along European lines of established success. He states that Russia alone produced 4,000,000 tons of peat fuel in one year—1900. Peat containing not over 25 to 30 per cent. of water has been found an ideal fuel for gas-producer work, requiring no additional steam and being quite free from high temperature and clinker. The long series of fuel tests at Montreal have served to confirm the results of our Government tests on lignites in demonstrating the great possibilities of these lignite deposits, especially in the Canadian northwest.

Gas Engine Troubles

A remarkable array of facts on gas-engine troubles was presented by Charles Kratsch in a paper before the National Gas and Gasoline Engine Trades Association during its recent meeting at Racine. The information was collected from the trouble calls arising from one hundred engines ranging from one horsepower to 125 horsepower multiple-cylinder verticals for generating electric current; the makes included nearly all types from the old slide-valve Otto of thirty years ago up to the modern types which are on the market today.

Seven per cent. of the failures came under the classification of causes due to installation. Among these causes were "engines installed by the purchaser to save first cost; gas bag too far from the engine; no coil in the ignition circuit; cooling water reduced so that the engine overheated, and cam-shaft gears not in mesh properly."

Thirteen per cent. of the failures were classed as causes due to fuel. The principal one of these was the location of the supply tank too far from the engine to feed sufficient fuel at all times; faulty fuel supply due to carbureters or mixing valves; fuel-supply pumps, or clogged piping was another.

Ten per cent. of the failures were due to lack of proper instructions for operation, some of the results of which were too much or too little gas; no cylinder oil; too much or too little cooling water; weak or dead batteries; defective or improperly adjusted vibrator on spark coil; parts put together wrong after the Saturday night tinkering.

Five per cent. were classed as due to faulty construction, under which head came defective parts blamable to design, such as crank shafts of too small dimensions; insufficient valve area; valves opening late or for too short a time; not enough lift to valves for perfect mixture or clear exhaust; bad gasket faces, causing water leaks.

Seventeen per cent. came under the head of causes due to natural wear and accident, of which the following were cited: worn cylinders; shafts cut, sprung or crystallized; valves needing regrinding; governor fingers worn out; lost motion in bearing brasses; loose flywheel; gaskets blown out; crystallization of connecting-rod studs; general overhauling; engine totally wrecked.

Nineteen per cent. were classified as causes due to ignition troubles, as follows: parts inside the engine damaged by wear and neglect; movable electrodes worn out; igniter plugs requiring new bushings, new points, springs, etc.

Twenty-nine per cent. of the failures were due to equipment and accessories and nearly one-half of these were troubles that could have been anticipated and shutdowns eliminated if an extra igniter had been furnished. Eleven of the 29 per cent. in the "accessories" class were ignition troubles caused by poor wire, defective switches, bad installation of wiring, poorly connected terminals, wires short-circuited through poor insulation, burned-out coils, poor magnetos and cheap batteries. The remainder of this division were troubles due to igniter points being burned off by excessive ignition current, the current being supplied by small generators driven at too high speeds or from lighting circuits presumably of too high voltage.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Electrical Barring Machine

The accompanying engraving shows a simple and compact motor-driven appliance devised by the American Ship

ELECTRIC BARRING MACHINE

Windlass Company, Providence, R. I. to do away with the difficulty attending the turning over of a large engine at the works of the Stanley Company, Bridgewater, Mass. The illustration shows the barring machine geared to the flywheel of a 32- and 36-inch by 60-inch engine, nominally rated at 2000 horsepower, and running at 75 revolutions per minute.

The machine consists merely of an electric motor worm-geared to the "barring" shaft, which carries on its outboard end a spur pinion meshing with an internal gear bolted to the inner rim of the 20-foot 75-ton flywheel. When the machine is not in use, the pinion is drawn out of mehs with the gear by means of a hand lever which slides the complete machine along rails on the bedplate. The motor is an 11-horsepower Westinghouse machine, which runs at 700 revolutions per minute on a 220-volt direct-current circuit. It turns the flywheel through one revolution in about a minute. It is especially wound for heavy starting torque and is provided with a reversing controller having five forward and five reverse positions.

An alarm bell is so connected with the outfit that it rings during the entire time that the pinion is in contact with the gear on the rim of the flywheel, thereby reminding the operator to throw the pinion and gear out of mesh before starting the engine.

The Electrical Equipment of a Large Department Store

By Norman G. Meade

The Gimbel building, located at the intersection of Broadway and Sixth avenue between Thirty-second and Thirty-third streets, New York, is the largest one in the country devoted to retail mercantile purposes. The electrical installation consists of approximately 25,000 incandescent lamps, 30 electric passenger elevators, 10 electric freight elevators and package conveyors, ventilating fans, pumps and the multitude of an auxiliary apparatus that is usually included in the equipment of a large building. The supply of electricity is obtained from the Waterside plant of the New York Edison Company.

Owing to the size and nature of the installation it was deemed expedient to install a regular substation in the building to receive current directly from the Waterside stations, which are about two miles distant. Consequently, three independent feeders were laid from the sta-

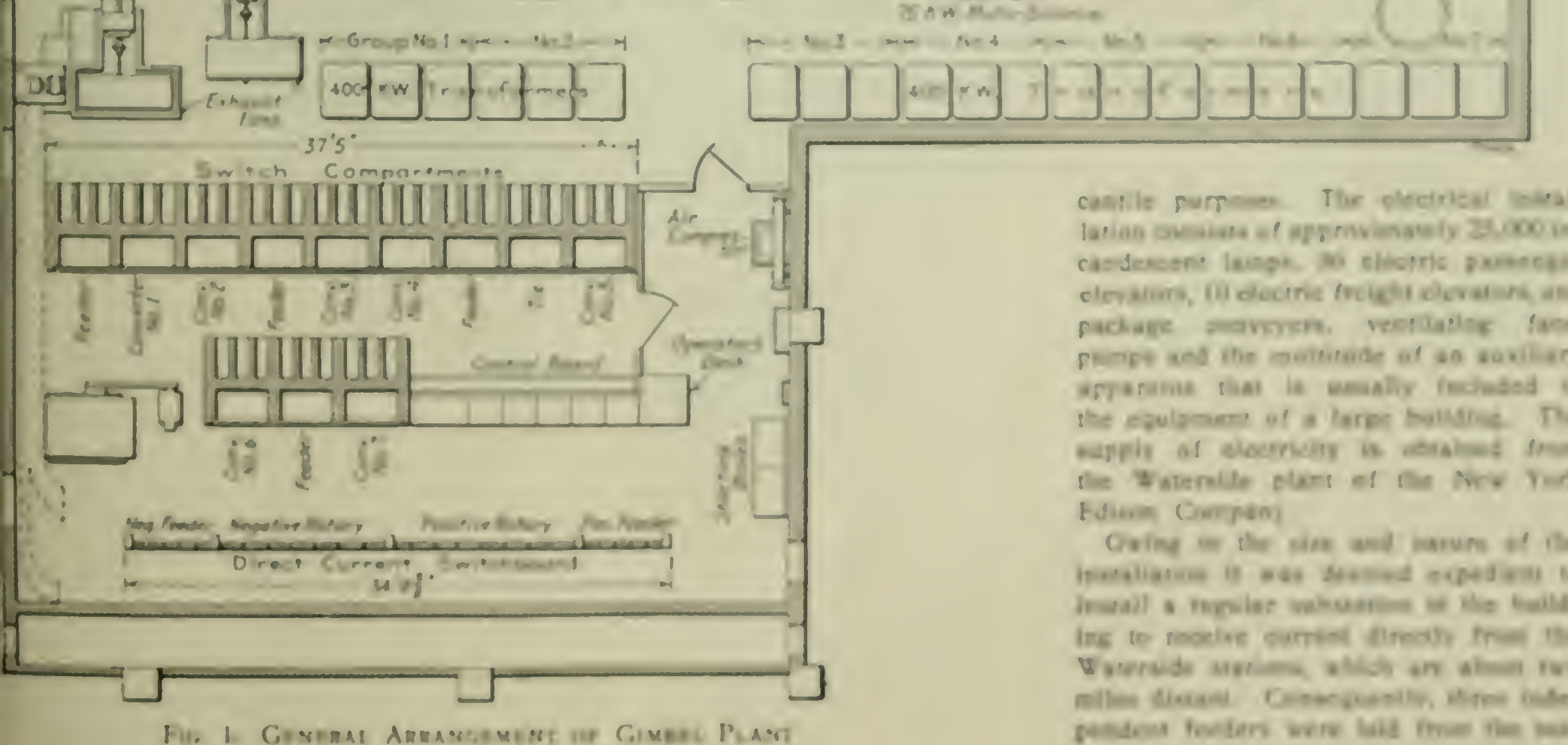


FIG. 1. GENERAL ARRANGEMENT OF GIMBEL PLANT

tions to the Gimbel building, carrying three-phase currents at 6600 volts and 25 cycles frequency. The equipment of the substation consists of six 1000-kilowatt Westinghouse six-phase rotary converters of the synchronous-regulator type, and

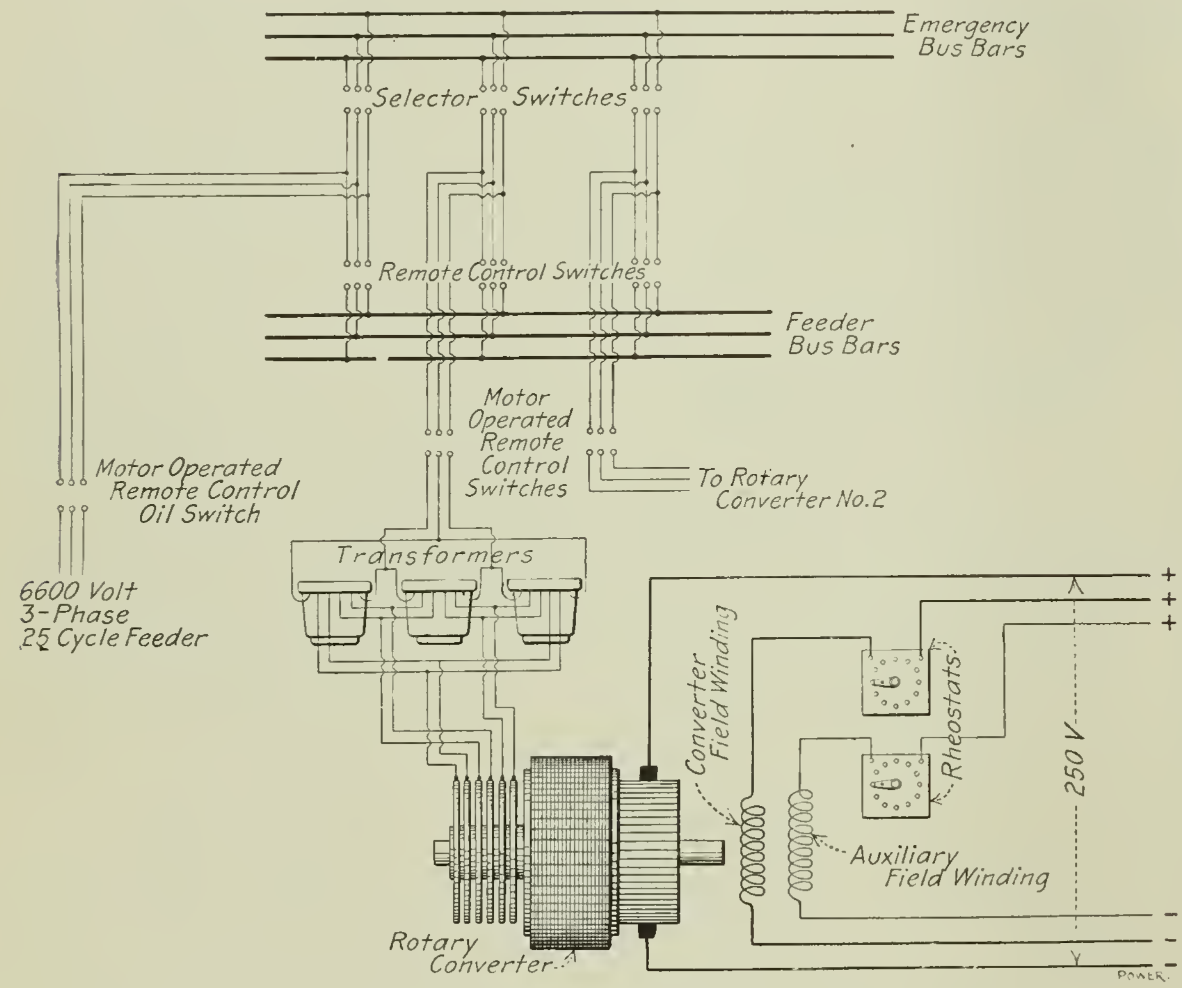


Fig. 2. Diagram of High-tension Alternating-current Wiring

one 1000-kilowatt General Electric six-phase rotary converter, controlled by an induction regulator. All of the converters deliver direct current at 250 volts. The high-tension alternating current is stepped down by twenty-one 400-kilowatt air-blast transformers, three to each converter, connected in delta at the primary terminals, and double delta at the secondary terminals to obtain six phases. In rotary converters of large capacity higher efficiency and more economical distribution of copper are obtained with

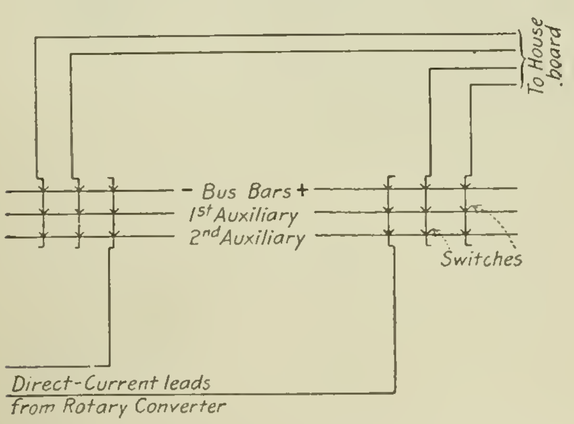


Fig. 3. Schematic Diagram of Direct-current Busbar Connections

the six-phase winding than with the three-phase winding.

The transformers are set in a single row across the room, over a large conduit or air duct. The air blast is furnished by two motor-driven blowers, one of which is held in reserve. The heated air leaving the transformer dampers is removed from the room by a motor-driven exhaust fan and discharged outside the building.

The high-tension switches are inclosed in masonry and are all of the remote control type, operated from the control switch board, as indicated in Fig. 1. The feeder and rotary converter switches

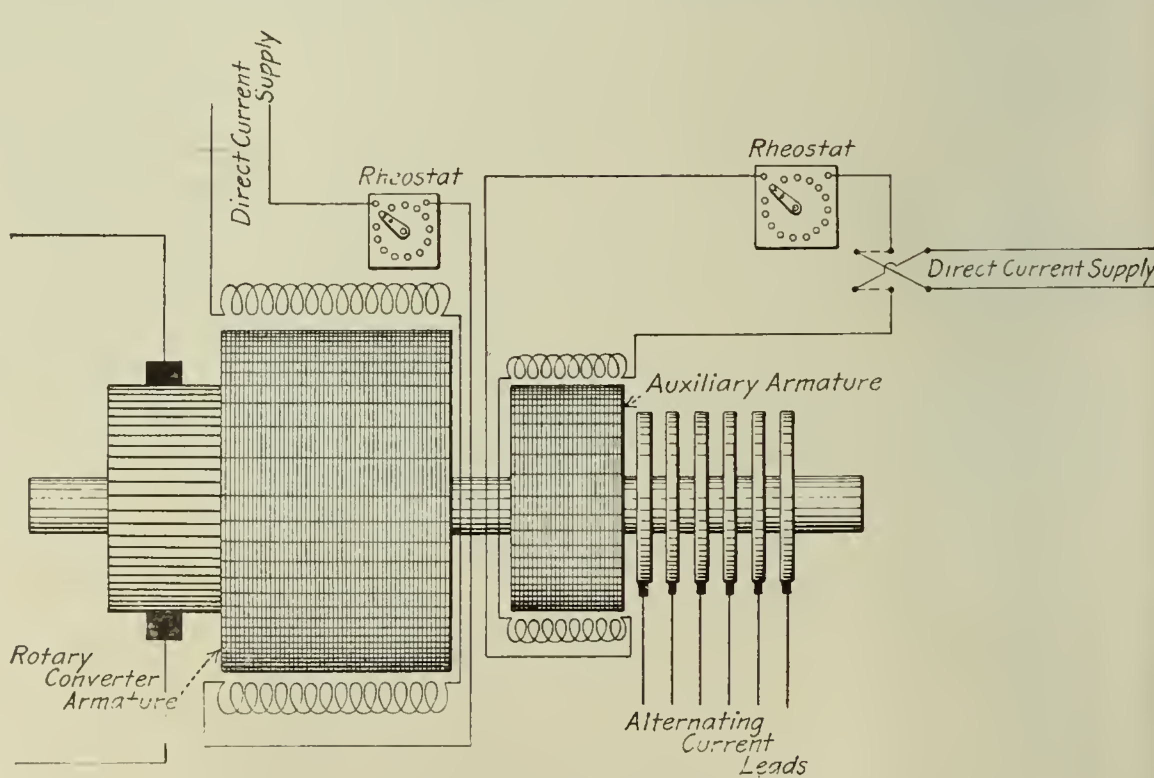


Fig. 5. Diagram of Synchronous Regulator Type of Rotary Converter

are motor operated and the selector switches are operated by solenoids.

The direct-current terminals of the rotary converters are connected to a direct-current switchboard provided with separate busbars for the rotary converters and the feeders. This board is connected to the house board controlling the building load and is also provided with a connection to the low-tension direct-current street mains of the Edison system.

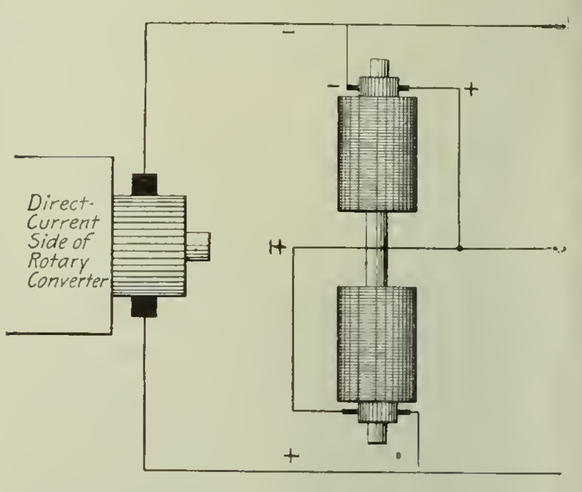


Fig. 4. Connections of Motor Balancer

Fig. 2 shows the elementary connections of the high-tension alternating-current wiring. The alternating-current switchboard is provided with two sets of busbars; the feeder busbars are divided into four sections but the emergency busbars extend the whole length of the board. Each feeder normally supplies two rotary converters. The seventh converter may be used in place of any of the other six, or may be used to assist other Edison substations by means of a tie-in feeder.

Each main feeder is connected to the alternating-current switchboard by a remote-control motor-operated high-tension oil switch, and in turn may be connected to the emergency or the feeder busbars by means of remote-control selector switches. Each converter is connected by means of a motor-operated remote-control switch and may be supplied with current from the emergency or the feeder busbars by closing the proper selector switch. This arrangement of connections is very flexible and makes it possible that in case of emergency one rotary converter can be substituted for another almost instantly. All of the converters are started from the direct-current side in a manner similar to the starting of a direct-current motor and when the synchronizing lamps indicate synchronism the high-tension converter switch and the proper selector switch are closed.

A schematic diagram of the main direct-current switchboard is shown in Fig. 3. It is provided with a main positive and two auxiliary positive busbars and one main and two auxiliary negative busbars. As will be seen from the diagram, which shows the direct-current leads from one converter only, any one of the three busbars on either the positive or the negative side may be used by throwing in the proper switches. Likewise the feeders to the house board or to the street network may be connected to the various busbars at the option of the attendant.

The building is wired throughout on the three-wire plan, and as the converters deliver the overall voltage (250) a motor balancer set is provided. This consists of two direct-current machines coupled mechanically and connected up just as they would be in a straight direct-current plant where the generators give the over-all voltage. Fig. 4 is an elementary diagram of the arrangement. The commutator of only one converter is shown, but the others are all connected in parallel with the one shown and do not affect the operation of the balancing set. The set is capable of taking care of 150 kilowatts of unbalanced load.

One of the most interesting features of this substation is the synchronous-regulator type of rotary converter, which differs considerably from the ordinary type of converter. The synchronous-regulator type of machine is provided, in addition to the usual component parts, with an alternating-current generator built integral with it and having the same number of poles as the main field magnet of the rotary converter. The armature of the alternator is mounted on the converter shaft and its winding is connected between the main armature winding and the collector rings. When the polarity of the field winding of the auxiliary alternator corresponds to that of the main converter field winding the voltage of the alternator armature is added to that of the rotary converter. Consequently, the ratio of alternating to direct voltages at the main terminals is increased and the direct-current voltage is lowered. If the polarity of the auxiliary field winding is reversed the electromotive force of the alternator or auxiliary armature opposes that of the rotary converter armature and the resultant alternating electromotive force is reduced correspondingly, with reference to the direct-current voltage; the latter is therefore increased, because the alternating voltage is fixed by the supply circuit and changing the converter ratio can change only its direct-current voltage. The degree to which the direct-current voltage is raised or lowered by the auxiliary armature is controlled by a simple rheostat in the auxiliary field circuit. This rheostat is operated by a motor which is controlled from the switchboard. The polarity of the auxiliary field magnet is changed by a reversing switch (shown diagrammatically in Fig. 5), also operated by remote-control from the switchboard.

Fig. 6. One of the Synchronous-regulator Converters

Electrical Accidents Due to Carelessness

By Howard S. Knowlton

No course of instruction in the university of hard knocks conveys a more lasting lesson than that of accidents and misfortunes. Year by year the study of casualties and their prevention leads to safer operating conditions in every branch of industry. Repeated reference to these matters is justified on the ground of economy in operation no less than that of preventing human suffering. New conditions are constantly arising and new men entering the field. The older men engaged in the operation and construction of engineering systems tend to overlook the sources of danger, while the fresh recruits frequently fail to realize the disasters which can result from small beginnings. This is peculiarly the case in the electrical industry. A review of the causes of a number of electrical fires and accidents which occurred within one year in a single municipality may well emphasize the importance of trouble prevention over a wider field. In the following paragraphs the essential features are given of troubles occurring almost entirely as a result of negligence, which in most cases were handled without serious financial loss, but which might easily occur anywhere and produce less fortunate results.

Some Electrical Fires

The careless leaving of an elevator motor connected to the supply main when the machine was stopped for the night roasted out the field winding and started an incipient fire, which fortunately was discovered before anything but the motor was injured. In another case, for lack of proper attention the brushes on a 1-horsepower motor became so badly worn that violent sparking occurred as the commutator and oil, dirt and sweepings, which had been allowed to collect, became ignited. In a third instance, a defective rheostat was in service in a basement, and when the operator of the plant started the motor-driven machinery serious overloading of the motor occurred; the protective equipment did not operate quickly enough to prevent a burnout, and the machine was badly injured. While the fire in none of these cases spread to cause any serious damage in the vicinity of the electrical equipment, it was due only to the prompt discovery of the situation through the smell of burning insulation and rapid accumulation of smoke that the fire loss was small.

Careless handling of wires during the installating of electrical apparatus is responsible for much trouble. A slight fire in a basement hallway was caused by linemen working outside on overhead wires, who permitted the circuits to sag sufficiently to make contact with a trolley wire and street lamp post at the same time, permitting current to pass from the wire to the post and thence by means of a gas main to the adjacent building, where a water pipe was in contact with a gas pipe running to a gas bracket on a side wall. Holes were melted in the gas pipe, the gas became ignited, and a small fire occurred. This occurrence illustrates the ease with which the improper handling of electric work may lead to troubles at some distance from the immediate locality where the negligence happens. In the same class of accidents are those where derrick guy wires and chains are unintentionally brought in contact with either the feed or trolley wires of an ordinary direct-current railway service, one side of which is grounded. The failure to screw the plugs of fuse cutouts tightly home is another efficient cause of trouble. The poor contact causes heating, which becomes intense through arcing or lowered conductivity, and if the fuse does not blow enough energy may be released in a small area to produce a disastrous blaze. One fire last year was caused by a porter leaving a coat and pair of overalls hanging over a cutout of the cartridge type. As a result of loose connections at the fuse clips, probably caused when the clothing was hung up, arcing and heating of the contact resulted, and the garments were set afire.

A small fire in a garage started on a table where several 6-volt ignition batteries were being charged. The batteries were left alone during the night and some had boiled over. Current leakage occurred between two of the jars, the liquid on the surface of the table having acted as a conductor. Here again the presence of heavy smoke warned the occupants of the building that something was amiss.

Two other representative fires were due to unrelated causes. One occurred through the burning out of the armature of a ¼-horsepower motor, which was due to the bearings becoming dry through inattention; the second was an out-of-door flare-up produced by the end of a wet rope coming in contact with one side of a series arc-lighting circuit. The rope had been used by the lineman of a signaling company to temporarily fasten a new cable in position, and the current was grounded on a rainy night.

Personal Injuries

In spite of the frequency with which workmen in power plants and on the structures of elevated railways are warned against making short circuits, severe personal acidents of this kind occur repeatedly each year, and almost always through carelessness in the use of tools. Where one side of the circuit is grounded the trouble generally reaches a more acute stage in point of arcing than where the circuit is metallic throughout. Among the accidents of this kind which occurred last year in the community in mind was one where two men, both regular employees of the company, received severe burns about the face and arms while at work in a power plant of the 600-volt railway type. Their injuries were due to a short-circuit through a wrench which they were using in the removal of an iron pipe coming in contact with the live metal of a fuse board at the time when one end touched the pipe.

In another case a lineman was soldering a very heavy cable used for railway service, when the metal ladle which he was using came in simultaneous contact with the joint of the live conductor upon which he was working and a grounded pipe carrying compressed air.

In a third case the workman accidentally brought a wrench in contact with a live third rail while engaged in loosening nuts on one of the running rails of the track. Heavy burns about the face, hands and arms resulted. Two other accidents arose from the careless use of tools in the vicinity of a third rail and feeder installation. The first was caused by a carpenter's saw engaged in cutting off the end of a tie coming in contact with the third rail and grounded elevated structure; the second by a hammer which was being used in a cable box coming into simultaneous contact with a bare live connection and a bolt which was in contact with the structure.

Bad facial burns were received by two wiremen as a result of a short-circuit due to their own carelessness. They were to remove an unused and dead wire from a conduit, it being necessary to cut the wire before its withdrawal; by mistake they attempted to cut the wrong wire, which was alive and a short-circuit was caused by the cutters making simultaneous contact with the live wire and the pipe. A similar accident occurred in a power station where a workman was inserting a copper filler between the plates of a busbar structure, simultaneous contact being made between the busbar and the grounded framework supporting it.

Low potential systems are capable of causing personal accidents no less than high voltage installations. Severe burns occurred on the hands of an experienced installer as a result of a short-circuit caused by a monkey wrench on the shunt connections of a low potential motor-generator set. The use of a jackknife in making temporary connections at a junction box also led to a short-circuit, which caused painful burns. Care is equally necessary to avoid trouble in the installation of insulating materials in the neighborhood of busbars. In one recent instance severe burns resulted from a heavy short-circuit which occurred when a workman was attempting to put a bolt through a piece of alberene stone and angle iron for the purpose of fastening the stone to the angle iron. The bolt end came in contact with a live storage-battery busbar, and the current grounded through the bolt and angle-iron hanger.

LETTERS

Identifying Alternating and Direct Current

Referring to H. Priestley's inquiry in the December 6 number for a method of finding out whether the current in a lamp socket is alternating or direct, I would suggest that this can be ascertained by holding one pole of a permanent magnet against one side of the globe of an incandescent lamp while the lamp is lighted. If the lamp is supplied with direct current the magnet will attract the filament to one side. If it is alternating current the lamp filament will vibrate, due to the alternations.

R. L. Mossman.

Tampa, Fla.

[Exactly the same suggestion has been received from E. F. Potter, Urbana, Ill., and Roy Stolp, of Chicago.—Editor.]

I believe that the liquid method is as simple and reliable as any. Take a glass of water and put a pinch of salt in it. Insert the two ends of the wires in the glass, which should be in series with the lamp on the circuit to be tested. With direct current the negative wire will give gas off freely in the form of bubbles, while with alternating current both wires will give off gas to some extent, but in equal amounts.

Louis J. Gorilla.

Ironwood, Mich.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

New Engine Required Lining Up

A new 12x16-inch engine was installed in a sawmill and, naturally, the management expected things would run smoothly. But for some time that engine did some queer stunts. It ran under, and the under guide ran hot. The engine seemed to labor hard and did not develop its rated power.

I was called upon to see what could be done and I found that not only the bottom guide of the engine ran hot but that the engine heated in other places also, although there seemed to be enough loose play. The crank box could be shaken at some parts of the stroke, but at other parts would be tight.

I put a line through the cylinder and got a surprise. The engine had a self-contained base, the outboard bearing and frame in one piece, and I could hardly think that the shaft would be out of line on this new engine, but in getting my line true with the cylinder base, I was surprised to find that the line was up above the shaft center, and that the cylinder was out of line with the guides.

Then, ignoring the cylinder, I tried to line up the shaft with the guides, and found that they were larger at the cylinder end than at the crank end, and were also smaller at the center than at either end.

There was no boring bar within miles of the plant, but, on looking around, I ran across a shaft that was of the same diameter as the stuffing box of the piston rod.

A box was found to fit this shaft and it was clamped to the crank disk. The shaft was then run through the stuffing box and the box on the disk.

I next made some clamps of heavy, flat iron to hold the tool, and then threaded a bolt long enough to feed the bar through the guides. A heavy bar of iron was placed across the cylinder end and was secured by two of the stud bolts. This end bar had a threaded hole in the center for the feed screw.

A handle was clamped on the crank end of the boring bar and two men were set at work turning the bar. With a set collar on the bar to feed against, I bored out the guide, and made a pretty good job of it, considering the tools I had to work with.

Next, the cylinder was removed from the frame in order to find out what made it hang down out of line, and I found that the frame had been faced off out of true. I did not care to try to face it up with the boring bar I had improvised, nor did I like the idea of putting any kind of soft packing in such a place. Then I thought I would try a plastic cement, and some was put in the opening left between the frame and the cylinder, and after lining it up I had a first-class job.

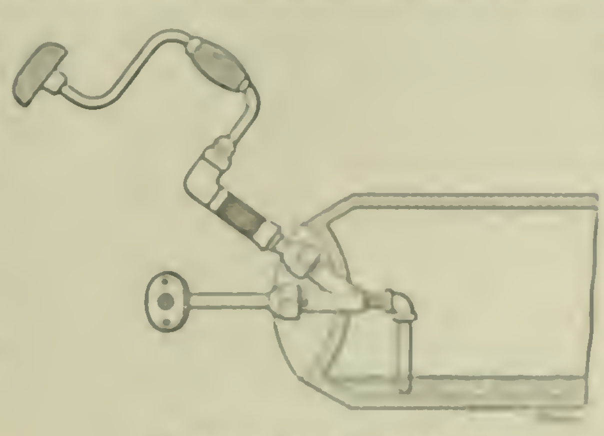
It was necessary to rebabbitt the main bearing to get the main shaft in line, but after this was done the engine ran like a new machine should.

JAMES W. LITTLE.

Fruitland, Wash.

Bit Brace as a Wrench

The following method of using a common bit-brace, tightened firmly on the valve stem of an ammonia drum, as shown in the illustration, may be of some



OPENING THE VALVE

value. I have tried different styles of wrenches, but for quickness and sure control in opening the valve I have found nothing to equal the bit-brace.

R. F. PREWITT.

Chicago, Ill.

Does It Pay to Waste Heat—Sometimes?

The writer had an interesting discussion a while ago with a prominent power-plant engineer in regard to a rather unique installation which has recently been completed for a large New England textile mill. Briefly, the plant consisted of three main turbine-driven units of 500 kilowatts each, with separate condensing units; four cooling towers with individual motor-driven fans; and the usual complement of auxiliaries of boiler-feed pumps, circulating and service pumps and a pump for the heating system.

Originally it was intended to utilize the condensed steam from the main units for heating the mill, there being no other use for which it could be utilized except heating the boiler-feed water. When this plan was presented to the owner he claimed that the "time factor" as regards heating had not been considered—that is, that the time he wanted the heating done was between 2 and 9 or 10 a.m., the greater part of which time the mill would not be running.

As a result it was decided not to utilize the exhaust steam for heating. Instead, jet condensers were installed for the main units, the boiler-feed suction being taken from the return line to the cooling towers. This is passed through a feed-water heater and was raised from about 90 degrees to 200 or 210 degrees by the exhausts from the various auxiliaries. The turbines operate at about 28 inches vacuum.

The mill heating system is of the hot-water, forced-circulation type, the water being heated by live steam except for the excess from the auxiliary exhausts which is utilized when the plant is running by passing it through a tubular heater through which the water for the heating system is pumped before going to the live-steam heater.

At first glance this layout may seem uneconomical in its utilization of heat units, but upon careful inspection it appears that, all factors being considered, the total cost of producing power may be less than in a plant where the effort is made to utilize every possible B.t.u. from the coal. There is a distinct economy in maintenance cost effected by the use of jet condensers and, furthermore, less circulating water is required. In this particular instance the water goes to the feed-water heater at about 90 degrees, whereas if it were taken from the condensed steam in a surface condenser it would reach the heater at perhaps 100 degrees with the turbines exhausting at a little less than 28 inches vacuum.

It seems very reasonable to expect that the cost of saving the heat represented by this 10 degrees might possibly be greater than the immediate loss due to throwing it away. As the plant is question has only been operating a comparatively short time, accurate figures are not yet available. The point brought out here may, however, be food for thought for both designing and operating engineers.

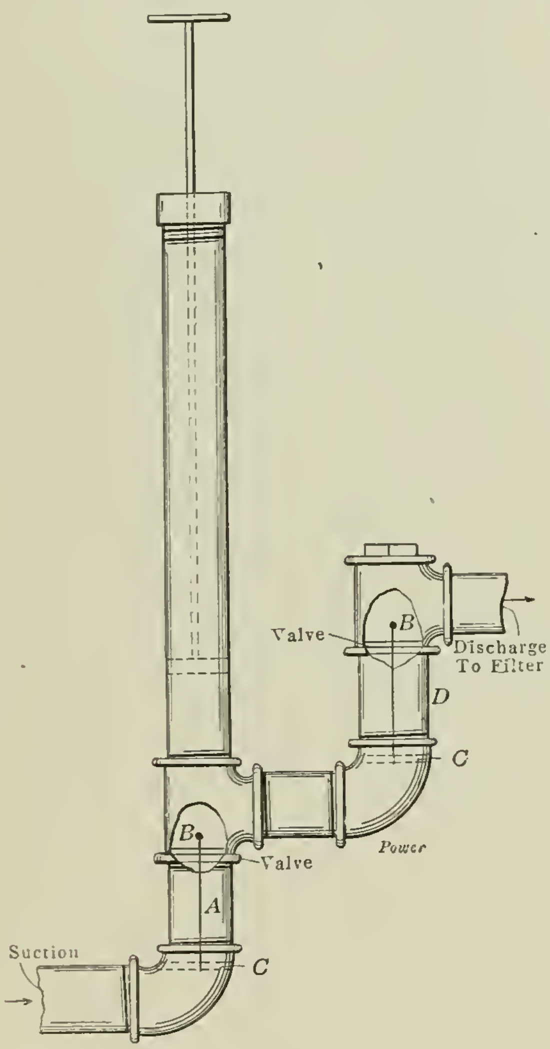
H. M. Wilcox.

Boston, Mass.

A Handy Oil Pump

When I took charge of a shift in a certain plant, I noticed that a compressor was fitted with a neat looking homemade waste-oil pump.

This compressor ran day and night



Details of Oil Pump

and, as it was of the vertical type, the waste oil drained into a receptacle in the base of the machine. Unfortunately the builders had neglected to provide means to remove the waste oil. Therefore, a hole was drilled through the side of the compressor wall and a pipe led through to the oil trays inside the base. The pump was then permanently attached to the machine, and the discharge pipe led to the oil filter. The cylinder of the pump was made of polished brass pipe and the other 1-inch fittings were given a coat of black japan.

The tops of the nipples *A* and *D* (see illustration), were filed flat and made excellent seats for the valves. Ordinary hard-rubber bibs were used as valves. A long nail extended through each valve and nipple and was riveted to a spider at *C*. This allowed the valve the proper amount of lift.

William Watt.

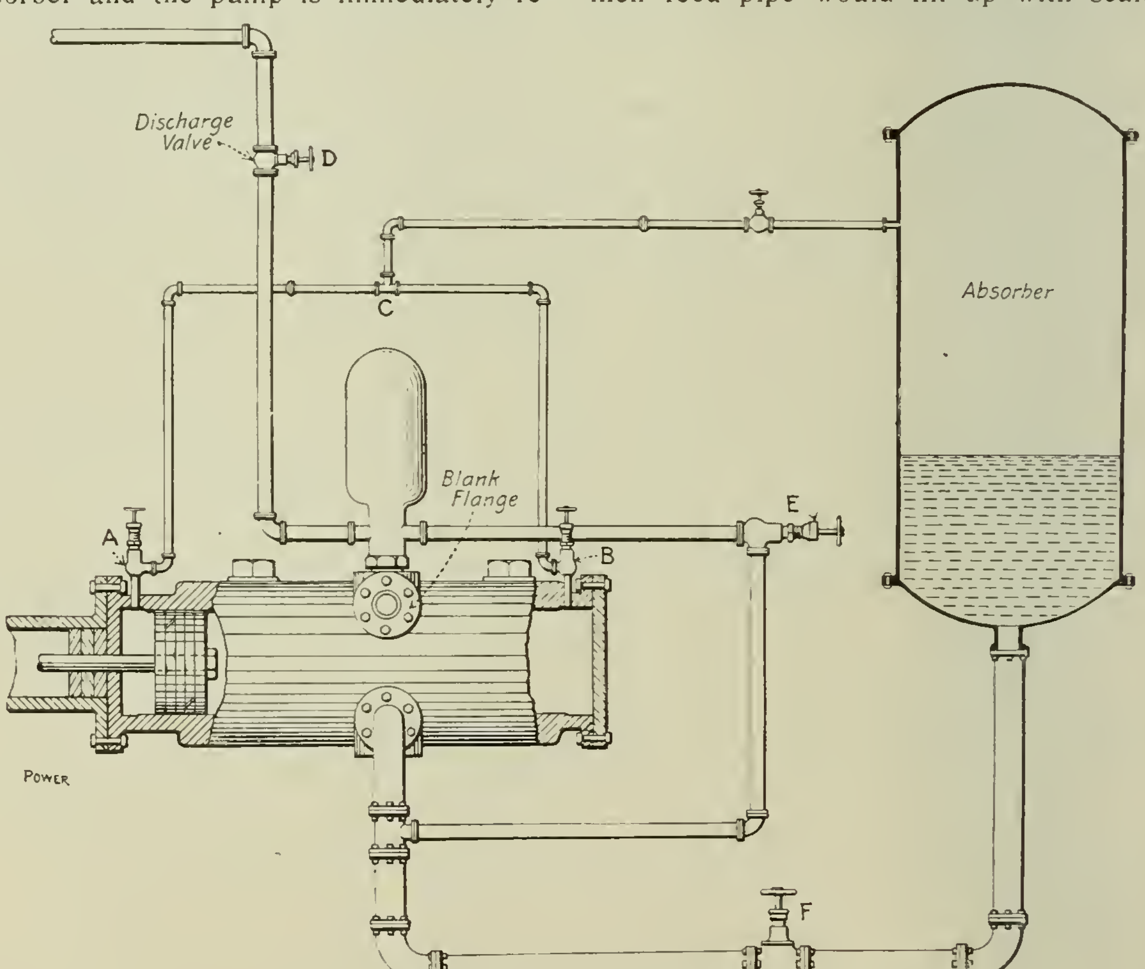
Lambton Mills, Canada.

Relieving an Aqua Ammonia Pump

Aqua-ammonia pumps are heir to the common ailment of becoming gas-bound, and when this happens, the engineer has no positive means of relieving the gas. Putting cold water on the pump and forcing the absorber pressure up does no good, as the pump will repeatedly become gas-bound when the pressure returns to normal. Sometimes it will take hours to get everything regulated so that the pump will work steadily, and during this time the temperature is rising.

The accompanying sketch shows a scheme that I applied to a pump with success. I drilled and tapped each end of the pump at the counterbore for a ½-inch connection and screwed in the valves *A B*. From these I ran two lines to the tee *C* and a line from *C* to the absorber.

When the pump plunger moves to the end of the cylinder, as shown, it compresses the gas and by opening the valve *A* a large portion of the gas will be driven into the absorber. When the plunger moves to the other end of the cylinder there is so little gas on the side of the plunger just relieved that the pressure will fall rapidly until it is below the pressure in the absorber. Then the liquor will be forced in from the absorber and the pump is immediately re-



Relief Pipes and Connections

lieved without interfering with the equilibrium of operation and without a loss of temperature.

The bypass from the discharge to the suction is very convenient when packing the pump. By closing the valve *D* and opening the valve *E*, after drawing a vacuum on the absorber, all of the ammonia is removed from the pump. Packing can then be carried on without being obliged to run from the ammonia fumes, but it will be necessary to close the valves *E* and *F* before starting to pack.

J. J. Nash.

New Haven, Conn.

Why Did the Feed Pipes Clog?

In a power plant in Nevada where I was employed for eighteen months prior to dismantling the plant about a year ago, we had seven water-tube boilers of various sizes.

The water was very good and the condensed steam from the jet condenser passed over a cooling tower and back to the boilers.

A 4-inch header extended across the boilers and a 2-inch pipe ran from the header to each boiler; there were five turns in the 2-inch pipe and the entire piping was of wrought iron with some cast-iron fitting.

There was no scale in the 4-inch header to speak of and very little in the boilers; surface well water was used at a temperature of from 160 to 190 degrees Fahrenheit.

These boilers were kept practically free from scale; in a few months a 2-inch feed pipe would fill up with scale so that a ½-inch rod could not go through the pipe.

Will some reader explain why the feed pipes would clog up and yet no scale form in the boiler? A compound was used in the feed water.

William E. Piper.

Farmington, Utah.

Cooling Cold Storage Rooms

In laying out cold-storage rooms the engineer has several methods of cooling from which to select.

The best method for any particular case depends entirely on the kind of work. If it is necessary to eliminate moisture from the room, the plant should be laid out with a small room connecting with the main room. This room should be practically filled with brine or ammonia coils, with the exception of a small space at each end which should be utilized for the cold-air flue. The coils should reach the entire width of the room, and extend from the floor to the ceiling, thus making it necessary for the fan to draw the air from the main room through the coils.

A fan should be placed at one end of the room, and from this the cold-air flue should start. This flue should be made of galvanized iron, and fitted with small slides or openings about every ten feet.

The return flue should start at the other side of the small room and run on the opposite side of the main room. The floor plan is shown in the illustration.

Arrangement of Cold-storage Room Air Ducts

This system will enable one to keep the main room free from moisture, but it requires more refrigerating capacity owing to the indirect manner of cooling the room. It is also necessary to clean the frost from the coils occasionally, as in time it becomes so thick as to completely shut off the circulation of air. The quickest way to rid the pipes of snow is to close the air slides to the main room, and use a hose and hot water, afterward sweeping as much of the water out of the room as possible and absorbing the rest with sawdust. The brine or ammonia is shut off during this operation.

If a little moisture will do no damage to the contents of the room it can be cooled in a better and more direct way by the brine or ammonia coils being placed directly in the room. Of these two latter methods the ammonia coils are the most direct, as the ammonia is doing no work until it has passed through the expansion valve; therefore, the heat is absorbed directly in the room to be cooled; in the brine system the heat is absorbed in the cooler, thus cooling the brine, which is then pumped through the coils in the cold room.

Comparing these two methods, the direct expansion is far superior to the brine system for four reasons:

First. The expansion of the ammonia must take place either in the cooler or in the room direct. If the expansion takes place in the room, it is bringing the temperature of the room down; if in the cooler, it is bringing the temperature of the brine down, and as the brine must be brought to a low temperature before it will do any work on the room, it is not difficult to see that the room can be cooled much quicker with direct expansion, thus making the operating expense less.

Second. A brine pump is required with the brine system, which also adds to the operating expense.

Third. The brine loses considerable in temperature in traveling to and from the cold room.

Fourth. A larger coil is required for brine, in order to obtain the same results as from the ammonia.

The brine system has one very good point in its favor, in that the ice machine can be shut down for repairs between four and five hours, and if the brine pump is kept running the room can be held at the usual temperature.

Another very good system is a combination of the brine and direct expansion. A small pipe runs through a larger one, and brine is pumped through the larger pipe, while the gas is expanded through the smaller one from the opposite end of the coil. With this system it is not necessary to have a cooler or ammonia coil in the brine tank, which is used only to hold the surplus brine.

In some plants economy requires the installation of both brine and ammonia coils. In operation the room is brought to a low temperature by the direct expansion; then the machine is shut down, and the room held at this temperature for a considerable time by circulating the brine through the room.

Walter C. Ebot

Philadelphia, Penn.

Ethics of the Engine Room

There is such a thing as ethics in the engine room, and to this any live engineer will agree. Ethics is defined as the science of human duty.

The spirit with which any man enters into his work largely determines his success or failure. The man who can put his whole soul into his work and who believes his work is worthy of his best efforts, is pretty sure to succeed, even though he be a plodder. No man ever won success by working only when he felt like it.

The man whose habits of living are correct and conducive to the conservation of his physical and mental energy is able to overcome any obstacles that may arise.

No man rises above his ideals. Many a man makes the mistake of not keeping an eye on the job higher up and working and studying to fit himself for it. Then when the time comes to move up the line, he is ready.

The fire engine and the harness are ready, the men and horses are drilled and trained for action, ready to go when the alarm sounds. If this preparation were not made, what would be the result? Some day a man will be required for a job and if the man who should be promoted is not competent to fill the place, someone else will get it and the fellow who was "weighed in the balance and found wanting" will work away at his old job in a disappointed and half-hearted manner that spells doom to him, so far as advancement is concerned, unless he takes "a brace," gets the vision and pursues it with a determination to win.

A farmer fills his wagon box with potatoes and starts to market, and as the wagon bumps along over the country road the largest potatoes work toward the top. So it is with the man who really desires something better and is willing to fit himself for advancement. It is this desire coupled with determination that makes him a "large potato" capable of rising toward the top as he bumps along over the rugged pathway of life.

It is not what one might do, however, if he had so-and-so's ability and education; but it is the use that is made of the brains and energy we have that marks for success or failure. Strive for advancement, for, by the very effort, you will have bettered his condition, even though his aims are not fully realized.

Many complaints are heard with reference to certain men having a "pull," as though they needed only to have a "friend" or in some way to "stand in" with the "boss." This is a matter that usually adjusts itself; for, though a "pull" may get a job, it will not help to "make good."

A wise man is continually learning. He looks after his employer's interests with the same painstaking care that he would expect should he be employing men in a business of his own. Some may say, "The boss does not appreciate my efforts and I am not going to exert myself to look after his interest." If the "boss" does not appreciate your efforts, someone else will. The man who fools the "boss" fools himself more. It is better for a man to outgrow his job than to let the job do all the growing.

There are certain relations that should exist between employer and employee. Not only should the employee come to his work with the right spirit, but the employer should greet his employee as a man and a coworker, show him that his efforts are appreciated and give him enough insight into the business so that he can see his own relation to the business and to his fellow employees. In doing this a man's efficiency will be greatly increased because he realizes the importance of his own particular part in the business and is filled with a desire to make the best possible showing. The employer who does this and who gives his employees fair treatment in all matters is building up a business that will be both pleasant and profitable for all concerned.

What is true in a general way in the industrial world is also true in the power plant and the engine room. This same spirit, if maintained, will make the tasks easier to perform.

The man who does not develop manhood along with his work is missing the best part of life. The practice of keeping the engine room neat, clean and orderly; the practice of economy in the use of materials and supplies; the reading of magazines and books pertaining to the engineering profession, the posting of suitable mottoes in conspicuous places, all help to make him a better man.

Some time in life every man bumps into his "stone wall." The real man lands on the other side—Think it over. Be not overcome by difficulties, but overcome difficulties with an effort born of determination to win.

I have seen men go home from their work in the power plant wearing dirty, greasy overclothes and with hands and face unwashed. I have gone into the plant where these same men worked and found the appearance of things there untidy also. Unfortunately—for these men and for the profession—engineering magazines, with their helpful suggestions, valuable information and inspiring influence, do not often find their way into such engine rooms. If they did, conditions would soon be changed. A neat appearance will go far toward making a man think better of himself and of his work.

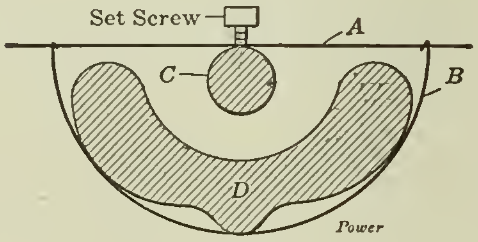
C. D. ELDREDGE.

Fairport Harbor, O.

Piston Rod Clamp

The piston rod of some types of pump is often ruined by using a pipe wrench to hold the rod when removing the jam nuts in the water cylinder when about to pack the plunger. After the piston rod becomes badly marked it is next to impossible to keep the stuffing boxes tight.

A device that will save the piston rod a great deal is shown in the illustration. The piece *A* is made of soft steel, 16 inches long, 1 inch wide and ½ inch thick. *B* is a piece of soft steel of ½ inch diameter and about 2 feet 4 inches long, bent so as to fit around the body piece *D* of the pump. *C* is the piston rod. The ends of *B* hook over the ends of *A*, which is slotted. To prevent the piston rod from turning, it is only necessary to tighten the set screw.



PISTON-ROD CLAMP

ALFRED WOOLCOCK.

Evelette, Minn.

Manholes in Boilers

Although boilers have been manufactured and used for years, there are many still made and installed where little attention is given to the very important feature of accessibility, and this applies both to the setting and the boiler proper.

It is safe to say that a number of disastrous boiler explosions can be partly or wholly traceable to the fact that the design of the boiler and setting prevented proper cleaning and inspection.

But a few years ago it was the custom of some manufacturers to put handholes in the bottom of the front and rear heads of horizontal return-tubular boilers, and these have undoubtedly been the indirect cause of many a bag, blister, fracture and burned blowoff pipe.

The handhole in the back head is usually a constant source of trouble. Of late years the majority of boilermakers are putting a manhole in the bottom of the front head and no hole at all in the bottom of the rear head. This is an improvement over the handholes, as it permits of proper cleaning and inspecting. Usually the manhole in the bottom of the front head is 10x14 inches and, while it is possible for a good-sized man to get through a hole of this size, it would be much easier if it were 11x15 inches, and in most boilers the larger size could be put in with no additional cost and without weakening the boiler head. Boilers made by a certain firm have crow-feet braces, so arranged that it is necessary for a person to make a quarter turn of the body, after getting through the manhole, so that he can drop down between the braces to the top of the tubes.

In nearly all uptodate water-tube boilers, the openings are ample, but in one type the rear drum is so obstructed by a large mud pan that it is almost impossible to get into it, or to do any cleaning.

The openings in the settings of water-tube and horizontal tubular boilers are of all shapes and sizes, but in most of the former type they are ample for the purpose. One manufacturer, however, furnishes castings with 14-inch round holes, which are about the worst thing that could be installed. The brick is laid in the wall to conform with the casting and the result is an opening that is very difficult to get through, or to hoe out ashes and dirt. Square holes about 14x18 inches would insure better care and inspection of this type of boiler.

Every prospective buyer of a boiler should insist that the manholes be made 11x15 inches, that the through and crow-foot braces be arranged to permit easy access, that the openings to the combustion chamber be at least 15 inches wide by 24 inches high, or larger, and so placed that ashes can be readily removed.

THOMAS J. HANNA.

Cincinnati, O.

Making a Low Pressure Trap

The engineers in a certain plant were kept busy running around blowing the bypass on the high-pressure traps in order to keep the pipes drained.

This trouble was due to the traps being worked at too high a pressure, causing the pot in each to hang up to its seat. Some of these traps were remedied by putting in pressure-reducing valves where the high pressure was not needed. The remaining traps were made suitable for high pressure by plugging the seats and drilling a hole through the plug one-half the diameter of the original opening, thus reducing the area of the seat against which the valve was held by the steam pressure. An automatic air valve was put on the cover of the traps and the engineers then forgot all about them.

W. T. MEINZER.

Brooklyn, N. Y.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Driving Keys

With reference to Mr. Taylor's letter on the above subject, which appeared in the issue of November 22, I believe that a few friendly criticisms will be beneficial.

Where is the necessity of marking or measuring the key at all, preparatory to driving it? The object to be attained is to take up whatever lost motion there happens to be between the pin and the brasses regardless of how far the key must be driven. He says that in driving a key the first time, in order to determine the proper degree of tightness, the connections should be moved sidewise or, if this is impossible, to drive the key solid and then back out the required amount. This is correct and the only safe method of performing that operation at any time; therefore, marking the key is of no benefit whatever unless when backing out after being driven solid. I fail to understand how anyone can determine accurately, as he says, just how far a key should be driven each time, as that is equivalent to knowing the exact amount of wear that has taken place, which is out of the question.

Again, he says that the wear is continually making the connecting rod shorter and putting in liners carries it back. From what he states about inserting liners on both sides of the pin he would have us believe by the insertion of liners on the key side we could rectify the length of the rod. A liner thus inserted, with the key remaining the same, would have the same effect as driving the key, thus making matters worse. If the key is on the side of the crank pin next to the cylinder the wear and consequent keying up will diminish the clearance in the head end of the cylinder. The same effect will be produced with reference to the crosshead pin if it be keyed on the side nearest the connecting rod.

In order to equalize the clearance, liners must be inserted behind the brasses on the side of the pins opposite the keys, or all may be put behind either one of them. This is assuming the piston rod to be keyed in the crosshead. If it be screwed in, the liners are unnecessary unless the keys have been driven clear up.

When the crank-pin key is driven the connecting rod moves while the crank pin remains stationary and in driving the crosshead key the connecting rod remains stationary and the pin moves.

The connecting rod may be assumed to be a long box. If we first key the crank-pin brasses to take up the lost motion, the connecting rod moves toward the head end, carrying everything with it except the crank pin and its inner brass. Then if the crosshead key is driven the pin will move still further toward the head end, forcing the piston along with it.

An engine with the crank-pin key or adjusting wedge on the opposite side of the pin from the connecting rod, and the crosshead key next to the rod, has a tendency to keep the clearance equal as the wear on one pin and set of brasses will offset that on the other. A great many engines are so built but the wear is rarely the same on both.

JOSEPH STEWART.

Hamilton, O.

Boiler Tube Failures

In the issue of November 29 there is an editorial, headed "Boiler Tubes," referring to some remarks made by Charles S. Blake, of the Hartford Steam Boiler Inspection and Insurance Company, regarding tube failures in recent times and citing one instance in particular, which is illustrated and described on page 2131 of the same issue.

It is hardly necessary to make any comment on Mr. Blake's contention that the thicknesses used today are identical with those used 25 years ago, whereas the pressure is now 80 to 100 pounds greater, for it is possible to obtain any gage required simply by specifying. Moreover, in those days charcoal iron was the only material used. Now we have hot- and cold-drawn seamless and lap-welded steel tubes, which, for the same gage, are nearly twice as strong as the charcoal iron under internal pressure, so that under the same conditions, by the use of a tube made of soft steel, twice the factor of safety may be obtained.

In the case of failure cited, it is clear that the low factor of safety was largely responsible for the trouble. The tube is reported as being of charcoal iron, No. 10 gage, which had been thinned down by wear to 1/32 of an inch at the point of initial rupture. Besides being nearly twice as strong for the same thickness, as well as more ductile, steel wears better and will not thin down so quickly as charcoal iron. Referring to failures of this kind the editorial states, "There is something wrong with the making of a tube which fails in that way." If charcoal iron is preferred for boiler tubes which are to be used under modern conditions, would it not be only reasonable, in order to maintain the same factor of safety as was provided for under former conditions, to increase the thickness proportionately?

F. N. SPELLER.

Pittsburg, Penn.

With Consulting Engineer Assisting

Mr. Weaver, in the November 29 issue, says, "operating engineers frequently say 'the engineer in charge is best qualified to pass on contemplated improvements.'" Well, it is my opinion that he *should* be, but it depends largely on the man whether he *is* or not. Every operating engineer should keep himself so well posted on the best modern practice that he could take intelligently in hand the rebuilding of his plant, or any part of it, at any time that it might be desirable.

How can he best do this? By carefully studying the advertisements that appear from week to week in such periodicals as POWER, and noting any item that would be of benefit in his plant, then writing to the makers for printed matter concerning these articles, carefully studying the literature thus obtained and filing it for use when needed. Then, when the time comes to make alterations and improvements, he is the man who should have the last word. A splendid source of valuable information in regard to any particular department will be found in the catalogs of the manufacturers of goods used in that department.

I have many times been saved from making errors, and have received information of much benefit to myself and my employers, by sitting down and talking with an intelligent salesman, and one rarely leaves me without first giving me some practical information to add to my store of knowledge.

However, the consulting engineer, from his broad experience in many plants, is not to be despised as an assistant to the operating engineer, and as such can be of great value, but the man that must operate the plant, perhaps 365 days in the year, should have the matter entirely in his hands from beginning to end, and his word should be final.

E. H. Roberts.

Norwalk, Conn.

What Causes the Engine to Run?

Referring to Mr. Teer's letter in the November 1 issue under the above caption, the following may answer his question:

Indirect, balance slide-valve engines take steam at the center of the valve instead of at the ends as in the direct, balance slide-valve types. When the bleeder valve on Mr. Teer's engine is opened, the steam passes through the bleeder pipe and enters the cylinder at both ends through the cylinder cocks. Ordinarily, the same pressure acts at both ends of the cylinder. But, if the engine is in the starting position, the steam that enters the head end through the cylinder cock cannot escape because the exhaust port is closed. Therefore, there is enough greater pressure in the head end to start the engine to turning over while the steam that enters the crank end through the cylinder cock escapes through the exhaust port until the engine has turned far enough to close this port for compression. Then, the momentum of the flywheel will carry the piston past the crank-end center when the exhaust port on the head end opens and lets the pressure drop. The crank-end exhaust port now being closed the steam cannot escape; therefore, there is enough pressure in this end to keep the engine turning over, and the momentum of the flywheel carries the engine over the center each time. Thus, the engine will continue to run as long as it gets steam in this manner.

Robert H. Dunlap.

Syracuse, N. Y.

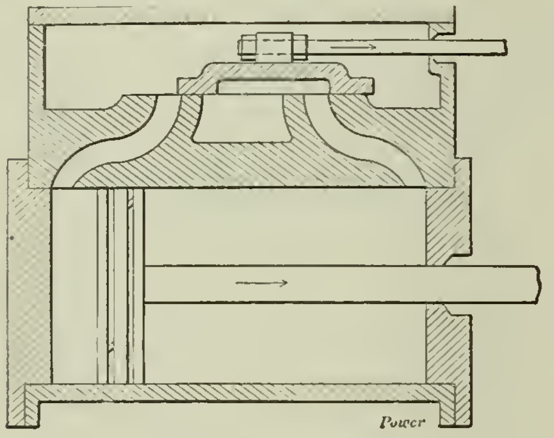
In the issue of November 1, E. R. Teer has a letter under the above title.

Referring to Mr. Teer's sketch it will be seen that with valve *A* open the steam is admitted to both ends of the cylinder through the drain cocks at either end of the cylinder as well as to the exhaust pipe. The reason that the engine will run is as follows:

The steam enters at both sides of the piston, but the pressure of the steam is not the same on both sides, as will be seen by a study of the accompanying figure.

The steam which passes up into the cylinder at the head end cannot get out but simply fills the steam chest, while at the crank end the steam passes up into the cylinder as before, but as the valve has moved almost to the end of its stroke to the right, thus opening the port to the exhaust cavity, the steam escapes through the exhaust pipe.

It is well known that there can be no flow unless there is a drop in pressure. Thus, there is a drop in pressure as the steam escapes through the exhaust port and through to the exhaust cavity at the crank end, while at the head end there is no flow and consequently no decrease in pressure. In this way a greater pressure is brought to bear on the head end, and if it is sufficient it will run the engine.



Section through Cylinder and Valve Chest

If, however, there is too much friction, there will not be sufficient pressure to run the engine.

E. S. Libby.

Chicago, Ill.

Power Plant Design and the Operating Engineer

In the November 29 issue I read Mr. Weaver's contribution under the above heading and, while the consulting engineer is appreciated if he is a good one, we must take Mr. Weaver's attack on the operating engineer as rather unwarranted. He said, in part, that every day one sees mistakes in the layout of power plants, owing to the designer being thick headed. The natural question is, who sees these mistakes? The answer is the operating engineer. Why? Because if he is an engineer of practical experience and technical knowledge, as every operating engineer should be, he has operated other plants and knows how he would have designed this particular plant to obviate the mistakes. Mr. Weaver further says that he believes that in the majority of cases blunders in power-plant design are due more to self inflation than to any other cause. I am glad that I can concur with him in this statement. As a rule this self-inflation is found in the inexperienced rather than in the mature and experienced engineers.

Mr. Weaver tells us that the consulting engineer laughs up his sleeve over mistakes made by the operating engineer due solely to ignorance of the laws of philosophy, simple laws which everyone should know. Perhaps Mr. Weaver has in mind starters-and-stoppers or oilers. The operating engineer can buy and read any engineering work published, providing he has the price. The engineering magazines keep him up to date. He may not be as good a draftsman or as conversant with the higher mathematics as the graduate of the school of technology, but he certainly has every means and method of obtaining engineering data that anyone has. And it is owing to this knowledge combined with practical experience that makes the operating engineer able to bring some semblance of order out of the chaos left him by some designing engineers.

Again, how can the engineer in charge secure uninterrupted and satisfactory service while watching the hundred and one things around a power plant, continually looking for places where improvements can be made and at the same time be a designing engineer? To begin with, if the engineer in charge could have the designing of his plant, he would not have a hundred and one places about his plant where improvements are needed and a smaller per cent. of his time would be needed to secure uninterrupted and satisfactory service. If he has had charge of a plant for some time and does not know where the improvements are needed he is a very ignorant or lazy man and should be replaced at once by an *engineer.* Will Mr. Weaver tell us how a man can properly design a steam plant who has not had a wide operating experience? Would he take swimming lessons of a man who had never been in the water above his knees? Would he employ a doctor of medicine who was just graduated and had no hospital or other experience? I think not. And no man should call himself a consulting engineer, no matter what his educational advantages may be, until he has had at least ten years experience operating steam plants. This is the kind of consulting engineer that is needed; men who are not blinded by preconceived ideas. Talk about the mistakes of the operating engineer, an issue of Power could be filled several times with details of the mistakes made by designing engineers. The operating engineer does not laugh up his sleeve or in any other way; he has to get busy and reconstruct and correct as far as possible their mistakes.

Mr. Weaver, like many other writers, uses the term *operating* engineer or chief *operating* engineer. In Webster's dictionary we find that an operative is a laboring man, a laborer, artisan or workman in a manufactory. The engineering papers and the men in charge of steam plants have been trying to make steam engineering a profession. No wonder Mr. Weaver thinks that we are on too low a social plane to associate with the self-styled consulting engineer of brains and achievements. In the Massachussetts engineer's and fireman's license laws, section 80, we find that the words, "have charge" or "in charge" shall designate the person under whose supervision a steam plant is operated. The person operating shall be understood to mean any and all persons who are actually engaged in generating steam in a power boiler. Perhaps Mr. Weaver was thinking of the fireman when he wrote the article under discussion, for no man who could not layout and install a steam plant would be a competent man to "have charge" of it after it was installed.

C. E. Bascom.

Worcester, Mass.

Does the Crosshead Stop?

We do not know that the editor of Power who answered the above question on page 1790 of the issue of October 4 needs any defense, but we cannot refrain from arguing the question with H. T. Fryant, whose letter appeared on page 2078 of the issue of November 22.

In Fig. 1, which is a copy of Mr. Fryant's figure, we point out that at the instant that the crosshead reaches the dead point H, the circle of motion of the crank-pin center is tangent to the circle described about H_1 as a center. Therefore, at the instant of dead center the crank-pin center is moving along the outer circle as well as the inner circle. Using, then, the argument obtained from Stevens' "Mechanical Catechism" that,

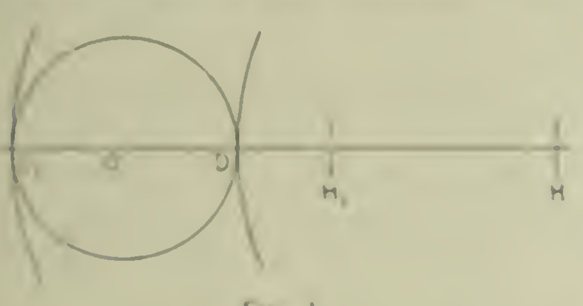


Fig. 1.

"The crosshead center could stand still only if the crank pin moved around it as the center," we have proved that the crosshead center does stand still at one instant. A similar argument shows this to be true also for the point H.

We submit, further, the following proofs, which may be more rigorous. In Fig. 2 let V represent the absolute velocity of the crank-pin center at any instant, being drawn to the point shown for the sake of clearness only. Resolving this velocity into its components perpendicular to and parallel to the motion of the crosshead-pin center we represent the velocity parallel to the motion of the crosshead by V_x and perpendicular to it by V_y. Let θ be the angle between V and V_x. Then

$$V_x = V \cos\theta$$

at any instant. V_x equals zero when θ equals 90 degrees. At the instant that the crank-pin center crosses the line of motion of the crosshead-pin center, θ equals 90 degrees and cos θ equals zero. Therefore, V_x equals zero and the motion of the crosshead-pin center is zero. An exactly analogous argument is used for either point H or H_1.

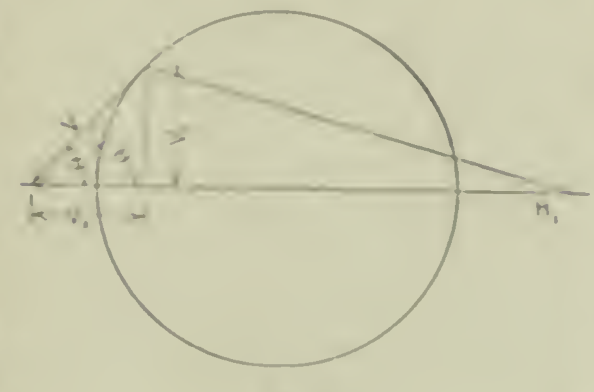


Fig. 2

In Fig. 3 is presented a third proof which we consider equally good with that connected with Fig. 2. Let ds be the infinitesimal distance traveled in a time dt. Then $\frac{ds}{dt}$ equals the velocity; that is,

$$\frac{Space}{Time} = Velocity$$

This distance ds may be traveled along the path dp perpendicular to the axis of the connecting rod, and then along dm parallel to the rod. The quantities $\frac{dp}{dt}$ and $\frac{dm}{dt}$ are, then, the respective components of the velocity $\frac{ds}{dt}$. Let φ be the angle between the axis of the connecting rod and the line of motion of the crosshead-pin center. The angle between ds and dp is a function of φ, say φ', by the geometry of the figure. Then, dm equals ds sin φ'. When φ becomes zero at the point H_1 or H, sin φ equals zero, and then dm equals zero, or the crank-pin center has no motion parallel to the axis of the connecting rod; then, since the crosshead pin center has no motion perpendicular to its line of action and since it can have at that instant no parallel motion, it must stop.

We do not doubt but that there is no

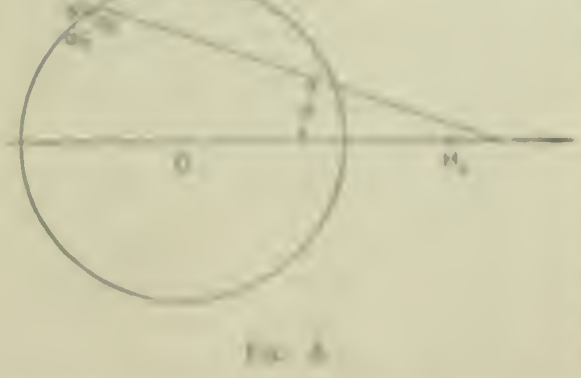


Fig. 3

interval "between the ending of one day, or month or year and the beginning of the next," but this has no bearing on the motion of a crosshead or on the pendulum motion of a clock. The clock merely serves as an indicator of the passage of time, and as such is necessarily subject to mechanical limitations which time is not. The pendulum of a clock does stop at either end of its arc, for at these points the kinetic energy of the pendulum mass, or its energy of motion, is all converted into potential energy or energy of position, which must then mean that the pendulum stops.

We have shown that the crosshead does stop, and that being the case, it does stand still, no matter how brief that time may be. The crosshead does not change direction without stopping. After the instant of stopping, say at the point H_1, the angles θ for Fig. 2 or φ for Fig. 3 become opposite in sign and there is an increase in the velocity component parallel to the axis of motion for the crosshead-pin center for Fig. 2 or parallel to the axis of the connecting rod in Fig. 3. The mathematics of this need not be discussed.

If there is anyone who still fails to see that the crosshead stops, we would like to have him show that a railroad train does not stop before it backs up.

C. R. Stoves and M. W. Fussen.

Boston, Mass.

The Economy of Vigilance in Small Matters

A correspondent in the issue of December 13 refers to losses due to small leaks. While this matter has been commented upon quite often, it should be kept continually before the eyes and drilled into the mind of every engineer.

There are several hundred valves and compression cocks, a large laundry, etc., in the building where I am at present employed. When I started to work here, some years ago, many of these valves and cocks were leaking and water was being wasted in other ways. By repairing all of the valves, and by continually requesting employees not to needlessly waste the water, the consumption was reduced by between fifteen and twenty thousand gallons every 24 hours. As much of the water which was being wasted was hot, and as many of the other leaks were steam, this saving meant also a saving in fuel.

As the men who deliver the coal to the boiler rooms and other parts of the building have an abundance of spare time, I got them to sift all of the ashes. During the first year that this was tried the fuel consumption was reduced by about 100 tons. This reduction has been kept up year after year. If extra help had been required to do the sifting, it would not have been a paying scheme, for one man's wages would have been more than enough to eat up the amount of money saved in the coal bill.

During eight years the only extra cost charged to this particular item has been $30 for repairs to the ash sifter.

James E. Noble.

Toronto, Ont.

Leakage through a Piston Valve

I was extremely interested in the publication in a recent number of results of tests made by George Mitchell, in the testing laboratory of the University of Pennsylvania, on the leakage of piston valves under actual operative conditions. I have made a great many visual tests myself on various forms of valves to determine the presence of leakage, but not to determine the actual amount. In these tests the method of showing this leakage was to set the valve in the center of travel, where it covered both ports; the exhaust valve under the engine in the exhaust line and cylinder drips were closed, the indicator plugs at both crank and head end of the engine were removed, and the throttle valve opened. In not one of over fifty of these tests for leakage of piston valves and flat pressure-plate valves was it practicable to open the throttle full for the reason that the leakage as shown by the steam escaping from the openings caused by the removal of the indicator plugs was so excessive that the room was immediately filled with steam.

Such a test naturally had to be made while the engine was in a state of rest.

The argument was often made that these tests were not fair ones, so far as the engine was concerned, inasmuch as a film of water between the valve and the bushing in a piston valve, and between the valve and the pressure plate in the pressure-plate valve, effectually eliminated the major portion of the leakage that was shown by these tests when the engine was not in operation.

The test, therefore, by Mr. Mitchell conclusively proves that the argument of water filling these spaces is a fallacy, as in his test the engine was operated under normal conditions.

The argument will probably be made that inasmuch as this valve was not equipped with packing rings, the leakage was greater than it would have been on a valve so equipped, but from the tests I have made I cannot notice any difference in the amount of steam escaping through valves equipped or not equipped with rings.

We have all heard the argument that the rings in a piston do not show excessive leakage, therefore why should the rings in a piston valve show any more leakage? The answer to this argument is simple:

If an engineer discovers a flaw or blow hole in the barrel of his cylinder, he would condemn the cylinder, for the reason that the piston rings traveling across this flaw would soon be cut and cause leakage. The rings in a piston do not travel across any ports, but merely up to the counterbore, whereas the rings in a piston valve must travel across the ports, and the ports are usually designed with bridges to prevent the rings from falling into them. The spaces between these bridges accomplish the same result, only to a much greater extent, as the small flaw in the cylinder would, for the reason that the bridges do not have as much bearing surface as the full bore of the valve seat and consequently wear faster. This greater wear at this point causes the rings to move in and out of the valve when crossing the ports, causing excessive wear on the rings, both on their circumference and on the side fit in the grooves.

I believe a test was made at Cornell University several years ago on a piston valve equipped with rings which could be tightened by hand, and I understand from one of those present that it was found that in three and a half hours after starting, the leakage was so great that the engine had to be shut down and the rings reëxpanded by hand.

I note a letter published in Power for November 8, by A. L. Ide & Sons, in which they give the results of several interesting tests to determine the increase in steam consumption with piston valves made 0.01 inch smaller than what they term "commercial fit." With 150 pounds steam pressure they got a consumption ranging from 26 to 27 pounds with valves with commercial fit. They then tested two valves that were made 0.01 inch under size and found that the steam consumption was increased in one case to 32.7 pounds. Taking an average of the results obtained with valves of commercial fit at 26½ pounds, it will be seen from these tests that a valve 0.01 inch smaller increased the steam consumption 22.3 per cent., which confirms Mr. Mitchell's findings of 22 per cent.

I think that any engineer will find on measurement that a piston valve, if it has been operating at least a year, will be even more than 0.01 inch smaller than the bore; in fact, I recently made a test of a piston-valve engine, the steam consumption of which was 54 pounds per brake horsepower per hour. I measured the valve and found it to be over 0.03 inch, or to be exact, 0.033 inch smaller in diameter than the bore.

Taking the calculations given by A. L. Ide & Sons, that each 0.01-inch wear increased the steam consumption 22.3 per cent., and assuming that the steam consumption of the engine I tested was 30 pounds per horsepower per hour when new, the leakage through the valve on this engine would be at least 3.3 times 22.3 per cent., causing an increase in steam consumption of 73.6 per cent. Therefore, if this engine with a tight valve would develop a horsepower-hour on 30 pounds of steam, 73.6 per cent. increase would result in a total steam consumption of 52 pounds, which is a trifle less than that indicated by the careful test which I made on the piston-valve engine.

I do not agree with the statement of A. L. Ide & Sons that a valve 0.002 to 0.003 of an inch under size is plainly a poor fit. The sliding fit for a hub on a shaft is from 0.002 to 0.003 inch for ordinary diameters, when the parts are cold, and I maintain that any piston valve must be at least 0.002 to 0.003 of an inch smaller than the bore to be free to slide.

From the visual tests I have made, the leakage on all flat-valve engines equipped with a pressure plate has been greater than on the piston valve. I say greater, for the reason that a greater amount of steam is always seen escaping through the openings left by the removal of the indicator plugs.

I have surprised a great many engineers by making this statement and the result has been that quite a number of these tests have been made, all of which confirmed my claims. Other confirmation may be had from the tests made by Messrs. Dean & Wood, the results of which were presented in a paper to the American Society of Mechanical Engineers at the meeting in Detroit, in 1908, an abstract of which, I believe, was published in Power. These tests also showed the flat pressure-plate valve to be a very leaky device.

I happen to know of a very fair test that was made on a pressure-plate valve engine in New York City recently, the results showing a steam consumption as high as 59 pounds per indicated horsepower per hour. All of which helps to prove the point that I am trying to make, viz., that a balanced pressure-plate valve shows greater leakage after a certain period of operation than the piston valve. This is probably due to the fact that the pressure-plate valve when absolutely new leaves the builder's factory with 0.003 to 0.004 of an inch clearance between seat and pressure plate. This clearance has been found necessary in order to provide freedom of action under all conditions, and this clearance becomes greater with use. Mr. Mitchell's test was made on a valve that was new, and had not been running for any considerable length of time, and I know from experience that this leakage would be much greater after the valve had been in operation for several weeks. According to the Dean & Wood report, valves can, and are, being made that are self-expanding to compensate for wear, and thereby eliminate leakage.

I wish Mr. Mitchell would make another leakage test on this valve after it had been run for four weeks' time, and also make a leakage test on a flat pressure-plate valve, when new and also after it has been in operation for a short time. These are just the tests that the engineering fraternity has been wanting for years, and Mr. Mitchell is to be complimented on his manner of making these tests, which method disposes effectually of any arguments that have been brought forth that both types of valves above mentioned do not leak steam under operative conditions.

F. A. SHOEMAKER.

Buffalo, N. Y.

Selection and Use of Packing

Engineers have but few subjects to consider that are capable of greater diversity of opinion than that of the results obtained from the various piston-rod packings now in general use. However good or however worthless they may be when considered separately, the results that are obtained are so conflicting that what is considered satisfactory by one is as honestly condemned by another. The great variety of conditions under which packings are used is, and always will be, understood as unavoidable. How to meet these different requirements could be answered by a hundred engineers, in a hundred different ways, according, of course, to the various experiences of each one, those experiences being due, of course, to the different conditions met with in each case, such as speed of piston, pressure, material, etc.

There are, however, faults attributable in many cases not only to the engineers, but also to the manufacturers and inventors of these articles of everyday use. It would be an injustice to assert that every engineer does not use intelligence in the matter of using an article. Yet it is often found that a well made article is condemned and thrown aside, owing to a want of knowledge as to its proper use or to carelessness in application. At the present time there is an abundance of varieties of packing, each one, of course, claiming a certain superiority over the rest. It is, nevertheless, true that in many cases quality has been sacrificed to price, notwithstanding the fact that manufacturers stoutly deny any difference in the quality of their product. Is it reasonable to suppose that such an assertion is true when one can buy at the present time for 50 cents an article similar in appearance to what formerly cost three times as much? I think not. This reduction in quality is often done in such an expert manner, however, that none but experts in fibers can detect it from outward appearance, and thus in numerous cases the poor results are attributed to some accident or carelessness in using.

This condition of affairs can only be remedied by the men who use the packing, and who should insist upon obtaining an article of high quality suitable to their own particular case, whatever the cost may be. The compensation will be obtained in the saving of wear and tear, fuel, power and in repairs. Packings having a flat surface against the rod allow the most perfect bearing and produce the least friction as the pressure is more uniformly distributed. Avoid those packings which produce a hard or rigid bearing beyond what is necessary to prevent leaking, which should be provided for by natural expansion. Of course, I assume that the rod is perfectly level and in line; trying to hold a rod steady by screwing up the packing hard when everything is out of line usually results in a miserable failure. If metallic packings are used the conditions must be more perfect to insure success than is generally the case with fibrous packings. However metallic packings are now being used with good success when applied intelligently and, when they are proof from the efforts of the monkey-wrench engineer, are giving excellent satisfaction. I have observed cases where metal packing was in use where when the least little moisture occurred around the rod, due to its not being exactly in line, or to a poor adjustment of the crosshead, the engineer screwed up on the nuts of the stuffing box until fire appeared. Men of this class will ruin any kind of packing, but it is a pleasure to say that they are very much in the minority. I do not presume to enumerate either the ordinary or the desirable makes of these goods, believing that these few hints may serve to arouse interest in the packing problem and thereby be instructive to engineers in general.

CHARLES H. TAYLOR.

Bridgeport, Conn.

Hotel Power Costs

In the issue of POWER for November 8, under the head "Hotel Power Costs," I saw the figures given by J. H. Morrow, chief engineer of the Great Northern hotel, Chicago. Mr. Morrow gave definite figures as to the power costs for a year before and after installing an isolated plant. I would be very glad to hear from other engineers of hotel and office buildings along this same line. Also, I should like to secure some data as to the cost of an installation per kilowatt.

Which would be the more economical for a small plant, a steam turbine or a reciprocating engine driving a generator where the exhaust is to be used in a heating system?

O. L. SHERMAN.

Duluth, Minn.

Introducing Solvents into Boilers

The article by C. H. Taylor in the December 6 issue on this subject will help quite a number of engineers who, like myself, have looked vainly through the advertising pages of POWER for a thoroughly reliable compound feeder. In several plants that I have visited there is some homemade affair that is doing the work with more or less success. Some time ago I went so far as to write a large manufacturing concern whose business was among other things, the making of force-feed lubricators, asking if they did not believe they could put something on the market that would "fill the bill," constructed on the lines of a force-feed lubricator which could be attached to the boiler-feed pump. Some compounds may have a sediment, thicken up, or contain acid which might attack the metal of the pump or valves. If any of the readers are using an ordinary force-feed pump with success, I would be glad to know it. There are quite a few little difficulties which crop up in connection with compound feeding.

Leakage at the gland would be particularly objectionable; hence a well designed stuffing box is essential. The tank or vessel from which the pump takes its supply should be elevated and have a graduated gage glass. The quantity pumped should be easily adjusted. An apparatus of this kind ought to command a ready sale. The amount of compound introduced would have a direct relation to the quantity of feed water put into the boiler, and this is a desirable condition. I have an apparatus that is working in a fairly satisfactory manner and which I partly made from scrap. The homemade product, however, is usually very crude, clumsy and quite frequently more costly than the originator would care to admit. There is so much of this homemade stuff to be found, so many ingenious, temporary repairs, etc., which, in the long run, are apt to prove extremely costly that anything of this nature ought to receive very careful consideration before adoption.

FRANK H. WILLIAMS.

New Haven, Conn.

The Problem of Smoke Abatement

Some time ago POWER published a paper by Mr. Randall, on the suppression of smoke. Mr. Randall's paper was very interesting and readable, but he gave no real solution to the smoke problem.

As things stand at present, particularly as regards the payment of the firemen, no device made is really satisfactory in the suppression of smoke. This is no fault of the device in many cases; it is simply lack of knowledge on the fireman's part as to the method of utilizing the device to do away with the smoke. Steam jets, special arches, special grates and special furnaces and all characters require expert handling in order to obtain results, and they rarely get it. An expert fireman can get an almost smokeless furnace, unless it is being forced to the limit, with almost any of the coal sold in New England. If, however, an inexpert fireman takes the shovel, the results are radically different, and no matter how good the furnace is, smoke will be given off in large quantities.

The majority of manufacturers look on the fireman as merely a device for feeding coal under the boilers. Brute strength is the main consideration, and brains receive but scant acknowledgment. This seems rather extraordinary when one considers that one of the heaviest expenses in the power plant is the coal pile. A manufacturer will employ a first-rate engineer and pay him a good salary, for the express purpose of keeping his engine and shafting in good condition. He will purchase and install a high-grade engine and condensing outfit, if possible, in order to economize in steam consumption, but when it comes to the man who is largely responsible for the amount of coal burned on the grate, he is always looking for the strongest man at the lowest price. At this very point there is a tremendous opportunity for saving. A good fireman is worth money, and he will more than save the difference in his wages through the use of his brains. Less coal will be required and less smoke will be made. Less coal will be required, because he will see that the amount of air admitted to the furnace is graded to the amount of coal he puts on the fire, so far as the construction of the furnace will allow, and, therefore, he will burn up the volatile matter in the coal to a very large extent, which under the firing of a poor man, goes up the stack in smoke.

There is, of course, vast room for improvement in the construction of the furnace at present used for bituminous coal. In the first place, the hight of the boiler above the grate is far too small. There is not a sufficient opportunity for varying the amount of air which enters above the grate. The ashpit door is not large enough to give a thoroughly good admission of air under the grates, and the greater part of the air goes up through the grates at the back of the furnace, instead of at the front. All engineers know the material abatement in the smoke nuisance that can be secured through the use of the dutch oven and the very long fire box. This is due mainly to the thorough mixing of the air and volatile gases and the opportunity offered for them to ignite before they go over the bridgewall. In order to burn these gases, it is necessary that they be mixed with a proper amount of air and brought to a sufficient temperature to be ignited when they pass over the rear part of the fire. If they are not ignited before they go over the bridgewall, there is little or no prospect for their being ignited at all. Special arches in many cases will improve the combustion to the suppression of smoke, and increase the efficiency of the combustion.

My solution of the smoke problem is, then, pay the fireman enough to make it worth while his staying on the job, and then train him. Adjust the furnace so that air can be admitted both above and below the grate and thoroughly mixed with the combustible gases before these gases go over the hottest part of the fire. Train the fireman to coke the coal at the front of the fire, so as to drive off the volatile matter from the front end of the furnace. Push this coal back as the fire burns out at the rear, and shovel again in the front. It might be said that the automatic stokers do away to a considerable extent with the skill required by fireman. This, however, is by no means true. The automatic stoker requires adjustment of the air just as much as does hand firing; and a poor fireman cannot do as well with an automatic stoker as a good one.

Boston, Mass. HENRY D. JACKSON.

Air Bleeder for Boilers

In the December 13 number, Mr. Mistele has a letter on the subject of water hammer, in which he speaks of the trouble he experienced with air in the boilers when raising steam and the remedy he applied.

I regard it as a wise plan to have all boilers tapped at their highest point with a 1-inch bleeder connection. In raising steam this should always be left open until the gage shows some pressure. It should be given a good, strong blow before opening the stop valve to the line; particularly is this the case where condensing engines are being run, as a boiler which contains very much air will frequently cause a condenser to go down unless it is thoroughly drained of air before being cut in.

Another desirable feature of such a bleeder is that it allows a much more rapid cooling of the boiler when a hurry-up job of washing out is in order, as is so frequently the case in small plants where but a few hours can be had in which to cool down and wash a boiler.

O. B. CRITCHLOW.

Woodlawn, Penn.

Faulty Design

Under the above caption, Mr. Rayburn, in the November 22 issue of POWER, describes a condition of engineering which is not engineering; an exception is taken to his ruling of the term "engineer." The manifold errors cited in the installation of this particular steam plant tend to prove that an engineer, a real engineer, was not in evidence—degradation should not be cast upon the engineering profession at large to style those who were engaged as "engineers." As in all walks of life, in the engineering business today there are engineers, and there are engineers—there is a wide distinction. The "catalog" engineer, the inexperienced engineer, the inefficient engineer, the engineer who could not fill a drafting position, who follows the calling haphazard, and subsists on the earnings derived from the enterprise promoter not familiar with such design, who accepts a fee from his client and an additional fee from some particular manufacturer whose product he specifies and insists upon, these are not engineers, nor are their efforts engineering—it cannot be classed in that category.

The real engineer, the man who knows his business, does not necessarily have "to smoke black cigars and carry a slide rule," knowledge is not contained in these two elements, and I am under the impression that some engineers use neither. The real engineer is not given to words or boasting; as a rule, he is open to reasonable argument, and his actions and methods show results.

The selection of a consulting engineer for a certain work shouid be made only after investigation as to ability and past performances; the real engineer is alive to the best interests of his client, he expects future business from him, he expects his recommendation to others. The competent engineer always proves to be the cheapest in the long run.

L. R. W. ALLISON.

Los Angeles, Cal.

Water Gage Connections

In the December 13 issue of POWER, Mr. McGahey has a letter relating to the placing of valves in water-column connections. The pros and cons of this matter have been discussed in the columns of the mechanical papers and outside of them many times, but I do not remember ever having seen stated what I regard as strong justification for their use; namely, their great value when the water connection becomes clogged. With a valve in the steam connection which can be closed, full boiler pressure can then be brought to bear to blow out any obstruction in the pipe, whereas, with no valve in the steam pipe, the opening of the blowoff valve on the column but imperfectly cleans the water connection between the column and the boiler, due to the fact that the pressure in the column is, to a great extent, balanced. The same principle applies here as in the case when we close the lower valve first when a gage glass breaks, allowing the steam valve to blow and thus hold back the hot water. I was once saved from the necessity of a shutdown at a critical time by having these valves to use, and later when a Hartford inspector recommended their removal, I was able to convince him that it was better to leave them in.

O. B. CRITCHLOW.

Woodlawn, Penn.

Steam Turbines and Generators

By E. D. Dickinson and L. T. Robinson

A paper presented at the December meeting of the American Institute of Electrical Engineers, taking up the subject of testing turbo-generators from the point of over-all efficiency under conditions which are as near as possible to those under which the machine is to operate.

In manufacturing steam turbines a great amount of testing is necessary to determine the effect of changes in design or to verify theories which cannot be established by calculation; much of this is of a laboratory nature. There is also a large amount of testing done to establish the over-all economy of the complete unit, which is all that is of commercial value to those operating steam turbines.

The one positive method of testing a turbo-generator is to measure the steam that goes in through the throttle, and the electrical energy delivered at the terminals of the generator. The surest way of determining how much steam enters the turbine is to collect and weigh all the steam after it has been condensed. This necessitates the use of a surface condenser. In making such a test two things are essential: first, that all the steam used on the turbine be condensed and measured; second, that no steam or water not used in the turbine be allowed to enter the condenser. The condenser should have the leakage checked, before and after each test. This is accomplished by shutting all steam off the turbine and running the condenser for some time with full vacuum, the discharge from the hot-well pump being accurately measured. Split tubes sometimes cause leakage which is difficult to locate as they open only when the condenser is heated by large flows of steam.

When the condensed steam cannot be measured, as is the case when the turbine is operating noncondensing, or when the condenser is of the jet type, the steam consumption is found by weighing the water fed to the boilers. In making such tests, the liability to error is very great, and every precaution must be taken in order that the results may be reliable within a certain degree of accuracy.

The steam piping connecting the boilers and turbine must be disconnected from all other piping, and all openings must be blanked off; valves must not be relied on. All blowoff and drain valves must have their outlets visible, and all piping between the boiler feed pumps and the boilers must be exposed and have no branches. Leakage of the boiler itself is difficult to locate, as all water or steam escaping is vaporized and carried up the stack. The boiler leakage should be checked before and after each test by closing the throttle to the turbine, or if necessary, blanking the pipes at the turbine and running a test measuring the amount of water required with full steam pressure on the boilers and piping. The feed water used should be weighed and not measured by meters.

Tests which have come under my observation have shown a boiler leakage of 10 to 12 per cent., and one particular case showed a leakage of over 20 per cent.

The comparison of efficiencies of different machines is the most satisfactory way of considering their relative merits. To determine the available energy in one pound of steam it is necessary to know the pressure in pounds per square inch, the quality and the temperature of the entering steam; also the pressure at the turbine exhaust. To measure the vacuum a full-length mercury gage should be used. If the steam be superheated, since there is some difference of opinion concerning the specific heat of superheated steam, the figure assumed must be given. In testing turbines consisting of several stages, the pressures in the different stages should be measured, as this affords a check and should show any abnormal conditions which otherwise might not be observed. The kilowatt output should be net, that is, the kilowatts for excitation should be subtracted from the generator output.

All instruments, including meters, gages, thermometers and scales, must be very accurately calibrated before and after the test.

Whenever possible, turbines should be tested under the conditions for which they were built to operate, as corrections for different conditions are liable to cast doubt upon the accuracy of the test. In general, the corrections for steam pressure, moisture or superheat are less liable to be misleading than that for a varying vacuum, as comparatively large changes in any one of the first three will but slightly affect the results, but a slight change in the vacuum makes an enormous change in the available energy.

Electrical Output

First consider the measurement of direct-current output. Usually, station instruments in connection with the generator switchboard have been provided, but unless temperature conditions can be very accurately controlled and the instruments can be checked under operating conditions they should not be used. The station voltmeters may sometimes be satisfactory, but it is the usual practice to supply direct-current station ammeters to operate from shunts of approximately 60 millivolt drop, which requires that the indicating part of the ammeter be largely a copper circuit; therefore, the whole combination is subject to considerable error due to variations in room temperature, and with some shunt arrangements, to variations in the current to be measured. For the precise measurement of direct-current output, portable indicating ammeters should be used having 200-millivolt-drop shunts, and permitting the use of indicating millivoltmeters whose circuit consists largely of resistance material having practically no temperature coefficient.

When using either switchboard or portable instruments the influence of any stray fields should be investigated. Also, care should be taken to correct the observed indications of the millivoltmeter for any electromotive forces that may appear in the shunt or leads due to thermo-electric effects. The amount of error due to this cause may be observed by reading the millivoltmeter at the close of the test with no current flowing in the main circuit. Referring again to the station type of shunts, unless the ammeter is checked with the shunt connected into the busbars, care should be taken to see that the distribution of current flow through the shunt is the same when the ammeter is used as when it was tested. It is quite possible to have large errors due to this cause.

Next it is necessary to consider the proper use of the instrument transformers which usually provide the only means of enlarging the capacity of the instruments to meet ordinary requirements.

In using instrument transformers it is necessary to observe the precaution to have the secondary connected load the same as that which is on the transformers when they were tested for the certificate. It is also necessary if the test is to be made under conditions that will give a low power factor on circuits, to know that the phase displacements in the instrument transformers are not large enough to appreciably affect the results. It is also well not to use instrument transformers with interconnected secondaries except for the common ground which should be employed as a safety precaution.

If possible, a test should be made on noninductive load, in which case, if all the test arrangements have been satisfactorily attended to, the apparent power as shown by the volts and amperes should agree within 1 per cent. with the wattmeter indications and the watts indicated should be taken as the true output. If the test cannot be made at unity power factor, the voltmeters and ammeters should be included so that the general conditions of distribution of load, etc., may be known throughout the test. For this purpose the station instruments would be satisfactory.

Watt-hour meters should never be used unless checked in place at the frequency, voltage, etc., which are to be used in testing. If it is not possible to run a complete test at a fairly steady load it is usually possible to make a few runs on the watt-hour meter under load conditions and to use this check as a basis for determining the output by means of the meters during the test run on an unsteady load. It is still advisable to read the indicating instruments at short intervals so that their indications may be made use of in computing the final result.

Single-phase indicating instruments for polyphase service are to be preferred for precision work to polyphase instruments, for the reason that indications of a polyphase instrument are made up by the two elements in such a way that it is not possible to apply corrections to either element to get the true total result unless the division of load is known by single-phase instruments; and if the single-phase instruments are required for this purpose they may as well be of the precision class and used for the actual determinations, and the polyphase instrument omitted.

Discussion

After the presentation of the paper the discussion was opened and consisted, in part, as follows:

Mr. Dunn: The paper deals principally with over-all efficiency tests, but before these tests become necessary there must be an enormous amount of detail and special testing both of the generator and the turbine. One of the important things to know in regard to both these pieces of apparatus is the proportion of losses chargeable to each.

It is found, for instance, when retardation tests are made on turbo-generators, that vibration, windage, etc., occupy a different proportion of the total losses than on the ordinary classes of apparatus; and the proportion of these losses is not determined by prior conclusions. Empirical methods, only, will bring these out. Consider the mechanical balance of turbo-generators. It is well known that below the first critical speed, if the generator is run in flexible bearings and the chalk held against that part of the revolving surface which seems to be highest, it will hit the heavy part of the revolving member. But when the speed has increased to the point where the apparatus gyrates around its center of gravity then the chalk mark will be moved theoretically 180 degrees from its first position. It may appear easy to calculate these critical speeds but even when the best knowledge on the subjects of vibrations, inertias and gyrations are applied, the result will not agree with that found in practice.

Again, regarding ordinary efficiencies, where the company builds both the generator and the turbine, its responsibility is founded on the amount of steam consumed and the electrical energy developed; but where they are made by separate companies the individual performances are more important.

Mr. Emmet: Individual study of the generator and the turbine is very desirable, but is extremely difficult. This is because the generator is a high-speed piece of apparatus requiring a large amount of power and cannot well be run by anything but the turbine itself. However, there is one method of investigating the generator alone which has considerable value; this is the "deceleration" method. It consists in bringing the generator up to a speed, by motor or otherwise, in excess of that at which it is to be operated and then allowing it to decelerate, noting the rates of deceleration and from these rates, with a carefully calculated moment of inertia, determine the amount of power exerted in deceleration at any particular instant.

A matter of much interest but one which is only slightly alluded to in this paper is that of the steam meter. We have been using steam meters in all of our turbine tests for a long time and at the same time have been weighing the water. The results have checked within 2 per cent. in practically every case.

Mr. Dreyfus: An important characteristic of the steam turbine is that the inlet pressure varies almost directly with the load, provided the same steam pressure, superheat and vacuum are maintained. This affords a means for graphically checking the performance of a turbine.

Clearance in Ammonia Compressors

At the recent meeting of the American Society of Refrigerating Engineers, Thomas Shipley, of the York Manufacturing Company, presented a paper dealing with the effects of clearance in vertical single-acting compressors of the false-head type and horizontal double-acting compressors of the spherical-head type.

The compressors were [illegible] same diameter and stroke and were driven by the same engine, that is, when one compressor was in operation the other was disconnected. The runs were made at suction pressures of 5, 15.67 and 25 pounds gage, and the condensing pressure was 185 pounds gage. The speed was 70 revolutions per minute and during the runs all conditions were kept as nearly constant as possible.

In the single-acting compressor the clearance was controlled by screwing the piston rod into the crosshead and in the double-acting compressor by placing metal rings between the cylinder flanges and the heads.

Table 1 shows the relative effect of clearance on the horsepower per ton, and Table 2 shows the effect on the capacities. It will be noted that the losses due to clearance in the double-acting compressor are much larger than those in the single-acting compressor, and that the losses increase inversely with the suction pressure.

TABLE 1. COMPRESSOR INDICATED HORSEPOWER PER TON.

Linear Clearance, Inch.	Clearance Volume in Per Cent. of Displacement.		5 Pounds Suction Pressure.		15.67 Pounds Suction Pressure.		25 Pounds Suction Pressure.	
	Single-Acting.	Double-Acting.	Single-Acting.	Double-Acting.	Single-Acting.	Double-Acting.	Single-Acting.	Double-Acting.
$\frac{1}{32}$	0.24	....	1.75	....	1.30	....	1.09	....
$\frac{3}{64}$	....	0.42	....	2.18	....	1.60	....	1.26
$\frac{1}{8}$	0.76	0.85	1.77	2.34	1.32	1.62	1.10	1.28
$\frac{1}{4}$	1.46	1.55	1.81	2.45	1.34	1.64	1.11	1.30
$\frac{1}{2}$	2.85	2.93	1.82	2.56	1.36	1.72	1.12	1.35
1	5.63	5.71	1.83	2.89	1.39	2.01	1.13	1.44

TABLE 2. TONNAGE PER 24 HOURS.

Linear Clearance, Inch,	Clearance Volume in Per Cent. of Displacement.		5 Pounds Suction Pressure.		15.67 Pounds Suction Pressure.		25 Pounds Suction Pressure.	
	Single-Acting.	Double-Acting.	Single-Acting.	Double-Acting.	Single-Acting.	Double-Acting.	Single-Acting.	Double-Acting.
$\frac{1}{32}$	0.24	....	2.27	....	38.0	....	50.4	....
$\frac{3}{64}$	....	0.42	....	19.2	....	33.0	....	47.4
$\frac{1}{8}$	0.76	0.85	22.6	17.3	37.4	32.1	50.1	45.1
$\frac{1}{4}$	1.46	1.55	21.0	16.0	35.6	30.0	49.1	44.8
$\frac{1}{2}$	2.85	2.93	19.7	14.3	34.4	28.9	47.0	42.3
1	5.63	5.71	15.5	10.6	29.7	22.9	42.6	36.5

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POWER

Condemn the Old Boiler

It is not often that the public exercises much concern as to the condition of steam boilers used in power plants, unless one of them explodes and kills somebody. Then censure is handed out right and left, and the less that is known about boiler practice the more harsh the criticism.

In the instance of a municipally operated electric-light plant those in charge decided that the lap-joint boilers were not fit for further service and new butt-joint boilers were accordingly installed in their place.

Before the old boilers were discarded, however, the taxpayers rose up in their might and loudly denounced the wastefulness of the town fathers for throwing out good boilers and wasting public money in purchasing new ones. In justification of their stand against this *needless* waste, a neighboring manufacturing plant was cited, where several boilers were in operation every working day of the year, and none of these boilers had been in service less than twenty years.

From a layman's standpoint these town folk were right in their views, and they were somewhat justified in taking the stand that if a set of boilers over twenty years old were good enough to serve a prosperous manufacturing company, their boilers, which were no older, were good enough to operate in the town lighting plant.

These town people were not aware of the fact that from the time a boiler is installed it begins to deteriorate, and that there comes a time when it is no longer safe to operate at the pressure originally allowed. Just when this time arrives is a matter of judgment on the part of those to whose care the boiler is intrusted.

Notwithstanding the opposition, the old boilers were thrown out and after the new boilers were installed and put to work the matter was dropped, except for muttered grumbling on the part of a few taxpayers.

Two years passed, and one day the air was rent with a mighty explosion; two men were killed and the boiler house of the manufacturing plant was completely wrecked. The old boilers that the town people had held up as safe and sound were lying in a heap of bricks and debris and one—the one that exploded—was a bent and twisted wreck.

Not one of the town folk can be found today who will intimate, let alone charge, that the town officials were wasteful of public money, or that they did not use the best of judgment when they threw out the old boilers.

There are but two reasons why an old boiler is allowed to remain in service: Either the firm owning it does not care to spend the necessary money for a new one, or the old boiler is made to do service while the new one is being installed, and it sometimes happens that the old boiler explodes in the meantime.

This matter of discarding old boilers will doubtless be allowed to rest with the judgment and conscience of the owner, in the future as in the past, a few States and cities excepted, until the death list becomes so great as to frighten owners into replacing their old boilers with new ones and, perhaps, convince the State legislature that every lap-seam boiler over ten years old is in reality a hidden mine, liable to explode sooner or later and add its toll of dead and wounded to the annual massacre.

Strength of Wheel Rims

Twelve or fourteen years ago, Prof. C. H. Benjamin presented papers on the "Bursting of Small Cast-iron Wheels" before the American Society of Mechanical Engineers which were remarkable in two ways: First, because he brought out complete and authoritative evidence on the subject, and, second, because of the small attention paid to them by engine builders. Some manufacturers today continue to place the flange between the spokes, just as they used to do, and they tell you with one breath that the strain in the rims of their wheels never exceeds one thousand pounds per square inch, and with the next breath that the efficiency of the flange joint is one hundred per cent. The professor stated in his paper that one would not think of putting a joint in the middle of a girder. This we can understand, but why do not these engine builders understand it? It is not that they do not understand that it is poor design to put a joint in the middle of a girder which is carrying a transverse load, but rather that they do not believe the girder is loaded in that manner; that instead of the rim of a pulley between two arms being loaded like a girder, it is in tension, and, therefore, if the flange has enough metal in it, and the bolts are as strong as the flange, the efficiency of the joint would be one hundred per cent.

In this discussion, we will confine ourselves to pulley wheels, by which we mean wheels with thin rims used to transmit or receive power by belting or ropes. Regular flywheels, having rims of heavy rectangular cross-section, give little opportunity for bending between the arms and, besides, in such wheels the rim is sufficiently deep to permit the use of links for fastening the sections together.

The assumption that the rim of a pulley wheel is in tension only, due to the centrifugal force, is wrong, unless the rim is not attached to the spokes—is free to expand under the influence of the centrifugal force and assume a truly circular form. There are a few such wheels, in which the arms fit into a socket in the rim, and as the wheel revolves the rim can increase in diameter. Such a wheel is said to have a "free" rim, and such a rim is in tension only. It is clear that if in such a rim is put a flange having no weight, the section of which is designed to withstand the tension due to centrifugal force, such a flange can have an efficiency of one hundred per cent. But the flange must have weight; and so, even with a wheel with a "free" rim, the efficiency must be less than one hundred per cent.

If, now, we assume a pulley wheel in which the rim is attached to arms which are absolutely rigid and will not stretch, the rim, when rotating, will tend to bow out between the arms and will act like a girder loaded with a uniformly distributed load.

So, we have two theoretical cases: one in which the rim is free to expand and take a truly circular form, in which case the rim is in pure tension and is not subjected to bending. In the other case, the rim is attached to rigid arms that will not stretch, in which case the strain is due wholly to the bending moment.

In practice, however, the pulley wheel is between these two extremes. The rim expands some and pulls out the arms, and though the arms stretch some, yet they pull in the rim, so it is not correct to consider the rim in tension only, or as a girder carrying a uniformly distributed load only, and, to complicate the matter further, we have a strain induced by the flange itself.

To determine the strength of an actual wheel, recourse must be had to the results of experiments, and for these we are indebted to Professor Benjamin. These experiments show that a wheel with a well designed flanged joint, which is placed between the arms, will rupture at about one-half the speed of a similar wheel with a solid rim. As the strain varies as the square of the speed, this means that the flange joint is only one-quarter as strong as the solid rim, or that its efficiency is only about twenty-five per cent.

The wheels upon which the experiments were made were only twenty-four inches in diameter, and some may say that these results would not apply to a wheel, say, sixteen feet in diameter; but there is no reason for such an opinion, because the efficiency is a ratio and not an absolute quantity, while the flanges were carefully made to scale from a larger flange in a larger wheel in actual use. If there is any difference, it would be in favor of the small wheel, on ancount of the thinner sections, and, therefore, the better casting.

Do not confuse the measurement of the efficiency of such a flange joint with the measurement of the efficiency of the joint in, say, a boiler shell. If we say, in referring to the latter, that the efficiency of a certain joint is seventy per cent., the rivet strength being high, we mean that thirty per cent. of the metal has been cut away and that only seventy per cent. remains, and it follows that the greater the pitch of the rivets (making up their area by increasing the number of their rows) the greater will be the efficiency. There are joints in boilers that have an efficiency as high as ninety-eight per cent., but a similar procedure cannot be followed with flange joints in a pulley wheel, where, as the joint is strengthened by the addition of metal, the centrifugal force of that same metal increases in the same ratio the strain it is called upon to bear. So, when we refer to the efficiency of a rim joint as twenty-five per cent., we do not mean that it contains only one-fourth the amount of metal in the rim, or that if put in a testing machine and pulled it would break at one-quarter of the load on the solid rim, but, rather, that the strain in it is four times as much as the strain in the rim. Take a wheel sixteen feet in diameter, running at one hundred revolutions per minute, which is equivalent to a rim speed of five thousand twenty-six feet per minute. If the rim is "free" and has no joint, the tension in the rim due to centrifugal force is seven hundred pounds per square inch. If, however, the rim is fastened to the arms, and there is a flange joint between the arms, whose efficiency is only twenty-five per cent., then the strain in the rim is twenty-eight hundred pounds per square inch, and that the factor of safety is low in such wheels is shown time and again by the short interval of time which elapses between the derangement of the governing mechanism and the moment the wheel goes to pieces. Wheels of reputable make have been known to stand only a few seconds of racing.

Talk to an engine builder who persists in the use of the interarm joint about the efficiency of the flanges in the pulley wheel which he builds and he will at once begin to talk about the importance of good design, good workmanship and careful foundry work. We have no desire to appear to slight these very important matters, but the point that we wish to make is that of two similar wheels, one with a solid rim fastened to the arms, and the other with the rim joined by flanges placed between the arms, the latter wheel may be but one-quarter as strong as the former.

Generating Power for the Navy

A recently issued report of H. I. Cone, engineer-in-chief of the United States Navy, says that designs have been prepared for battleships with water-tube boilers, fitted for the use of oil fuel and coal, the oil fuel to be used in conjunction with coal or independently, and designs for destroyers for water-tube boilers with oil fuel only.

A high-speed marine steam turbine with reduction gear is being installed in the collier "Neptune," now building at the works of the Maryland Steel Company, Sparrows Point, Md. She is to be a twin-screw vessel, displacing 19,360 tons with a speed of fourteen knots. Steam at a pressure of two hundred pounds will be supplied by three double-ended Scotch boilers to a Westinghouse-Parsons turbine on each shaft, each turbine developing about four thousand shaft horsepower at one thousand five hundred revolutions at full power. Between each turbine and its propeller shaft is to be interposed a Melville-McAlpine gear, reducing the propeller speed to 136 revolutions per minute.

Tests have been completed during the year at the Norfolk navy yard of nineteen representative types of internal-combustion engines for launches. Of this number nine proved to be fit for naval service.

Considerable progress has been made on shore in the development of bituminous producer-gas power plants. Owing to a lack of funds the Bureau has been unable to do its part in the development of the internal-combustion engine for large naval vessels. As stated in the Bureau's last annual report, we cannot afford to delay this development and the recommendation is renewed for authority to expend as much as $250,000 for the purchase and installation of an internal-combustion engine plant and an able collier or other suitable hull in the event that it is thought wise to experiment along this line.

The generally accepted belief in the safety of water-tube boilers seems to have received a severe jolt by the recent explosion in Brooklyn. The authors of text-books upon boilers will have to get out revised editions.

The tendency is in the direction of getting more service out of a given amount of boiler-heating surface than has been thought practicable. Shall it be by putting in more grate surface or by burning more coal per square foot of grate?

Inquiries of General Interest

Engineer's First Duty

What is the first duty of an engineer on taking charge of a new plant?

E. F. D.

He should learn the condition and arrangement of the plant, what it will do and what is required of it.

Pressure Due to Heat

From a tank on the roof two pipes lead to the cellar. One is quarter-inch and the other two inches in diameter. Will a pressure gage read the same on the bottom end of each pipe?

P. D. H.

Yes, the pressure per unit of area for the same hight of water will be the same regardless of the diameter of the pipe.

Volume before and after Compression

How far will the piston move in compressing air to a pressure of 100 pounds in the cylinder with no rise in temperature?

B. A. C.

As the volume of air compressed in the cylinder will be inversely as its pressure, the volume of the compressed air will be

$$14.7 \div 114.7 = 0.128$$

of the original volume and the piston will, neglecting clearance, leakage and the heating of the air, move

$$1 - 0.128 = 0.872$$

of the stroke in compressing air to 100 pounds gage pressure.

Exhaust and Inside Lead

What is the difference between exhaust lead and inside lead and how much exhaust lead should a valve have?

E. I. L.

Inside lead is the opening which the exhaust port has when the valve is in the middle of its travel. Exhaust lead is the opening which the exhaust port has when the piston is at the end of the stroke, and should be sufficient to allow full port opening early in the return stroke so that there will be no excess in the back pressure. It is sometimes customary to make the exhaust lead twice the steam lead.

Load on Braces

How can I know that each brace in a boiler carries its full load?

L. O. B.

By being sure that none are loose when the boiler is empty but that all are equally or nearly equally tight, as may be proved by sounding with a hammer.

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Air Compressor Capacities

How may I find the required lift for a 2½-inch gas-compressor valve? Give a rule to find how many cubic feet a gas compressor, 32x60 inches, with five pounds pressure above the atmosphere in the suction pipe and seventy-five pounds discharge, will deliver at one stroke?

A. C. C.

A lift of one-fourth the diameter of the valve will give a discharge area equal to the area of the valve but it has been found that 75 to 80 per cent. of this lift is sufficient. The volume of gas compressed may be determined by the formula

$$\frac{14.7 + 5}{14.7} \times \textit{Piston displacement} = \textit{Volume compressed}$$

and the volume after compression and subsequent cooling to the original temperature will be the above quantity multiplied by $\frac{14.7}{75 + 14.7}$. The actual amount will probably not exceed 85 to 90 per cent. of the theoretical depending on the volumetric efficiency of the compressor.

Steam Engine Dimensions

In making a small engine, how shall I proportion the different parts to make it look right? I mean such parts as the shaft, piston rod, valve stem, crank pin, connecting rod, etc.

S. E. D.

Make the main bearing one-half the diameter of the cylinder and two diameters long, the crank pin one-half the diameter of the shaft and one and one-quarter diameters long, the piston rod one-fifth the diameter of the cylinder and the connecting-rod length three times the length of the stroke and the diameter of the necks equal to the diameter of the piston rod.

Air Compressor Operation

We have lately installed a cross-compound two-stage air compressor. The governor is set to stop the compressor at an air pressure of 95 pounds and the engine invariably stops on the center on the high-pressure side, and before the air pressure falls sufficiently for the low-pressure side to start the engine again the steam in the receiver condenses and the pressure falls so low that the engine will not start until live steam is bypassed to the receiver.

We thought of placing a pressure-reducing valve in the bypass pipe leading to the receiver, and set it at 30 pounds, the pressure carried in the receiver, and keeping the valve in the bypass open so that the receiver pressure could not drop below the regular amount carried; would this interfere with the proper working of the engine in any way?

W. W. W.

The governor should be so set that the engine will not stop when the desired pressure is reached but will "creep" past the center. If a reducing valve is placed in the bypass it should be set to maintain a pressure in the receiver which will be just sufficient to move the engine off the center when the air pressure falls below the desired pressure.

Uptake Temperature

If the pressure carried in the boiler is 100 pounds, what should be the temperature of the escaping gases?

B. F. T.

From 450 to 500 degrees Fahrenheit.

Air Pressure for Lifting Water

In an air lift with 200 feet submergence, what pressure of air will be required to raise water 50 feet?

A. L. W.

The pressure required to start the water will be

$$\text{Submersion} \div 100 \times 0.434 + 5 = \text{pressure}$$

Once started the air pressure will depend on the quantity of water delivered but will never be less than is required to support a column of water of a hight equal to the lift.

Pressure in Radiators

Is a steam-heating system, is the pressure in the radiators farthest from the boiler the same as in those which are nearest?

P. I. R.

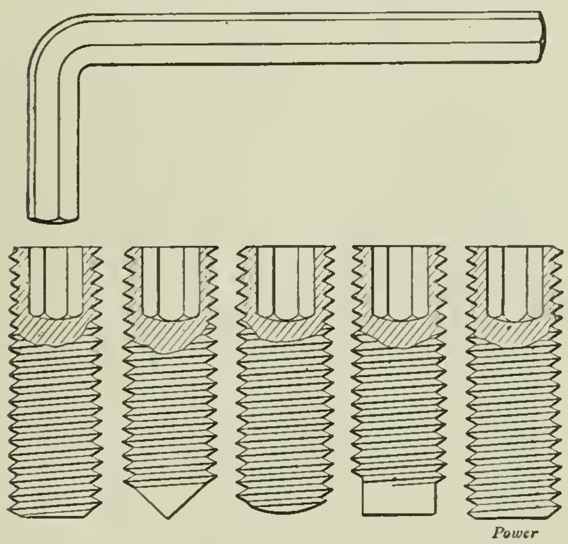
No. In order for steam or any other medium to flow from one region to another there must be a difference in pressure. In a one-pipe system the pressure is highest in the radiators in the upper part of the building.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

The Allen Safety Set Screw

A safety set screw made from a solid bar of steel and guaranteed not to mushroom or upset in the hole has been recently placed on the market by the Allen Manufacturing Company, Hartford, Conn. These screws are made in a number of

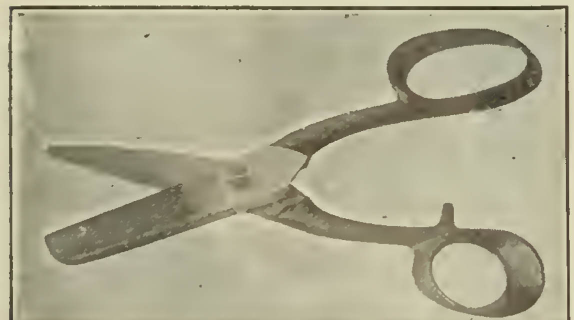


Group of Allen Set Screws

different sizes ranging from 3/8 to 1 inch long and with a variety of points such as cup, conical, oval, dog and flat which are shown in the figure. A hexagonal hole formed in the other end serves as a hold for the wrench which can be made by bending a piece of hexagonal steel of the proper size at right angles, as illustrated in the above drawing.

Scissors for Belting, Packing etc.

The cut shows a pair of scissors for cutting leather, rubber, packing, linoleum, etc., which are being put on the market by Schuchardt & Schütte, 90 West street,



Scissors for Belting and Packing

New York. The upper blade is a regular shear blade but with a longer handle than usual to give greater leverage.

The trouble with the ordinary scissors when cutting the materials mentioned is that the goods being cut is apt to be pushed along the blades instead of being cut. This is overcome in these scissors by having the edge of the lower blade serrated so that it prevents the material from slipping while the upper blade does the cutting.

These shears, known as "cogged scissors," are made in two sizes, 8½ and 11 inches respectively, and they will cut single-ply leather belting as easily as the ordinary scissors will cut cardboard.

The Stilwell Combination Water Heating and Softening System

In the illustration, Fig. 1, is shown a combination feed-water heater, filter and purifier built by the Platt Iron Works Company, Dayton, O.

This apparatus consists, as shown in Fig. 2, of a cast-iron heating chamber containing a system of pans over which the water and chemicals must pass, thereby thoroughly mixing the two and bringing them in direct contact with the exhaust steam. This heating chamber, which is fitted with an efficient oil separator, may be used either on the thoroughfare or induction principle. It is located on top of a large purifying and filtering chamber built of heavily ribbed cast-iron

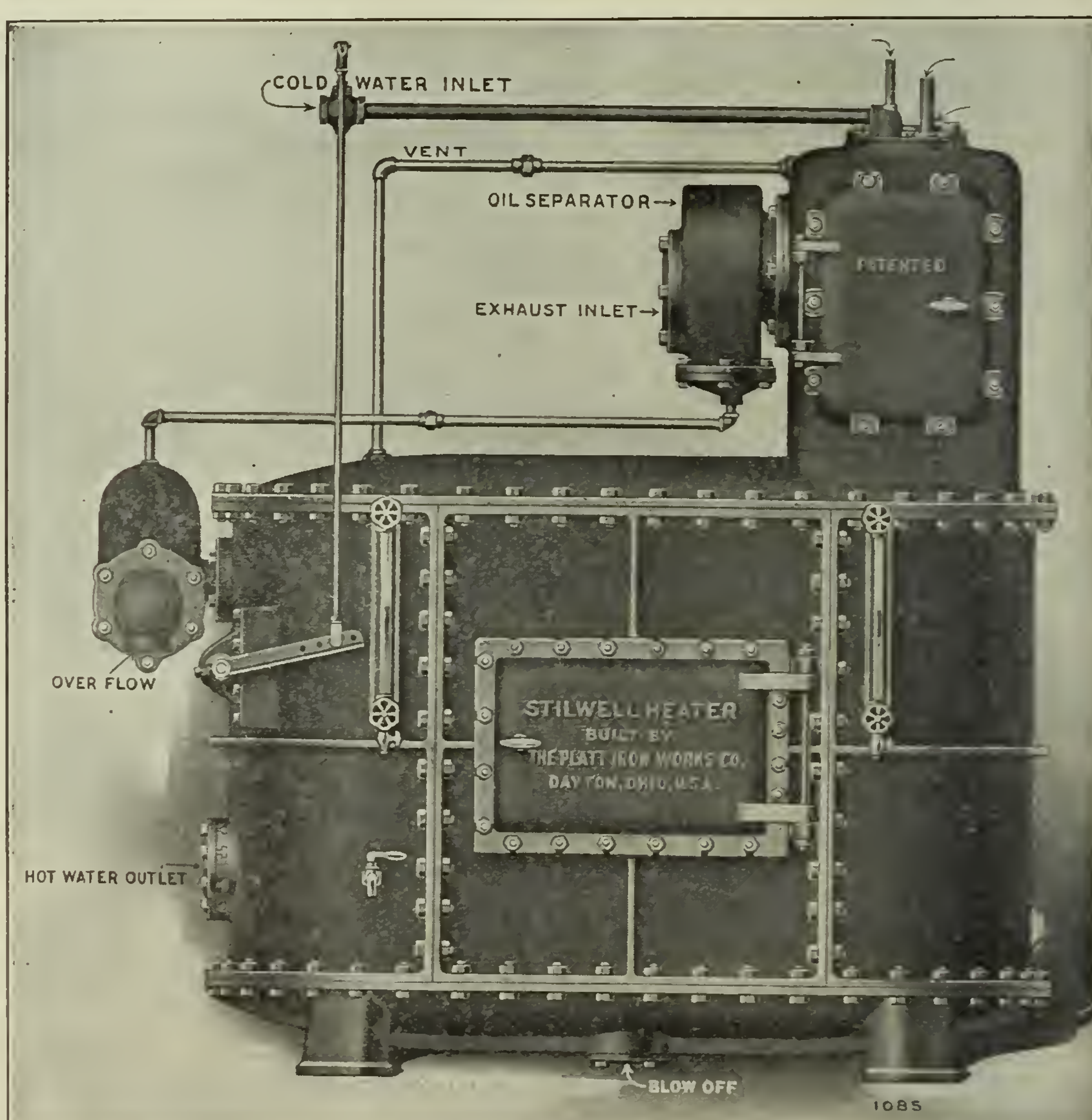


Fig. 1. Exterior View of Stilwell Heater

sections, with ground joints and permanent gaskets, and is designed to withstand ten pounds back pressure.

The system consists in using the heat

of the steam for removing the temporary hardness, such as carbonates, chemicals being used to remove permanent hardness caused by sulphates, chlorides, etc. In operation it is designed that the reagent will be fed continuously in proportion to the cold water, both entering the heating chamber at the same point, the reagents being handled by an auxiliary plunger on the feed pump.

After the water has passed through the heating chamber it reaches a settling chamber below, in which the greater portion of the impurities will settle to the bottom, from which they can be blown off. The water then passes upward through a blanket filter into the purified-water chamber from which the pump suction takes its supply.

A device recently designed and made part of this system consists of a water-sealed supplementary bypass which insures the delivery of hot treated water to the boiler-feed pumps in case the filter blanket, if neglected, should become clogged up. The bypass automatically operates when the water rises to the proper level in the heating and purifying chambers. This special feature, being water sealed, prevents any scum or floating particles from passing over into the purified-water chamber.

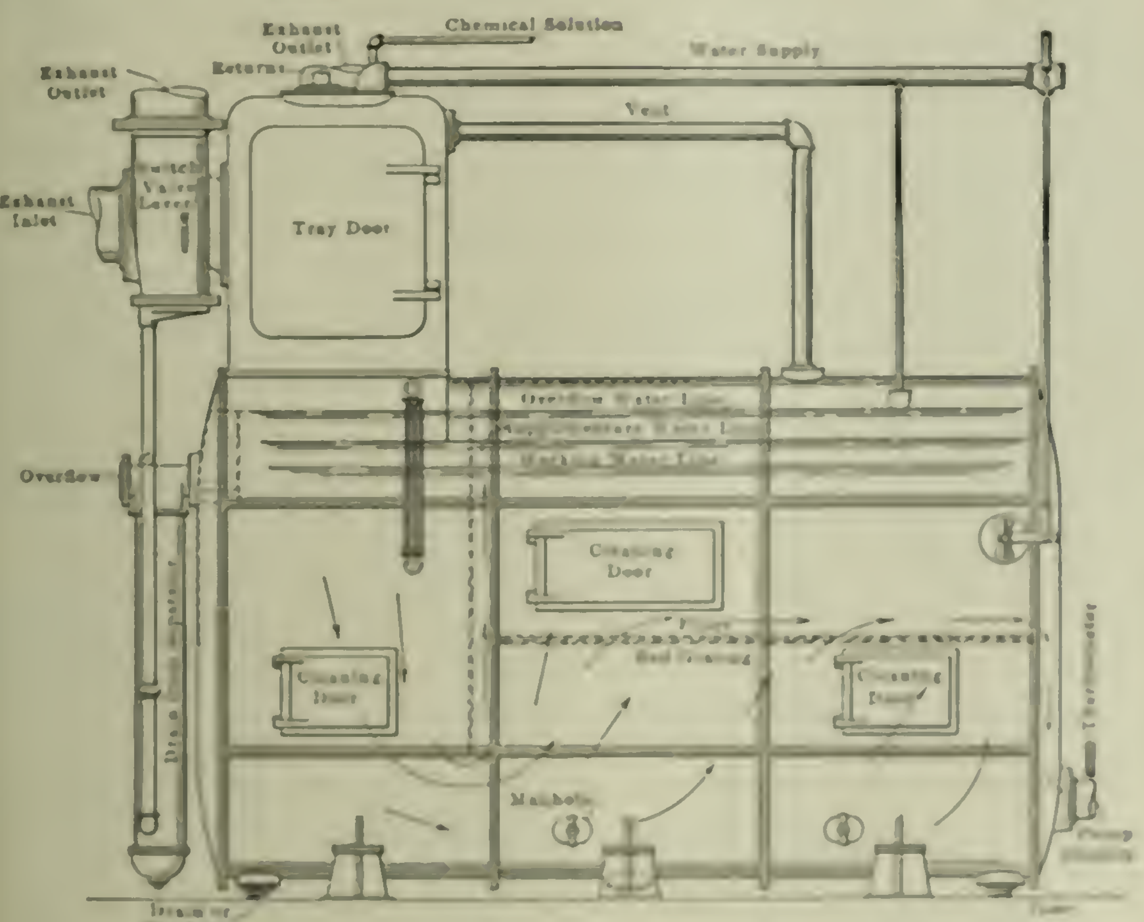


Fig. 2. View of Heater, Indicating Interior Construction

A skimmer is provided in the heating chamber for skimming the surface of the water, this skimmer also acting as a point of overflow into the trap. Large hinged doors are provided, permitting easy access to all parts and any internal part can be readily removed through these doors. Float valves, mixing tanks and auxiliary pumps for forcing chemicals in proper proportion to the feed water, make up the system, which is automatic when once installed.

The "Change Blade" Screwdriver

A new screwdriver is being put on the market by Kinckiner & Scott, 626 North Twelfth street, Philadelphia, Penn.

The handle is of red brass in skeleton form, with a covering of mahogany. The blades are of tool steel with a tempered cross pin, which engages with a slot in the brass handle and takes the strain of the work. The end of the blade, which enters the handle, is threaded to fit the cap nut which retains it in position in the handle. The blades are made in 3-, 6- and 8-inch lengths and are easily interchanged.

A change-blade screwdriver is made especially for electrical work. In it the entire handle and blade are insulated with the exception of the extreme end which engages the screw slot.

Congress of Refrigeration to Be Held in America

The executive committee of the American Association of Refrigeration held an important meeting at the Great Northern hotel, Chicago, on December 15, to perfect an organization and provide ways and means for the third international congress which the recent second congress in Vienna voted shall be held in the United States. Several members of the committee came from widely separated sections of the country. Rivalry for the privilege of entertaining the scientists who will represent the refrigerating interests of more than forty foreign countries is already active. New York, Washington, Philadelphia, Birmingham, St. Louis and Chicago are among the places advocated. Chairman Homer McDaniel, of Cleveland, was authorized to appoint a committee of five to prepare a budget of the necessary expenditures for conducting the congress, to decide upon the most suitable date and place for holding it, to prepare a general scheme of entertainment for the foreign delegates, and to report the results of their labors to the next regular annual meeting of the association. It was the general opinion of those present that the committee will without difficulty secure a sufficient fund to justify our Government in extending its invitation to foreign countries to participate in the congress by the appointment of official delegates, as was done by our Government for the Paris congress of 1908 and the Vienna congress of this year.

Brooklyn Engineers Hold Annual Dinner

The Brooklyn Engineers' Club held its annual dinner on December 15, 1910, at the Hamilton Club, Brooklyn; the fact that there was such a large call for tickets led the committee to arrange for greater accommodations than the club's own banquet room affords.

George A. Orrok, the retiring president of the club, who acted as toast master, briefly reviewed the work accomplished during the year.

The first speaker to be introduced was Dr. Rossiter W. Raymond, secretary of the American Institute of Mining Engineers. Doctor Raymond's talk was on the "Panama Canal" and was based on the information he obtained during the excursion which he and other members of the Institute of Mining Engineers recently made to the canal.

Dr. Alexander C. Humphreys, president of Stevens Institute of Technology, was next introduced. His topic was "Engineering Education, the Concrete Rather than the Abstract." He maintained that much valuable engineering knowledge can be learned only in the school of experience.

Major John F. O'Rourke, president of the O'Rourke Engineering and Contracting Company, spoke on "After-dinner Engineering."

After the dinner, the following officers of the club for 1911 were elected: President, Major Winfield H. Roberts; vice-president, John M. Stalnaker; secretary, Joseph Strachan (reëlected); treasurer, William T. Donnelly; directors, H. C. Keith and W. F. Wells.

There were about 100 members and guests present.

Steam Pipe Bursts in Lowell

It is reported in the daily press that on December 24 a steam pipe burst in the Perry street power plant of the Lowell (Mass.) Electric Light Company. Six men were injured and fragments of the pipe damaged the brickwork of the building to some extent. The plant was shut down for an hour.

OBITUARY

Rudolph Wolf, founder of the Great Engineering Works at Magdeburg-Bugkau, inventor of the Wolf compound engine and identified with the early use of superheated steam, died on the twentieth of November in his seventy-ninth year.

Matthew Kennedy, treasurer of the Kennedy Valve Manufacturing Company, Elmira, N. Y., died on November 26 at his home in Coxsackie. He was born in Ireland in 1840, and with his brother Daniel established the business with which he was so long identified.

BOOKS RECEIVED

DYNAMO ELECTRIC MACHINERY. By Samuel Sheldon. D. Van Nostrand Company, New York. Cloth; 328 pages, 5x7½ inches; 210 illustrations; indexed. Price, $2.50.

ELECTRICITY EXPERIMENTALLY AND PRACTICALLY APPLIED. By S. W. Ashe. D. Van Nostrand Company, New York. Cloth; 344 pages, 5x7½ inches; 422 illustrations; indexed. Price, $2.

BROOKES AUTOMOBILE HANDBOOK. By L. Elliott Brookes. Frederick J. Drake & Co., Chicago, Ill. Leather limp; 701 pages, 4x6½ inches; 320 illustrations; tables; indexed. Price, $2.

THE CONSTRUCTION AND WORKING OF INTERNAL COMBUSTION ENGINES. By R. E. Mathot. D. Van Nostrand Company, New York. Cloth; 554 pages; 5½x9¼ inches; fully illustrated; indexed. Price, $6.

DESIGN OF MARINE MULTITUBULAR BOILERS. By James D. McKnight and Alfred W. Brown. The Technical Publishing Company, Ltd., and D. Van Nostrand Company, New York. Cloth; 48 pages, 6x10 inches; illustrated; indexed. Price, $1.50.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

WATER WHEEL. Arnold Pfau, Milwaukee, Wis., assignor to Allis-Chalmers Company, Milwaukee, Wis., a Corporation of New Jersey. 978,335.

ROTARY ENGINE. John W. Larimore, Benton, Ill. 978,602.

WAVE MOTOR. Thomas Nixon, Santa Barbara, Cal. 978,628.

ROTARY ENGINE. Samuel Haudenshield, Carnegie, Penn. 978,743.

BOILERS, FURNACES AND GAS PRODUCERS

STEAM GENERATOR. James J. Bush, New York, N. Y. 978,135.

SMOKE CONSUMER. William McArdle, Montreal, Quebec, Canada, assignor to the Perfect Simplex Combustion Company, Montreal, Canada. 978,467.

SHAKING AND DUMPING GRATE. Chas. F. Hutchinson, Kingsville, Md., assignor to Hutchinson Bros., Kingsville, Md., a Corporation. 978,589.

GENERATOR AND SUPERHEATER. John G. Massie, East St. Louis, Ill., assignor to the Massie Generator and Radiator Company, East St. Louis, Ill., a Corporation of Illinois. 978,769.

OIL BURNER. John R. Pring, Shawnee, Okla. 978,780.

CRUDE-OIL BURNER. Emory A. Wales, Oklahoma, Okla. 978,797.

POWER PLANT AUXILIARIES AND APPLIANCES

GAGE COCK. Charles Wright, Youngwood, Penn., assignor to the Wright Specialty Manufacturing Company. 978,256.

ENGINE-STARTING DEVICE. Peter P. Au Buchnon, French Village, Mo. 978,264.

VALVE. John William Harkom, Melbourne, Quebec, Canada. 978,288.

AUTOMATIC CUTOFF VALVE. Francis Hodgkinson, Edgewood Park, Penn., assignor to the Westinghouse Machine Company, a Corporation of Pennsylvania. 978,294.

BOILER-TUBE CLEANER. William L. Miggett, Ann Arbor, Mich., assignor to Raphael Herman, Detroit, Mich. 978,326.

ROTARY PUMP. James Baguley, Evanston, Wyo. 978,350.

CONDENSER. Royal D. Tomlinson, Milwaukee, Wis., assignor to Allis-Chalmers Company, Milwaukee, Wis., a Corporation of New Jersey. 978,411.

VALVE AND VALVE-OPERATING MECHANISM. Fred Loedige, Chicago, Ill. 978,463.

OIL CUP. Verner J. Wahlstrom, New York, N. Y. 978,521.

PISTON-ROD STUFFING BOX AND LUBRICATOR. Walter McLain, Spiritwood, N. D. 978,611.

HOSE COUPLING. Bernard Morgan, Newport, R. I. 978,619.

PUMP. Garl Nicholls, McFall, Mo. 978,626.

PUMP. Edwin E. Slick, Pittsburg, Penn. 978,668.

CONDENSER. Evi W. Christie, Sewaren, and Tom Roberts, Roselle Park, N. J., assignors to Wheeler Condenser and Engineering Company, Carteret, N. J., a Corporation of New Jersey. 978,697.

STEAM TRAP. Vernon Bradley Convis, Toronto, Ontario, Canada. 978,701.

VALVE. James E. Davidson, Butte, Mont. 978,706.

ROTARY PUMP. Michael E. Durman, Detroit, Mich. 978,715.

GRAVITY VALVE CAGE AND VALVE FOR PUMPS. Jesse B. Garber, Salem, Ohio, assignor to the Deming Company, Salem, Ohio, a Corporation of Ohio. 978,729.

VALVE GEAR. Hiram P. Graves, Elmira Heights, N. Y. 978,737.

VALVE. Joseph Huebsch, Milwaukee, Wis. 978,752.

CENTRIFUGAL PUMP. Joseph Hurst, Louisville, Ky. 978,753.

CHECK VALVE. Jonathan Johnson, Lowell, Mass. 978,757.

DEFLECTOR FOR SMOKE-BOX SUPERHEATERS OR FEED-WATER HEATERS. Samuel M. Vauclain, Philadelphia, Penn., assignor, by mesne assignments, to Baldwin Locomotive Works, Philadelphia, Penn., a Corporation of Pennsylvania. 978,795.

LUBRICATOR. Carl Roberts Briggs, Ravenna, Ohio. 978,819.

ELECTRICAL INVENTIONS AND APPLICATIONS

APPARATUS FOR ELECTRIC SMELTING. Frank Creelman, New York, N. Y., assignor to the Wilson Carbide Works Company of St. Catharines, Ltd., St. Catharines, Canada, a Corporation. 978,137.

ELECTRIC MOTOR-CONTROLLING APPARATUS. Harry Ward Leonard, Bronxville, N. Y. 978,173.

COMBINED SWITCH SOCKET AND PLUG. William Pinkney McNeel, San Antonio, Tex. 978,322.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., Prof. J. D. Hoffman; sec., William M. Mackay, P. O. Box 1818, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting, St. Louis, Mo., January 16-21, 1911.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION.

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

POWER

NEW·YORK, JANUARY 10, 1911

THE comparison of our progress through life to the scaling of a ladder is a much better one than we sometimes realize.

Often the comparison is borne out in ways that we do not stop to notice. For instance, take the man whom fortune has favored with a thorough early education. When he gets into the world of business—the steam engineering field, perhaps—he has a vast advantage over another man who has been less fortunate. He easily puts below him the first few rungs of the ladder.

The rise of the less fortunate man is slow and laborious; he must grope his way up, almost blindly, wasting much time and often losing hard-gained ground in testing false rungs. At length he reaches a point where there is a gap in the ladder—one or two of the rungs are missing because of his lack of early advantages.

The first man, looking down from his higher and more secure position, is able to see clearly just what the latter's difficulty is.

If the man higher up is worthy of the name—if he is a real MAN of 45-gage construction—he will reach down his hand and give the man below the "lift" that he so badly needs.

If the man above is only a pigmy, only 22-gage, he will kick the other man in the face and shake his hold, or he will ridicule and try to discourage him.

How often such things occur your own experience shows. How many times have you needed a "hand," sometimes to be disappointed by refusal and sometimes to be surprised by the unexpected source from which the aid was given?

How many "lifts" have you given and how many withheld? Are you 45-gage or only 22?

No man can attain such a hight on the ladder of success that he can afford to ignore the appeals for assistance of those lower down. The time is likely to come any minute when he, himself, will need a "boost" from someone in a humble position. But, even allowing that he may never need further help, common decency should prompt him to do what he can to help others along, for unless he had received aid from others, undoubtedly he never could have mounted as high as he did. So, to discharge his debt to his benefactors, it is his duty to help others where and when he can.

All this applies to you, be your station high or humble.

Edward Everett Hale, now dear to memory, originated a saying which contained more than many a long sermon ever did. The sense of it is: "Look out, not in; look forward, not back; look up, not down, and lend a hand."

Power Plant of the Raike Building

By Osborn Monnett

A plant of 160 kilowatts capacity furnishing power by means of electric drive to a number of manufacturing establishments located in the building. An interesting feature of the equipment is the arrangement of the combustion arches in the boilers.

In the Louis Raike building on Jackson boulevard, Chicago, is to be found a model little steam plant of 160 kilowatts capacity which furnishes power through a system of electric drive to the various manufacturing establishments occupying the building. In a plant of this capacity, although reliability must be attained, together with a certain degree of economy, it is not justifiable to burden it with an excessive first cost for complicated and elaborate auxiliary equipment, which, although saving labor and money in a larger plant, would not justify the expenditure in one of this size where an operating force of only two is required. In the present case these features have been worked out in a satisfactory manner.

Boilers

Steam is supplied by two Brownell horizontal return-tubular boilers 66 inches in diameter by 18 feet long, having quadruple-riveted butt joints. A pressure of 139 pounds is allowed by the city-boiler inspector, but 110 pounds is the pressure usually carried. A view of the boiler room is shown in Fig. 1. Undoubtedly, the most interesting feature of the boiler setting is the arrangement of the combustion arches at the bridgewall. In the end and side elevations, Fig. 2, the arrangement of these arches is indicated. They are built of the best grade of fire tile, the two central piers, together with the side walls, permitting a triple arch at this point, the top of which closely fits the boiler shell, compelling the products of combustion to pass through the arches and breaking up the current of gases. In this type of setting the heat radiating directly from the fire is taken advantage of for making steam. It is interesting to note that, although this plant has been in operation for about twelve months, using Pocahontas coal, it has never been accused of violating the smoke ordinance. Another interesting feature of the furnace construction is the fact that the dead plates immediately in front of the fire doors can be lifted, making an opening direct to the ashpit through which ashes and clinker may be raked when the fires are being cleaned, thereby keeping all the dirt and dust in the ashpit during this operation and not on the boiler-room floor, as is ordinarily the case with hand-fired stationary grates, such as are here employed.

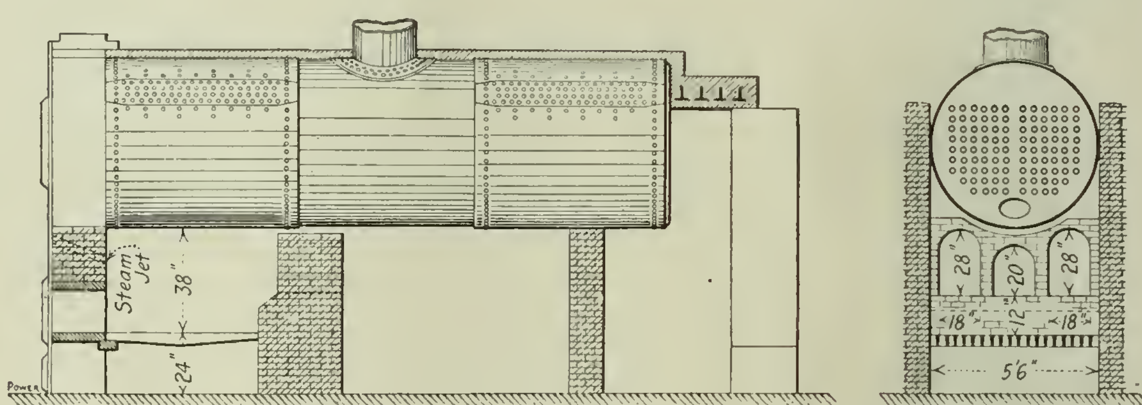


Fig. 2. Boiler and Setting, Showing Arched Bridgewall

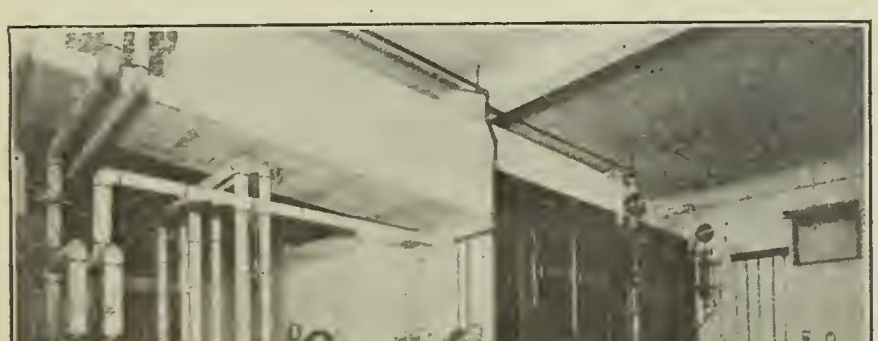


Fig. 1. Boilers and Feed Pumps

Fig. 3. Feed-water Heater, Surge Tank and Exhaust Connections

Provision has been made for a coal-storage capacity of twenty-five tons and coal is discharged from an alley in the rear of the building either direct to the coal-storage bin or onto the passageway between the boiler room and coal-storage bin, so that in the future, if desired, a coal conveyer may be installed which will deliver the coal to a point in front of the boilers.

Piping

The steam piping is laid out on an extremely simple though efficient system. Resting directly on the rear of the boiler settings is a short 12-inch header into which 5-inch steam connections from the two boilers enter through angle valves. These steam connections are provided at the boiler nozzles with angle stop valves and nonreturn valves, all valves and piping being extra heavy with screwed flanges. From the header, long-radius bends lead to the engines, with steam separators directly above the throttles.

The 10-inch main exhaust rests in a concrete trough in the engine-room floor, covered with iron plates. This leads to a Webster open feed-water heater, first passing through an oil separator and having a connection to the exhaust-heating system. An atmospheric relief valve is also located at this point. Fig. 3 shows this part of the equipment, and also the surge tank through which water for all purposes enters the plant. Dearborn feed-water feeders are installed on the feed-pump suction line between the heater and the pumps. Two 6 and 4 by 6-inch Dean-of-Holyoke pumps are used for boiler-feed purposes, one always being held in reserve, and another pump of the same size is used for house service. All of these pumps are cross-connected (see Fig. 1) and may be used either for feeding the boilers or for house service. Force-feed lubricators are installed on all pumps and also on the main engines.

The house service consists of a hot- and a cold-water supply, the latter coming direct by gravity from a tank on the roof, while the former is supplied from an auxiliary heater, using exhaust steam, but having a live-steam connection for use when necessary.

Heating System

The steam heating is done on the Bishop & Babcock air-line vacuum system and contains 8000 square feet of direct radiation. In this system there is a single steam-pipe connection to each radiator, and the air is removed through an automatic air valve into a vacuum maintained by a hydraulically operated pump. The operation of the vacuum pump will be apparent on reference to Fig. 4. The suction line of the pump connects with the main air line through a coil placed in an open condensing tank to which the discharge from the water cylinder of the pump is piped in such a manner that the amount of drip may be observed as shown at S. The overflow from the tank goes to the sewer. The tank is for condensing any steam that might be drawn through the air valves due to leakage or improper setting before entering the pump. A diaphragm valve is placed in the water supply and is connected to the pump suction and can be adjusted to maintain any degree of vacuum.

Engine Room

One 60-kilowatt and one 100-kilowatt Ridgway direct-connected generating units have been installed in the engine room. These are of the new Ridgway side-crank construction, but have slide valves of the single, balanced type, with a splash system of lubrication. On the acceptance tests made at the shops of the builders, they delivered a brake horsepower on slightly less than 29 pounds of steam per hour.

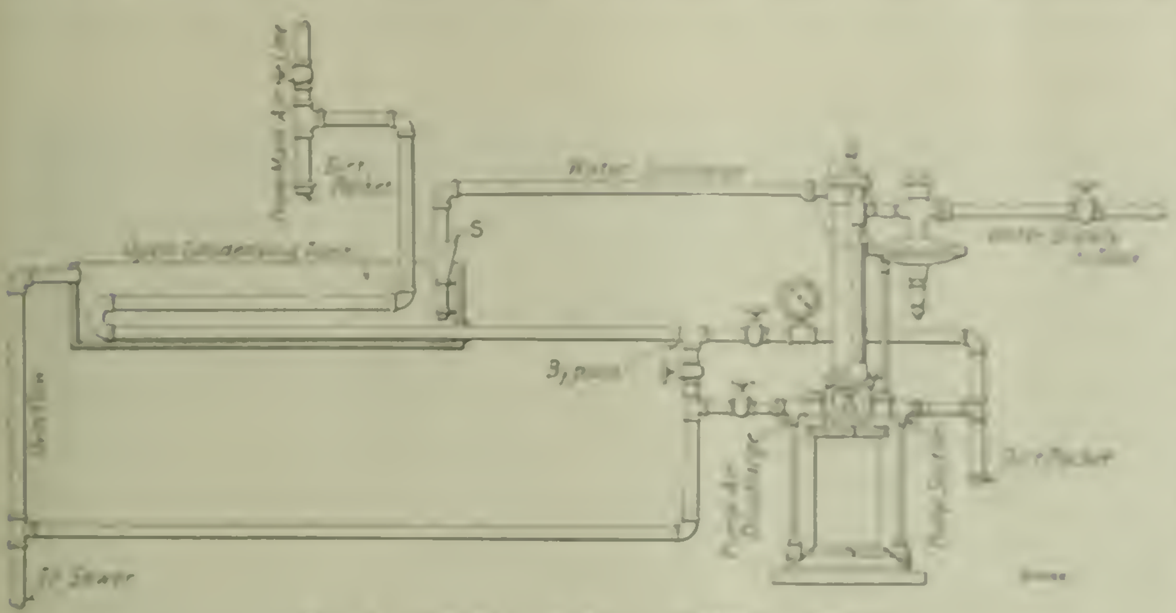


Fig. 4. Piping Layout of Vacuum System

Fig. 5 is a view of the engine room. The decoration of the room consists of a green-painted wainscoting with cream-colored walls and ceiling. The engines are finished in green enamel with gilt trimmings and harmonize well with their surroundings. The engine-room floor, which is usually a perplexing problem when made of concrete, has been treated with a cement-floor filling and covered with two coats of lead-colored paint, making a smooth, neat and easily cleaned surface which adds materially to the appearance of the room.

Fig. 5. General View of Engine Room

Electrical Equipment

The electrical equipment is of Thompson-Ryan make, direct current being furnished on two-wire system at 220 volts.

On the lighting circuits both tungsten and carbon-filament lamps are used; the latter are connected directly across the 220-volt circuits and the former are connected two in series, the series arrangement avoiding the necessity of using a balancer set and materially simplifying the lighting circuits. There is one light and one power circuit, the latter supplying a variety of motors ranging from ½ to 20 horsepower. This power is metered to the various tenants and on each floor are located two cut-out panels, one for power and one for lighting.

A record transmission voltage for Europe will be established by the Lauchhammer power station in Germany, which will transmit power at 110,000 volts. The different works of Messrs. Lauchhammer, Ltd., have heretofore been supplied from separate power stations. Finding that their works at Lauchhammer were situated on a rich lignite field, it was decided to build a central power plant to supply the various works. At the same time, a central station was being planned at Gröba to supply four districts of the kingdom of Saxony. Arrangements were accordingly made to utilize, instead, the power generated at the Lauchhammer plant. Three turbo-dynamos of 5000 kilowatts each are being installed, and two more units will be added later. The current is generated at 5000 volts, and raised by means of transformers to the transmission tension of 110,000 volts. The plant will have a capacity of 40,000 kilowatts, or nearly 50,000 horsepower.—Exchange.

A Slowly Moving Positive Valve Gear

By Dr. Alfred Gradenwitz

Separate steam and exhaust valves of the piston type arranged tangentially to the cylinder and operated by eccentrics on a lay shaft which revolves at one-half the speed of the main shaft.

E. Frikart, of the Alsatian Machine Building Company, at Mulhouse, Germany, has designed a novel valve gear for steam engines, in connection with which the admission and outlet piston valves are arranged separately at each end of the cylinder, tangential to the latter and at right angles to its axis, being actuated through an eccentric from a side shaft which moves only at half the speed of the crank shaft of the engine, so that the opening and closing of the steam channels, with two strokes of the working piston, occur during one stroke of the valve. The steam admission is controlled immediately by a governor acting on the admission piston valve of the high-pressure cylinder.

It is well known that the increasing speeds used in connection with modern steam engines entail a positive motion, gear and the waste spaces are reduced to a minimum, both in regard to their surface and volume. For the same reason an entirely positive valve gear can be used, in connection with which any spring for actuating the slide valves is dispensed with.

same side of the cylinder, is operated by the same eccentric mounted on a side-shaft, parallel to the cylinder axis, which is actuated from the crank shaft through a pair of gears at a ratio of 1 to 2. Thus the eccentric turns through only 180 degrees during each full revolution of the crank, so that the admission valve operated by it moves from right to left only. The eccentric then moves an equal distance during the ensuing revolution of the crank, thus performing a full revolution of 360 degrees, and causing the slide valve to return to its initial position from the left to the right.

Each full revolution of the eccentric thus corresponds to two full revolutions of the crank, or to put it in other terms, while the piston in the cylinder changes its direction of motion twice, the slide valve makes only a single change in direction. The channels in the valve box

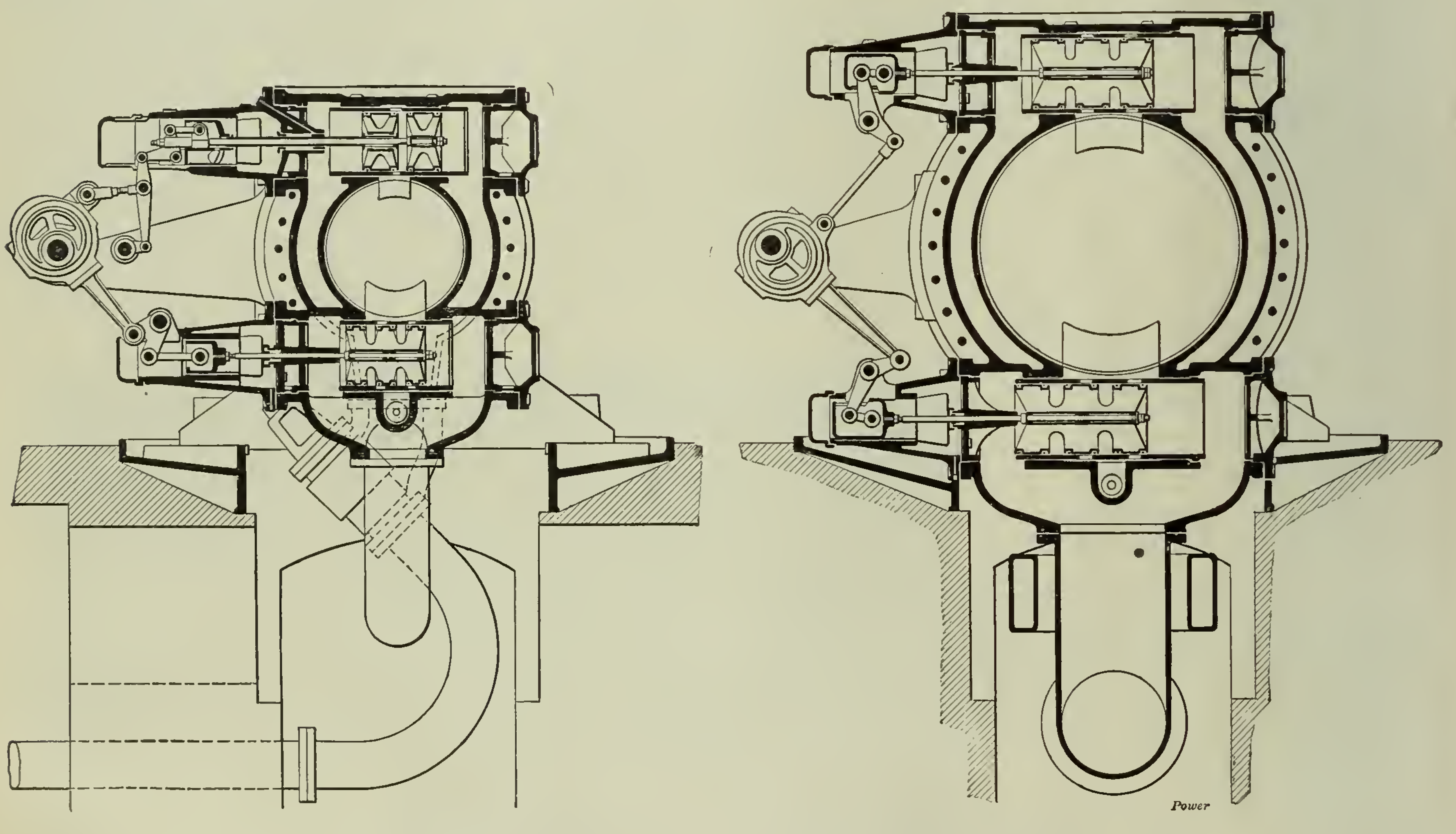


Fig. 1. Cross-sections through Valves of High- and Low-pressure Cylinders

while the high steam pressures and high temperatures require the arrangement of balanced slide valves, so as to insure a smooth working of the engine. Such valves are, for instance, piston valves with self-tightening obturating rings which slide in turned boxes arranged tangentially at the ends of the cylinder. These piston valves will grind themselves of their own accord into their boxes, so as to require no special grinding. The steam distribution, owing to the large lap, is entirely insensitive in regard to end play in the outside valve

This advantage is utilized in a most ingenious manner in connection with the positive valve gear described herein, which works at only half the speed of the steam engine. Fig. 1 shows a cross-section through the slide valves of the high- and low-pressure cylinders of the 1000-horsepower tandem-compound engine represented in Fig. 2. Figs. 3 and 4 show the corresponding diagrams of the valve gears.

Each system of two slide valves, the upper one of which admits the steam while the lower one exhausts it from the

are opened and closed by the slide valve in the following manner:

Supposing the admission slide valve in opening the channels to move from the right to the left, until the eccentric has completed its motion (corresponding to a full revolution of the crank), during the same time these channels should be opened by the slide valve, and closed again after the steam has been allowed to enter the cylinder. The opening, as represented in Fig. 3, is effected by the valve edge *e* and the closing by the edge *f*. The slide valve thus passes by the valve port in a constant direction both in opening and closing the channels. The latter will be opened entirely when the valve apertures of equal magnitude are situated exactly between the edges of the valve port. From this moment they again begin to close.

During the next full revolution of the crank, the steam admission in regard to the cylinder will be the same. However, the eccentric now moves through 180 degrees and the slide valve, without any alteration in its direction of motion, returns to its initial position from the left to right. During this motion of the valve, the edges *f* and *e* exchange their respective positions, the former effecting the opening and the latter the closing. The valve thus actually undergoes only half the number of changes in direction as the piston itself.

On account of the manner in which the path of the eccentric is utilized for the stroke of the piston, the motion of the eccentric can be transmitted immediately to the slide valve, thus dispensing with any spring or horizontal displacement as otherwise used with a view to reducing the lap. As the slide valves both in opening and closing maintain their sense of direction unaltered, their effective opening path is determined by the circumference on the eccentric circle intermediary between the opening and closing points, which in comparison with the whole path of the eccentric is considerably longer than the pitch of the arc between these points as otherwise used for actuating valve gears working at normal speeds.

The relation between the neighboring edges of a slide valve, and the width of the corresponding steam port in the valve box depends on the effective valve stroke for a given duration of steam admission and exhaust. Any alteration in this duration will increase or reduce the distance between these neighboring valve edges. This is how, by dividing the high-pressure admission valves into halves, Fig. 1, the steam admission to the high-pressure cylinder can be controlled, a considerable distance between the edges corresponding to a considerable admission and output of the engine, and vice versa. When the two halves of the slide valve come in contact so that the edges strongly strike one another, the steam admission to the cylinder is entirely discontinued.

In order to allow this valve distance to be regulated by the governor, each half of the valve is connected separately with the outside valve gear. The valve rod of the front valve is hollow, being traversed by the valve rod of the rear valve, Fig. 1, and both rods terminate in the outside valve guide box in slides connected to the gear by an angle lever, the motion of which will displace them relatively to one another, thus altering the distance between the slide valves, and accordingly the degree of admission.

As seen from the cuts, the two admission valves are actuated through a guide and a vertical lever immediately from the eccentric, the reciprocating motion of which is transmitted to the valves without altering their mutual displacement. The valves will move across the port in the box a constant distance with each piston stroke. Only when the guide, by turning the governor shaft around, lifts or lowers the vertical lever which connects the guide with the angle lever, will this distance be adjusted by the angle lever oscillating round its pivot.

The lifting of this vertical lever, as effected by adjusting the governor shaft, will increase the distance between the edges, and accordingly the duration of steam admission, while by lowering a diminution is obtained. This enables another alteration of the valve motion which is likewise of much importance for the regulation of the engine. Any alteration in the distance between the valve edges would in fact alter not only the

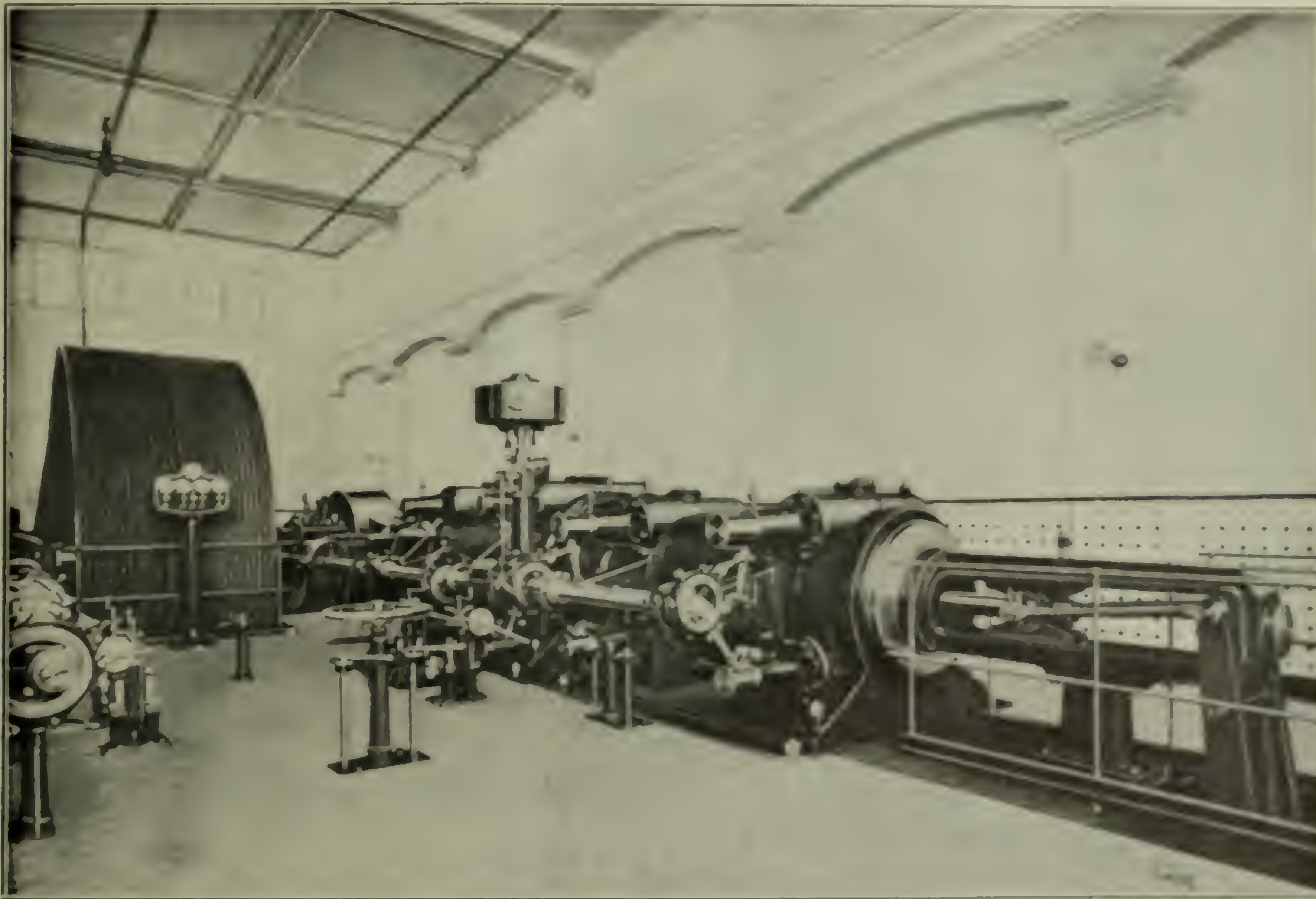


Fig. 2. 1000-horsepower Tandem-compound Engine with Frikart Valves

duration of steam admission, but the admission lead as well, an increase corresponding to a considerable admission, and a decrease to a small one. In order to prevent this the governor shaft by the action of the vertical lever raises the guide of the eccentric into a given position, corresponding to a constant advance in regard to the eccentric curve. In spite of any alteration in the distance of the edges, as adjusted by the governor to the duration of steam admission, the port opening thus commences

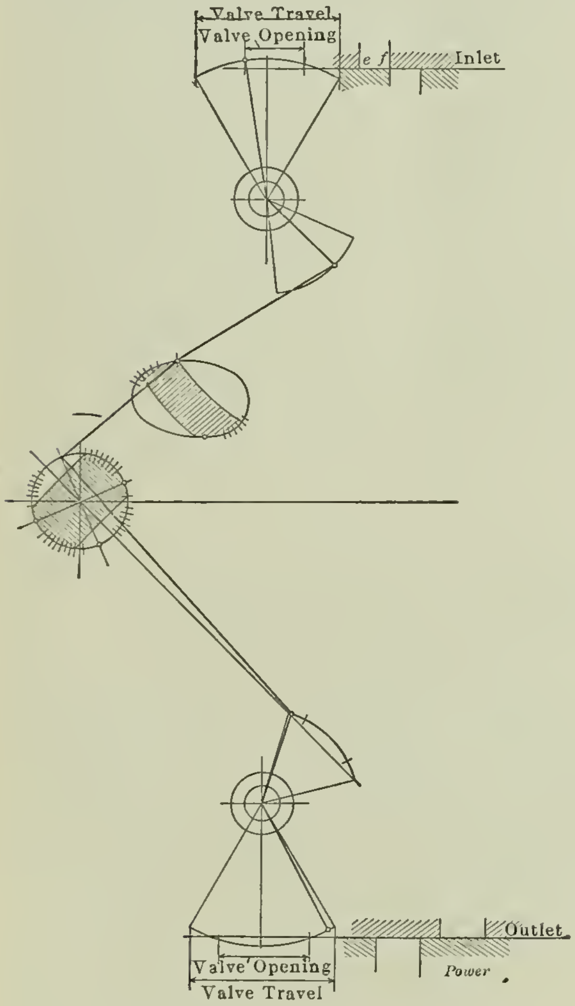


Fig. 3. Diagram of Valve Gear for High-pressure Cylinder

always at a given point of the eccentric curve.

The passage opening between the two valve edges corresponds, with any change, to a given ratio between the steam and piston speeds, so that even with the higher position of the governor, no throttling is noticed in the entering steam. As the piston valve is balanced while its frictional resistance, like those

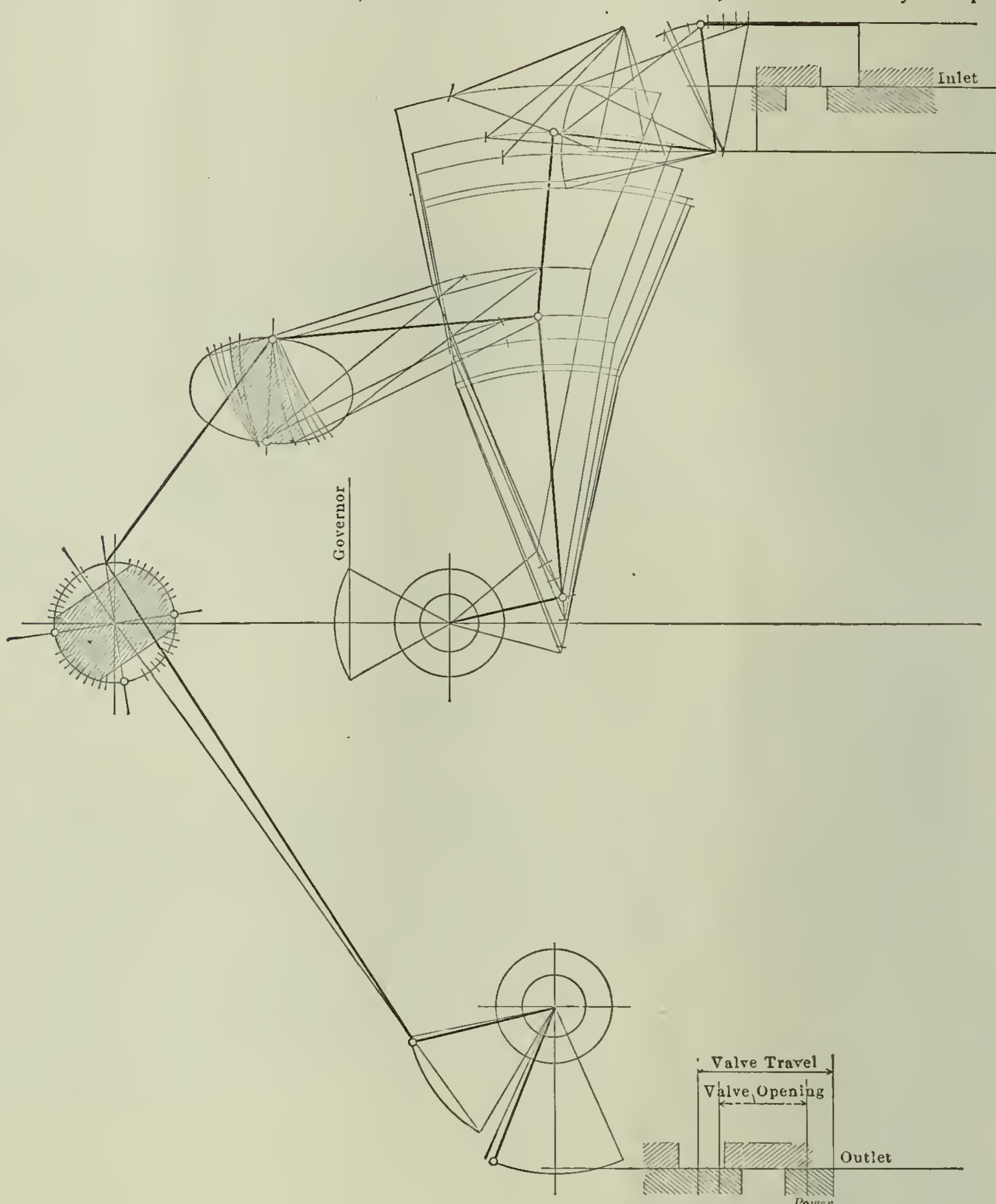


Fig. 4. Diagram of Valve Gear for Low-pressure Cylinder

of valve rods moving in metal stuffing boxes, is quite immaterial, the reaction on the governor is extremely slight, and owing to the absence of any spring actuating the slide valves, practically constant.

This half-speed valve gear is specially adapted for high-speed engines to which an entirely smooth running and increased efficiency are insured by the positive motion. As the slide valves are arranged tangential to the cylinder, no attention need be paid to the valve gear, all the parts of which are visible and accessible during the mounting and unmounting of the piston.

Water Hammer and Boiler Explosions

By A. Vincent Clark

Theories of cause of boiler explosions in which water hammer and the sudden liberation of large quantities of steam resulting from quick opening of a valve explain violence of some explosions.

In a previous issue a correspondent asked, "If water hammer is possible when a master valve is opened, even with haste, why is it not present with all of its alleged destructive effects every time that the safety valve blows?"

It is generally accepted that these two cases are not analogous. It must be borne in mind that the following explanations are theories, for it is practically impossible to obtain definite proof of the actual phenomena which occur when water hammer is set up or when a boiler or a steam pipe bursts. These theories, however, are the ones most easily reconcilable to the facts of the occurrences.

It is with explosions similar to that which recently occurred at Canton, where an apparently sound boiler exploded from a cause which could not definitely be ascertained, that these theories help toward a solution; it must be admitted that an engineer faces one of the most difficult tasks in his profession when he is called upon to give the cause of such an explosion, and there is not a subject upon which greater diversity of opinions is held by experts.

Water hammer in steam pipes is not an uncommon occurrence; it more often occurs when turning on steam to a line of piping, and its presence can be guaranteed if the steam is turned on too quickly; but it will also occasionally occur in pipes which have been conveying steam for some time; however, it is held by many engineers that this latter case is completely overcome if the steam-pipe line is arranged so that it has a continuous fall from the boiler-stop valve to the engine, with no sharp bends, and with all branches provided with a stop valve close to the pipe, or the branches efficiently drained.

In the only case with which the writer has had experience this opinion was found to be justified, for a most unmanageable water hammer, which occasionally occurred even when the main engine was running with a steady load, was completely cured by providing efficient traps for all of the branches of the steam line.

In all cases of water hammer the pipes are subjected to severe shocks, and when it is very violent, such as is caused by rapidly turning on steam, a broken stop valve or a burst pipe is the result.

There are two explanations of the phenomena which occur in this case which receive general acceptance: One is, that water lying in the pipe is caught up by the incoming steam and is blown like a shot until it is brought up by the end of the pipe or by the stop valve; the other is, that steam coming into contact with the cold water lying in the pipe is suddenly condensed, thus producing a vacuum into which this steam and water are projected with explosive force.

It will be seen that these two theories can account for all of the accidents due to water hammer, and it can be realized how important it is that the velocity of the steam first entering the pipe should be very low; for the attainment of this low velocity the boiler stop valve should be opened very slowly.

There is also another reason why the sudden opening of the boiler-stop valve is dangerous for the steam-pipe line; it is well known that a safety valve often discharges as much water as steam. The action of opening the stop valve quickly is exactly similar to the opening of the safety valve; therefore, it is quite probable that, by opening the stop valve quickly, water from the boiler enters the steam pipe at a high velocity and is shot along the pipe until it is brought up by the end of the pipe, thus causing a very violent water hammer.

Nearly fifty years ago D. K. Clark and Zerah Colburn advanced a theory regarding the violence of boiler explosions which, even now, is the best that we have and receives a general, although qualified, acceptance.

They held that in violent explosions the breaking up of the boiler is due to water being driven with great violence against the shell by the steam formed under the surface of the water directly the pressure is relieved.

It is admitted that this theory explains many of the violent explosions, but there are some exceptional cases which cannot be satisfactorily explained by it.

Taking cases of boiler explosions due to the corrosion of the plates, it may be assumed that in the case of the violent explosions the plates suddenly gave way, thus immediately allowing a great reduction of pressure and consequently, the very rapid production of a large volume of steam, whereas in the case of the less violent explosions the initial fracture of the plate might be small and simply produce an effect very similar to that of the opening of the safety valve, and the extension of the fracture be produced during the escape of the steam and water.

This explanation is probably correct, as it is well known that the intensity of any explosion is dependent upon the time. It, however, is only applicable to cases where the boilers gave way due to the weakness of their plates, and these are not a large proportion of the violent explosions.

Some explosions have been attributed to the steam generated by the pumping of cold water into a boiler when its flues have been overheated due to the water level getting low; in such cases, unless the flues are weakened by the overheating or by being bulged, it is difficult to conceive how a boiler can explode, for, when the mass of metal and the specific heats of the substances involved are taken into account, it may be definitely said that the red-hot flues would not generate more steam than the safety valve would carry off.

The probable result of the overheating would only be leaky seams and rivets, if, as is assumed, the strength of the boiler is not affected, and it seems that unless an inspection reveals signs of this the cause of the explosion must be sought elsewhere.

Another theory regarding the violence of boiler explosions and also their probable cause has been advanced from Professor Deluc's observations of the effect of absorbed air upon the boiling point of water. He found that water entirely freed from air by ebullition could be raised to 112 degrees Centigrade without boiling, but when it boils it does so with almost explosive violence. Boiling-nut water covered with a layer of oil can be raised to 120 degrees Centigrade without boiling, but above that temperature it suddenly begins to boil violently.

If this phenomenon is possible with water at atmospheric pressure then its occurrence should be possible when the water is under pressure in a boiler, and, if so, almost the ideal conditions for D. K. Clark's theory are attained, for the water next the flues would, without doubt, boil first and the water above it would be driven violently against the shell of the boiler.

A somewhat similar theory has been evolved from the knowledge that water will become spheroidal if there is a defective circulation. In this case there exists a film of steam between the water and the plates and, due to the retarded transmission of heat, the temperature of the latter will be increased; if the circulation of the water be now improved by suddenly reducing the pressure, by opening the stop valve or the safety valve, then the water coming in contact with the plates is rapidly evaporated and the steam thus formed drives the water above it violently against the boiler shell.

The last two cases are not at all similar to the one preceding them, for in that case there is no water above the steam that is rapidly generated by the overheated flue.

It is well known that it is extremely dangerous to suddenly connect a boiler to a live-steam main if there is a difference of pressure between the boiler and the main, and it is held by many engineers to be equally as dangerous to connect a boiler to a steam main quickly even if it is definitely known that the pressures are exactly the same in both cases.

Unless certain conditions are present, it is very difficult to conceive why this should be so dangerous, for in itself the connecting of two boilers at exactly the same pressure should be a safe proceeding however quickly it is carried out; even if the two boilers were not at exactly the same pressure it is difficult to see that anything other than the equalizing of the pressures would occur.

The branch from the stop valve to the main is usually not in the path of the steam from the other boiler and it is quite probable that condensation would occur in this branch, so it may easily be conceived that there may be an accumulation of water above the stop valve to be opened; by remembering one of the theories of the cause of water hammer it can be seen that these are just the conditions necessary to produce an explosion when the stop valve is suddenly opened. The steam from the boiler at once comes into contact with the water and becomes suddenly condensed, a vacuum is thus formed into which the steam and water are projected with explosive force; now, if the pressure in the main is higher than the pressure in the boiler, it is certain that the water which was above the stop valve would be driven violently into the boiler and might easily be the cause of an explosion.

Experience has changed the making of boilers to almost a science. And when the lessons of experience are learned as thoroughly by the operators then boiler explosions will be less common; an examination of the records of explosions shows that very rarely is the design of the boilers at fault, and that far too often the want of adequate inspection, or the want of care in the operation of the boilers, is the cause of the explosions which are occurring at an average of nearly two a day in this country.

The Steam Turbine in Germany

By F. E. Junge and E. Heinrich

For high economy at competitive prices a Curtis wheel in the high-pressure part, utilizing about one-third of the available energy, and Rateau wheels in the low-pressure part is the construction adopted as standard by the great majority of German builders of impulse turbines.

Rateau Wheels

The distribution of the whole drop of energy over the single stages is performed in various ways. Of importance is the consideration of the critical-pressure ratio (1.83 for superheated and 1.73 for saturated steam), a limit which one does not like to surpass as long as guiding apparatus with parallel walls are employed, though, today, the necessity of competing with other makes forces the designer, by decreasing the number of stages, to reduce the floor space of turbines, thereby lowering also the cost per horsepower. Thus it often becomes necessary to go beyond the above-named limit of critical-pressure ratio, especially in the last stages of turbines. Often a lower drop of energy is employed in the first stage in order to diminish the windage and friction work of the first wheel and to get as low pressures as possible upon the stuffing box.

Generally speaking, it is customary to divide the total drop of energy in such a way as to attain as far as possible equal outputs for each stage; that is to say, the effective velocities of issue from the guiding apparatus of each stage are then the same. In the case before us we have attempted to attain this condition for the sake of simplicity. In view of the fact that the sum of the respective energy drops of each stage becomes somewhat greater than the total theoretical drop of energy on account of the reheating of the steam—by the influence or rather influx of the heat caused by the losses—and further, in view of the other fact that to the energy drop of the second and third stages is added the exit energy $\frac{c_2^2}{2g}$ from the preceding stage, we have determined the energy drop in the single stages by way of experimentation.

Fig. 17 shows the Mollier diagram containing all the values of the steam in the various stages. Thus for the first stage the heat drop is found to be 52.2 B.t.u. Fig. 18 shows the velocity diagram.

The theoretical velocity of the steam leaving the first stage is

$$c_o = 223.8 \sqrt{52.2} = 1618 \text{ feet per second}$$

The effective velocity of issue

$$c_1 = 1618 \times 0.95 = 1537 \text{ feet per second.}$$

The circumferential velocity, as determined above, is $N = 515$ feet per second. By completing the entrance triangle we get w_1, while coefficient ψ, from Fig. 12, for a blade angle of 24 equals 0.82. Hence, $w_2 = 0.82\, w_1$, and by completing the exit triangle, $c_2 = 442$ feet per second.

Thus we get from equation 9 (January 3)

$$M = 0.6 \frac{442^2}{2g \times 778} = 2.3 \text{ B.t.u.}$$

The energy drop of the following stages we take as 49.9 B.t.u. and get as the energy of the steam issuing again $49.9 + 2.3 = 52.2$ B.t.u. The same result is attained in the third stage. As was said, this accordance of the velocities of issue and therefore of the outputs of the various stages cannot be quite exactly figured out beforehand, but must be found out by trial, more or less.

The indicated efficiency is found from the diagram to be

$$\eta i = \frac{2.515\,(1485 + 272)}{1618^2} = 0.69$$

hence,

$$R = (1 - 0.69)\ 52.2 = 16.2.$$

The windages are determined with the assumption of a mean admission diameter of $D = 3.28$ feet, and a mean blade length of ½ inch = 0.0416 foot. The specific volumes v and thereby the specific weights $\gamma = \frac{1}{v}$ are found from the Mollier diagram.

The losses through leakage on the wheel hubs were determined from equation 7 under the assumption $d_o = 190$ mm. = 0.624 feet, $s = 0.3$ mm. = 0.000985 feet (see Fig. 11), which corresponds to conditions as they obtain in actual practice. The results of the calculation of losses have been assembled in the accompanying table, the sum of losses being composed according to equation 11. The energy utilized in each stage is obtained as the difference of the converted energy and of the losses. (All amounts of loss in the accompanying table are expressed in B.t.u.)

Stage.	1	2	3
1.) R..........	16.2	16.2	16.2
2.) $\frac{V}{g}$..........	4.4	2.8	1.7
3.) $\eta_i h_o \frac{g_o}{g}$.......	....	1.9	1.1
4.) M..........	2.3	2.3	2.3
$L = 1 + 2 + 3 - 4$	18.3	18.6	16.7
Converted energy..	52.2	49.9	49.9
Utilized energy....	33.9	31.3	33.2

From this table the total amount of utilized energy is obtained as

$$H_e = 33.9 + 31.2 + 33.2 = 98.3$$

Therefore the internal efficiency of the Rateau stages:

$$\eta = \frac{98.3}{146} = 67.4 \text{ per cent.}$$

With the assumptions upon which we have based this calculation the thermal efficiency of the Curtis wheel is 64.4 per cent. and that of the Rateau wheels 67.4 per cent. As far as heat economy is concerned the Rateau wheels for the size of turbine in question appear therefore superior.

Additional Losses

To the above losses as determined by calculation is to be added a comparatively small amount of such losses, the heat of which does not reënter the steam but is carried off through conduction and radiation one way or another. These losses are: (*a*) the external mechanical losses through friction of bearings and stuffing boxes, as well as by the work which is consumed for operating governor and oil pumps; (*b*) the steam losses through the high-pressure stuffing box and other leakages; (*c*) the losses through radiation of the casing.

We note that the sum of these additional losses amounts for the size of turbines considered to some 10 per cent. of the total losses, which is about 3 per cent. of the total capacity of the turbine. Concerning loss *a*, both systems are on a par. As to the losses *b* and *c*, the Curtis system is somewhat superior, because it employs lower pressures and temperatures in the casing. Thus in consideration of these losses the comparison comes out somewhat more favorable for the Curtis wheel, more favorable at least than the above numeric result would imply. Yet, in view of the comparatively small amount of additional losses, the Rateau wheel after all appears undoubtedly superior.

Influence of Size of Turbine

So far we have only dealt with the high-pressure part of a turbine of 1000 kilowatts capacity. Considering equation 11 for the losses

$$L = (1 - \eta_i)\, h_o + \frac{g_i}{g}\, \eta_i\, h_o + \frac{\gamma}{g} - M$$

we find the amount

$$l = \frac{g_i}{g}\, \eta_i\, h_o$$

which occurs only with Rateau wheels, grows smaller with increasing steam weight g and therefore with increasing output of the turbine, provided that all the dimensions remain the same and only the cross-section of steam flow is enlarged. That is to say, with increasing output the efficiency of the Rateau wheels increases and therefore the superiority of the Rateau over the Curtis type. On the other hand, with decreasing capacity of turbines the influence of the leakage losses of Rateau wheels will be more pronounced and the Curtis wheel appears more advantageous.

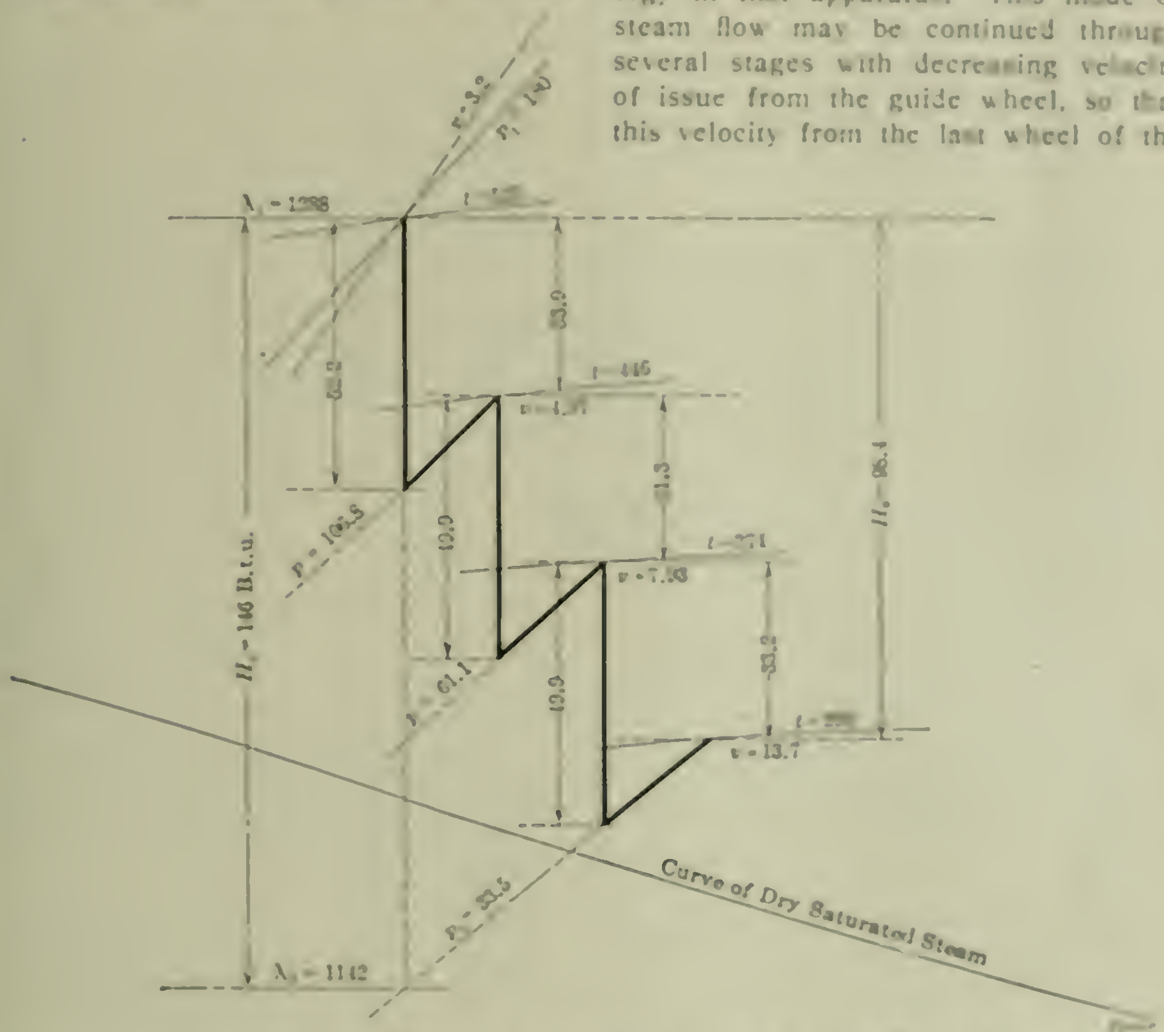


FIG. 17. MOLLIER DIAGRAM OF THE RATEAU WHEELS

COMBINATION OF CURTIS AND RATEAU PRINCIPLES

Some designers, who apply the constructive principles of Rateau and Zoelly according to Fig. 14, have adopted the Curtis principle as far as the flow of steam is concerned. They use the following mode of design: In order to expand down to lower pressure immediately with a view to keeping the windage of the first wheel and the losses through the high-pressure stuffing box as low as possible they provide in the first stage a high steam velocity by using conically diverging nozzles. In this case the velocity of issue from the first revolving wheel is still considerable and must be utilized in the following guiding apparatus to the highest possible extent. But in contradistinction to the pure Curtis principle a certain amount of heat is at the same time converted in the second guiding apparatus.

One expects from this conversion in the second guiding apparatus a better avoiding of losses by whirling than is possible without transformation of energy in that apparatus. This mode of steam flow may be continued through several stages with decreasing velocity of issue from the guide wheel, so that this velocity from the last wheel of the group is very low. Thus the ultimate loss of energy of issue is kept comparatively small.

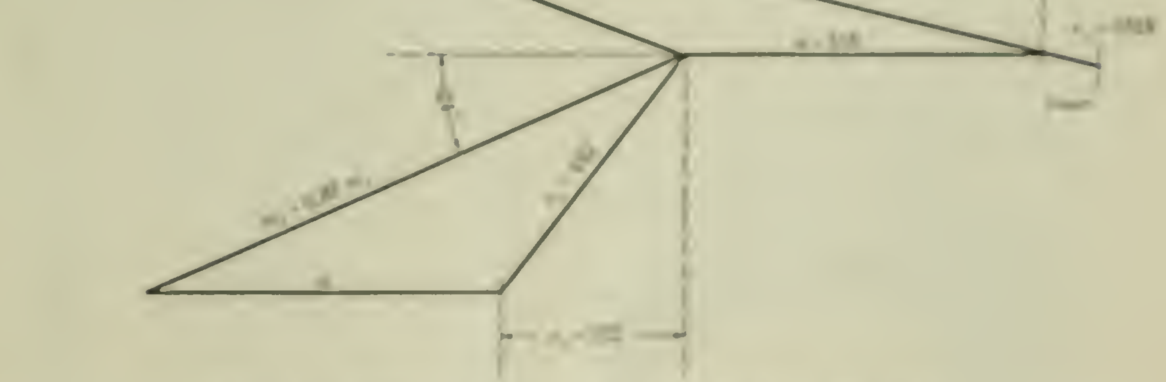


FIG. 18. VELOCITY DIAGRAM OF THE RATEAU WHEELS

This system affords a combination of velocity and pressure stages which, however, in our notion does not offer tangible advantages. It possesses the constructive features of the Rateau type, having the disadvantage of higher weight and higher initial cost of building, while as an advantage is claimed a good economy. But the latter can only be attained with very careful design of the guiding apparatus and equipment with limit blades or, what we call "profiled blades," which, of course, augments the first cost against the pure Rateau type, provided that both have the same number of stages.

RESUME

Summing up the results of our investigation we may say: At the present state of the art of steam-turbine building it appears unreasonable to point to any one system of steam turbine as the one best fitted for all sizes and conditions. There are questions of size, first cost, fuel economy and operation which should determine the selection of the system. Generally speaking, one may say that the Curtis system is superior for the smaller sizes of stationary turbines, as regards heat economy and first cost, while for the larger sizes the Rateau system, certainly in the low-pressure part, is superior in heat economy. Yet even in the larger sizes the somewhat cheaper cost of construction, lower weight and smaller floor space may swing the decision in favor of the Curtis type. In the case which we have considered above, high-pressure part of a turbine of 100 kilowatts capacity, the Rateau system apparently is more advantageous as far as heat economy is concerned. All points considered, the arrangement: Curtis wheel in the high-pressure part, utilizing about one-third of the available energy, Rateau wheels in the low-pressure part, utilizing about two-thirds of the available energy, which is now being adopted by the overwhelming majority of German builders of impulse turbines as standard construction for a wide range of outputs, appears justified for stationary practice whenever conditions demand high economy at competitive prices.

Device for Preventing Smoke

By W. H. Odell

Some of the excess air in the flue gases is drawn from the breeching by means of a jet of superheated steam and directed into the combustion chamber. This hot blast aids in the combustion of the particles which would otherwise escape up the stack unburned.

Much has been written and many devices used in the hope of finding some practical method of burning bituminous coal in steam boilers without producing an undue amount of smoke, but, because of the numerous failures, the problem is looked upon by many mill and factory owners as a joke. There are many arrangements of furnaces on the market at present that accomplish the desired result if properly handled, but the great drawback is their excessive first cost and lack of durability. However, there is a method by which at small first cost any mechanic can equip a horizontal tubular boiler having a flush front in such a manner that with proper care the results will equal if not surpass the expensive outfits installed in many large plants.

The immediate cause that led to the construction of this device was the fact that some years ago a large manufacturing company had been induced to buy a cargo of 500 tons of Nova Scotia coal, and if there is anything that can beat it as a smoke producer, I have yet to learn what it is. I was called upon to devise a means for overcoming the difficulty and accordingly installed practically the same device as here shown, except that there was no coil in the breeching to superheat the steam, and cold air was taken in from the fire-room floor and fed in through the jets, whereas in the system herein described the air is drawn in from the breeching at a temperature which averages about 600 degrees Fahrenheit and there is always enough oxygen in the uptake to support combustion. This has been proved repeatedly in some of my later installations by closing the ashpit doors, and opening only the fire doors when feeding the furnace.

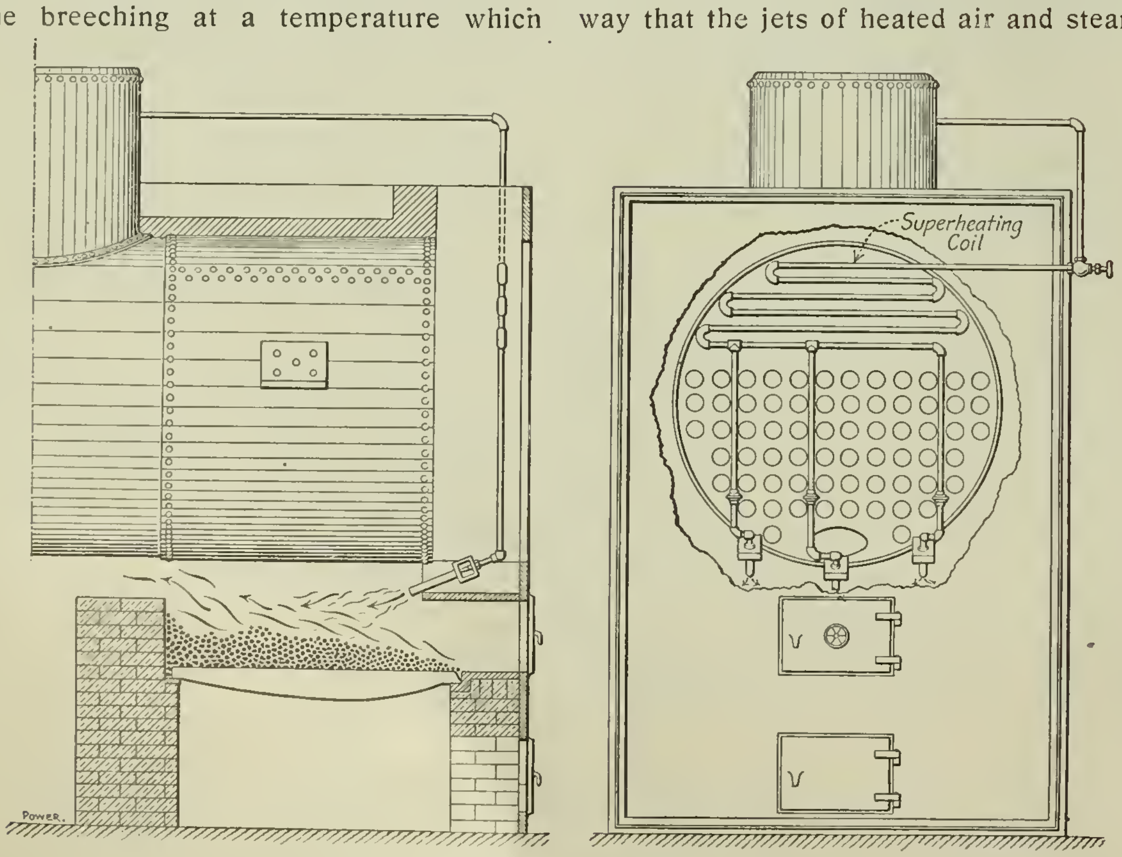


Fig. 1. Coil in Place

Some years ago an inventor made the claim, and apparently proved that there were two currents of air in a smokestack, the heated air or gases ascending the center of the stack while a thin film of cooler aid descended at the outer edge of the stack, and my experience with the ashpit doors closed seemed to confirm this theory.

I have never tried this device for economy with bituminous coal, but have tried it with anthracite coal and found a gain of about 6 per cent. when supplying the furnace with the heated air. The steam consumed by the device is about 1 per cent. of the total steam generated by the boiler.

As shown by Fig. 1, three small cast-iron boxes open at two sides are placed in the bottom of the uptake and are connected to the superheating coil in such a way that the jets of heated air and steam can readily be directed at any desired angle, although the best practice seems to be to direct them at an angle to meet the junction of the grate bars with the bridgewall. An enlarged view of the steam jet is shown in Fig. 2 in order that its construction may be more readily understood. These jets are of cast brass about four inches long with a ½-inch pipe thread cut on the outside, well down so that adjustments can be made if desired and then fixed by means of a locknut. The connection to the steam jet is made with a ½-inch tee in one end of which is a plug; this is to permit the insertion of a wire for removing any obstruction that might get into the jet.

This device was patented during 1880 but as the life of the patent ran out many years ago there is nothing to prevent anyone from using it. I did not make any serious effort to put this device on the market because of the fact that about the time it was perfected I became engaged in other work which was more pressing; but as an object lesson to some young engineers it may be of interest to relate some of my experiences with it, as they show what many inventors have to contend with.

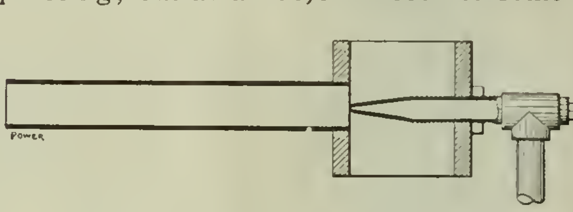


Fig. 2. Section through Jet

At the plant for which this device was gotten up there were six horizontal-tubular boilers, and as the service required only five of the boilers, it was arranged that I should have the spare boiler upon which to experiment. I took the precaution to insert a piece of 2-inch pipe through the back wall of the boiler setting about 6 inches below the bottom of the shell and as the outer end of this pipe was covered with glass we had a convenient peep hole without admitting any air.

When all was ready the five boilers were fired with anthracite coal, leaving the spare boiler to be fired with bituminous coal. Previous to cutting in with the hot blast at every firing a volume of dense black smoke would issue from the top of the stack and would continue for several minutes.

When one of the partners of the firm reached the factory about 9 o'clock, he immediately came to the fire room and began to upbraid me, saying he had been watching the top of the stack all morning and there was as much smoke as when all the boilers were fired with soft coal. I replied that my device had not been tried as yet and that I wanted him present when it was turned on for the first time. Then I asked him to take his station at the peep hole; a heavy charge of coal was put on the grates, the fire door was closed and nothing could be seen through the peep hole except an occasional tongue of flame showing dimly through the smoke. However, the instant the hot blast was turned on the effect was as if a gas jet had been lighted in a dark room.

In about a minute the blast was shut off and the smoke appeared again at the top of the stack, apparently as dense as ever. We made this change from dense smoke to no smoke at all, four times before this first charge of coal was of no further use to us.

Leaving the device for a few days that it might be tried out to the full satisfaction of the factory owners as well as any of their interested employees, I finally called on them for the $75 which had been promised if the device were a success, also to learn when it would be convenient to have their other five boilers fitted in a similar manner; but this time I met with the other partner, who, in this case, was also the purchasing agent, and who assured me that their engineer had told them he could fit the remaining boilers up for about $35 each. I admitted that this was approximately the cost of the material used and as they would not have to pay anything extra for the engineer's services it could probably be done at the figure named, but reminded him of our agreement. He replied that he did not care about the agreement, and as I had not made any move toward patenting my invention at that time I could do nothing but order my helpers to take the device out.

My second experience at smoke prevention was while representing a boiler manufacturer at the cotton exposition at Atlanta, Ga. I there met a couple of young fellows who owned a small cotton mill at Selma. They had heard of this device and wanted me to install it on their two boilers as they were greatly annoyed by heat and smoke. My engagements at the exposition prevented, but in order to help them out I made drawings, told them to go ahead and install it themselves and if after three months' trial it proved satisfactory they could send me their check for $25. I did not hear from them until several months later when I received a letter saying my device made such a hot fire that it had burned their boilers and they wanted me to pay the bill.

Notwithstanding these experiences, this simple device which any ordinary workman can install in a few hours is one of the most efficient yet produced, and much of its efficiency depends upon the use of the heated air.

Notes on Riveting Boiler Plates

By H. S. Jeffery

Suggestions as to the proper clearance between the rivet and the hole, and the means used to upset the rivet so as to fill the hole. Methods of forming the rivet head and of obtaining a tight joint.

The first consideration in driving rivets is the pitch for a given size of rivet and a given thickness of plate. Rivet holes should be spaced close enough to permit of good calking of the seam; at the same time, they should be spaced far enough apart to give the strongest joint obtainable for a given thickness of plate. In a triple-riveted double-strapped butt joint, the outer row of rivets has a wide pitch, and in order to insure efficient calking, the outside butt strap should be heavy enough to withstand the calking without springing between the rivets.

Most boiler rules stipulate that the thickness of the butt straps shall not be less than five-eighths of the thickness of the shell plate, but with boilers having shell plates from ¼ to ½ inch, the better practice is to make the butt straps the same thickness as the shell sheet. The chief difficulty with the light butt strap is that it will spring between the rivets under the necessary calking, forming small water chambers between the sheet and the butt strap, and tending to loosen the sheet around the rivets.

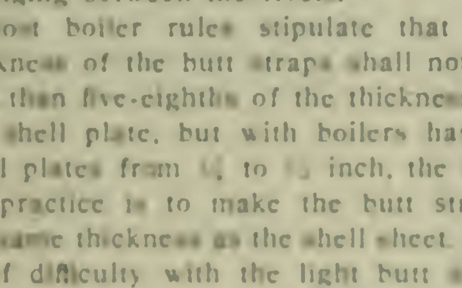


Fig. 1. Incorrect Way of Forming Rivet Head

It is almost universal practice to make the rivet holes 1/16 inch larger than the diameter of the rivet, the adoption of this clearance being traced back to the early days when only iron shell plates and rivets were used. With modern progress, however, the diameters of rivets are more uniform, and this, coupled with the fact that rivet holes are now drilled or reamed, permits less clearance, and some modern shops are now allowing only 1/32-inch clearance.

With hand-driven rivets, the rivets are upset from one end only, and if the clearance between the rivet and the hole is large and the rivet passes through several thicknesses of plate, the rivet will not be upset its entire length so as to fill the hole completely. This, together with the scale which every rivet has to a greater or lesser degree, causes rivets to leak under the breathing of the boiler. The main consideration in order to have steam-tight rivets is to fill the rivet holes. The rivets should be hit heavy blows for the purpose of upsetting them their entire length, if possible. Knocking the rivets with light hammers results in upsetting the rivet only a short distance, as that part of the rivet which should be driven into the hole is just formed there by the use of light hammers, and, therefore, becomes a part of the rivet head, which becomes larger than intended. Some boilermakers, when the rivets are too short for the upset and the head, upset the rivets so as to have sufficient metal for the rivet head, regardless of how the hole is filled.

Snap riveting, in which the rivet head is formed with a cup-shaped rivet set by striking the set several blows from steel mauls, is usually finished by knocking the rivet down with the same mauls as used for striking the rivet set. With this kind of riveting the rivet usually projects beyond the hole considerably more than with hand riveting, and the heavy blows delivered by the mauls upset the rivet a greater length. The set should be held erect during the formation of the rivet head, and to tuck in the edges it should also be held erect, holding the center of the set to one side of the center of the rivet and working around the

Fig. 2. Correct Position of Holding-on Bar

rivet in this manner until the entire edge is chased. Rolling the set around the rivet, that is, tipping the set in an effort to trim the edges, usually results in a ring or groove being cut in the sheet around the rivet head, and this should by all means be avoided.

The same rules which govern snap

riveting also govern pneumatic riveting to a great extent. With hydraulic riveting, it is possible to upset the rivet from both ends, this being accomplished by converting a cone-headed rivet into a button-headed rivet. With hand, snap and pneumatic riveting, the newly formed rivet head is usually on the outside of the boiler, while with hydraulic riveting it is usually on the inside of the boiler. In the former cases the rivet hole is filled in the outer sheet, and in the latter it is filled in the inner sheet. But, by converting the rivet head as mentioned, the rivet hole is usually filled in both the inner and outer sheets.

Regardless of the manner of riveting, the sheets should be metal to metal, for, if apart, the rivet will upset and form a ridge between the sheets, which will keep them apart and also require the rivets to be longer than would be necessary if the plates were metal to metal.

The manner of holding the rivet when driving is equally as important as the manner of driving. The rivet head should at all times be well up against the sheet at all points. The holding-on bar should bear against the rivet so as to not shape the rivet head as shown in Fig. 1. With snap riveting there is a tendency for the rivet heads to crack, and to overcome this the usual practice is to cup the holding-on bar to suit the rivet head, but the depth of the cup is made from 1/8 to 3/32 inch less than the depth of the head so that the holding-on-bar will not come in contact with the plate; this is indicated in Fig. 2.

An Investigation of Bearing Metals

By H. B. McDermid

Actual conditions under which tests were made of seven different bearing metal mixtures of tin-lead-antimony and copper-tin-antimony alloys.

The choosing of his materials of construction, in the face of modern competition, often becomes a serious problem to the manufacturer of machinery, and is worthy of serious study.

The use of some 400 tons of babbitt metals per annum, by a company engaged in the manufacture of heavy power-plant prime movers, was deemed to be a sufficient reason to justify a thorough investigation of the physical properties of those metals. In consequence, a series of friction tests were carried on, of sufficient length to quite completely determine the running characteristics of a number of different mixtures.

The object of the work done was largely to determine whether or not the cost of making bearings could be reduced without lowering the factor of safety to a dangerous point.

The cost of materials for the different mixtures varied from about 7 to 33 cents per pound. In view of this fact, some of the results obtained were decidedly interesting. There are many places in modern machine construction where the designs can be made such as will permit of low unit pressures on bearing surfaces, so that a cheaper bearing metal can be safely introduced.

Cheaper Construction

In many instances, pressures now used will permit of less costly construction, especially as, in some instances, the higher-priced metals do not show as high-grade performance as some mixtures whose costs do not exceed 40 per cent. of their more costly competitors. This is markedly true of bearings running under good lubricating conditions, with the pressure constant and always in one direction, as in many forms of motor bearings, generators, steam turbines, etc.

An example of this is a 6500-kilowatt dynamo running in two bearings 14x48 inches each, where the unit pressure due to dead load is but 70 pounds per square inch, and where, being direct connected to an hydraulic turbine, the pressure is always steady and in one direction. This machine was furnished with a supposedly high-grade babbitt at a cost of some 25 cents per pound, when test results proved an 8-cent mixture to be superior in every case under those conditions, and showed it to be fully capable of carrying the load at all times, even when the magnetic pull due to an unbalanced air gap was taken into consideration.

Conditions of Tests

The tests were run, for the most part, upon a homemade machine, so arranged

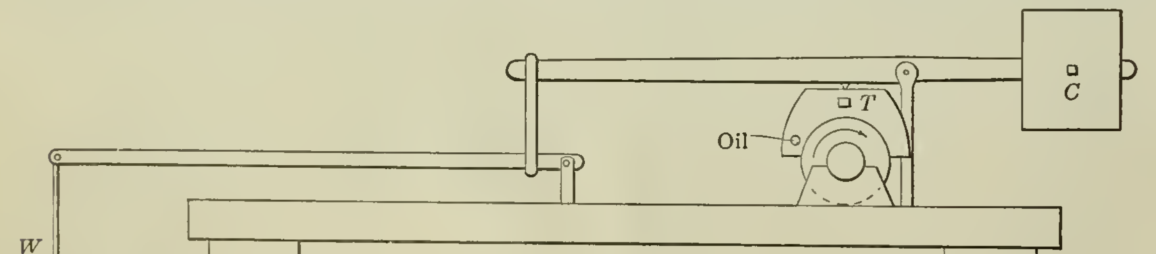


Fig. 1. The Testing Machine for Bearings

that any desirable load could be placed upon the test piece, which was made in the form of an upper half box, covering a full half of a 7-inch journal. The journal was carried in side bearings of ample area to insure their safely carrying all loads imposed upon them. The surface speed at the test piece was 480 feet per minute and at the side bearings 220 feet per minute.

No appliance was provided for the direct measurement of the friction developed, so that the rise in temperature was taken as the only indication of the friction of the rubbing surfaces, and with cool running side bearings so that no outside error could creep in to any extent. This method was found to be amply accurate and satisfactory for the comparative tests desired.

The Test Machine and Bearings

The general arrangement of the machine is shown in Fig. 1, where C is an adjustable counterweight used to balance the system of levers shown, and W is a weight pan used for loading the test piece T. The ratio of the force exerted at W to that at T was 1 to 70. It was thus comparatively easy to get relatively high unit pressures on the test piece, which measured 7 inches in diameter and 2 inches long.

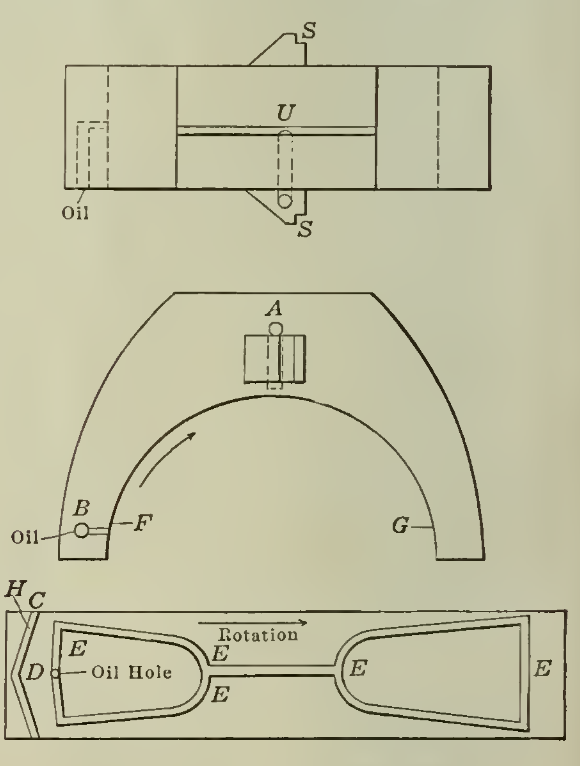


Fig. 2. The Test Bearing

A side elevation and plan, and a developed plan of the test bearings is shown in Fig. 2. Here A indicates a thermometer well, drilled diagonally down through the stop piece S which is on each side. During actual work, this stop piece rests against the frame of the machine in such a manner as to prevent rotation about the shaft. To render the sketch clearer, this portion of the frame is not shown in Fig. 1. The thermometer well was drilled so the bulb of the instrument would rest at a point ½ inch above the bearing surface of the babbitt and in the middle of the test piece, as measured along the axis of the shaft. B is the place for introducing the lubricating oil, which was fed from a drop-feed oil cup during the final tests.

In the developed plan, a system of air and oil grooves is shown. These were the same for each specimen, and were cut so as to finish 3/16 inch half round in section. The air groove was found necessary in order to carry off air that was drawn in by the rapidly rotating shaft, which otherwise was forced out at B in quantities great enough to render uncertain if not absolutely destroy the lubricating of the piece. In order to have it in proper working condition the edges of this groove must tightly fit the journal at the inside edge D and be loose and free at the outer edge H. The mixture of air and oil that adheres to the shaft is then scraped off by edge D and deflected to the sides of the piece, thereby insuring undisturbed lubrication of the rubbing parts. To insure thorough spreading of the entering oil, the oil channels are well relieved at the sides E.

Precautions Taken

Every precaution possible was taken to insure uniform working conditions for each test piece, so that the test might be dependably accurate, at least for comparative results. It was ascertained that after minute and careful inspection two test pieces might appear exactly alike, might be of the same material, have apparently identical smoothness of glazed surface, be treated as closely alike as possible, and yet run widely different final tests.

To this end, then, the babbitt was carefully melted, in clean ladles, so no dross nor undue burning or overheating might form gritty or abrasive spots or surfaces that might cause friction and heating; the metal was carefully anchored in the shells so that it might always have solid, positive, uniform backing to transmit the heavy pressures of the system of loading levers with no springing, breaking, or pinching; it was closely bored to fit the journal, and machined to exact dimensions; and the journal was ground straight and cylindrical, so that for each piece tested, the conditions were made as nearly uniform as good mechanical skill could make them.

The test piece was fitted to the machine by placing it upon the journal and fitting the stops SS, until both bore equally upon their stops on the frame of the machine within the limit of 1/1000 of an inch, thus eliminating the possibility of any sort of side twist being introduced. The casting at U was so beveled that the load perforce had to bear vertically downward and thus eliminate all pressures not in a vertical plane passing through the center of the bearing, normal to the axis of the test journal.

By these means it was believed that reasonable accuracy in conditions had been obtained and correspondingly dependable results were secured.

Preparing the Bearings

The bearing was next "spotted in" upon the slowly revolving shaft and scraped to as close a fit as possible, the oil and air grooves were then cut and finished and the journal placed in an oil bath and run at full speed. The bearing was placed under very light loads at first and this gradually increased, as the thermometer record showed it could stand it, until the bearing possessed a perfect glazed contact with the journal from F to G, and would run at a cool uniform temperature under heavy loads.

This latter point was very important as two bearings may apparently have an equally good fit and glaze, and yet even though of the same material, one will easily stand up under a load that would shortly ruin the other, due to minute differences which even the closest inspection must fail to detect, and which cannot be detected except by a running test under identical conditions.

This preliminary "running in" occupied from ten to thirty hours, according to the material tested and to the care with which the preliminary and subsequent fitting had been done. During this preparatory stage the temperature was never allowed to rise above 220 degrees Fahrenheit, so the oil would not carbonize upon the rubbing surfaces under any conditions and so permanently injure them.

TABLE 1. CHEMICAL ANALYSES OF ALL MIXTURES

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I	[illegible]	15	[illegible]	[illegible]	[illegible]
I	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I	[illegible]	[illegible]		[illegible]	
T	[illegible]	[illegible]	[illegible]	[illegible]	
T	[illegible]	[illegible]		[illegible]	

The run was kept up as continuously as convenient with each specimen until it would stand from 900 to 1000 pounds per square inch under oil bath conditions and still run fairly cool. The machine was then allowed to cool down over night to practically the temperature of the room, and without anything occurring that could disturb the accuracy or perfection of the fit of the rubbing surfaces of either the journal or test piece, the final test was begun.

Final Tests

The following rules were closely adhered to in conducting the final tests after the specimens were fully prepared:

1. All tests to be started with the whole machine and testing system practically at the temperature of the room.

2. The oil to be a standard high-grade engine oil with a sufficient supply on hand to permit of the whole series of tests being run with the same lubricant.

3. A standard sero oil cup to be used and the oil fed upon the bearing at 45 drops per minute; the rate of feed being checked every ten minutes.

4. Each bearing to be loaded at the start with a pressure of 200 pounds per square inch. Readings of time and bearing temperatures to be taken every five

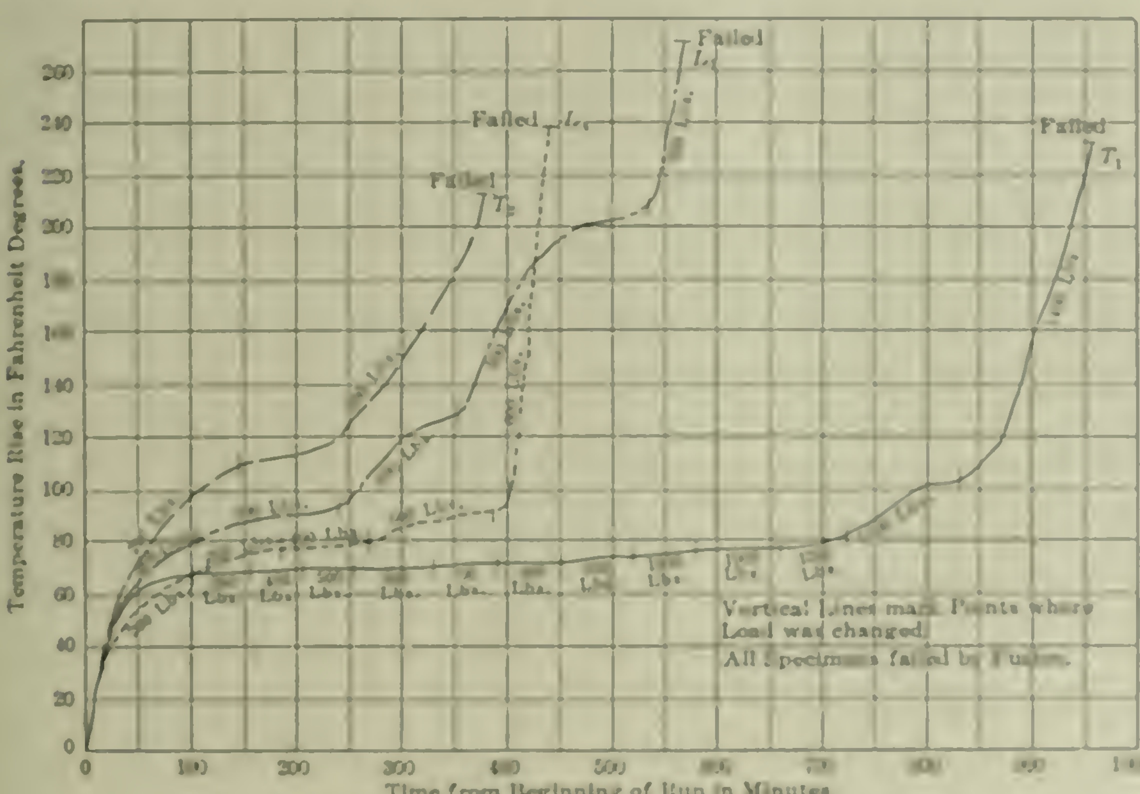


Fig. 3. Average Test of the Four Highest Mixtures

minutes, until the temperature of the bearing became constant within two degrees Fahrenheit for three-quarters of an hour. The load then to be increased to 300 pounds per square inch with temperature readings taken as before. The load then to be increased to 400 pounds, and so on until failure occurred by fusion of the mixture under test.

5. All tests must be judged by the same thermometers. The thermometer well must be filled with oil at starting so the heat from the bearing will be readily and accurately transmitted to the bulb of the instrument.

6. Care must be taken to have all parts of the machine in proper adjustment and kept so. All other conditions must be kept as nearly standard as possible, so the working will be thoroughly reliable as a comparative test.

Duplicate Tests

After the test had been run to the finish by "failure," a process that necessarily had to be completed without interruption of any kind, and which lasted from 3 to 15 hours with varying grades of metals, the machine was dismantled, and the journal taken out and reground until it was again perfectly true, straight and cylindrical. A second bearing was then put through its preliminary preparation and its final test run under the same conditions as the first had been, as nearly as care and skill could reproduce them.

Each mixture, as it was physically tested, was also chemically analyzed so that the effect of the various ingredients could be noted and recorded. Its price was also taken into account, so that a comparison of worth per dollar of cost could be made. In every case several duplicate tests were run in order that checks on each of the earlier tests could be had, with each mixture and in every case, and the average of several tests is used in compiling the accompanying data:

Four mixtures containing high percentages of lead were used, and three containing high tin percentages. Table 1 gives the chemical analysis of all the mixtures used. The capitals *L* and *T* indicate the major portion of each alloy, as being either lead or tin.

Details of Tests

The chart, Fig. 3, of the final test performance is plotted with time as abscissas and differences between room and bearing temperatures as ordinates. The first section represents the record under 200 pounds load, the second that of 300 pounds load, etc.; the point where the load was changed being indicated by a short vertical line. The sudden vertical break in the last section indicates the point where lubrication failed and the oil grooves smeared over, resulting in the complete and rapid destruction of the piece under test. To avoid confusion and undue crowding only the four most representative records are plotted.

Table 2 summarizes the increases in temperature for each load, the duration of run under each load and gives an approximate price per pound of each mixture.

The behavior of these bearings under the preliminary tests as well as in the final tests was very interesting. For instance, the high-lead mixtures, which, of course, would not stand peening into the shell, gave considerable trouble at first in obtaining a good support or backing for the bearing metal to the shell. This was because of their high shrinkage coefficient. The high tin alloys which do not shrink so much, in case of the anchors not being sufficient, could be peened solidly into the shell, and so eliminate troubles of this sort.

The high-lead bearings being the softer, were brought to a good running fit easier, but they would not recover when neglected or abused, with anywhere near the facility of the high tin mixtures.

The Mixture to Choose

Those mixtures showing a high content of antimony, as *L*3, were naturally hard and took a considerable length of time to come to their running fit. They were, therefore, somewhat less desirable than the softer materials, since any of the mixtures, well lubricated, will wear well enough for ordinary machine work, and the important quality of a babbitt mixture is its ability to adapt itself quickly to a deformed or roughened journal without undue heating or cutting.

The tenacity of the tin and copper in mixture T_1, combined with the ductility, render it easily the best of the group, but the high-lead mixture *L*4 seems the best of the combinations here listed, for ordinary work.

The high cost of mixture T_1 puts it entirely out of the question, except where special service requiring high quality to stand rough hard usage is demanded, or where the type of service makes uninterrupted running so important as to overshadow the item of first cost. In all other cases, of ordinary service, the tests show such an alloy as *L*4 to be very satisfactory, especially where, under reasonable conditions, a bearing may be expected to have good ordinary care, and a steady load in one direction, without violent and sudden reversals of pressures.

Even under such conditions, some practical master mechanics of long and varied experience in heavy rolling-mill work, have assured me that they would just as soon have a mixture like *L*4 placed in the bearings of a number of 3000-kilowatt gas-engine units, then under discussion, as to use the mixture sim-

TABLE 2. AVERAGE TESTS OF ALL THE DIFFERENT MIXTURES.

Name.	Cost per lb. in Cents.	200 lb.		300 lb.		400 lb.		500 lb.		600 lb.		700 lb.		800 lb.		900 lb.		1000 lb.		1100 lb.		1200 lb.		1300 lb.		1400 lb.		1500 lb.	
		Time Min.	Temp. Rise. ° F.	Time Min.	Temp. Rise. ° F.	Time Min.	Temp. Rise. ° F.	Time Min.	Temp. Rise. ° F.	Time Min.	Temp. Rise. ° F.	Time Min.	Temp. Rise. ° F.	Time Min.	Temp. Rise. ° F.	Time Min.	Temp. Rise. ° F.	Time Min.	Temp. Rise. ° F.	Time Min.	Temp. Rise. ° F.	Time Min	Temp. Rise. ° F.	Time Min.	Temp. Rise. ° F.	Time Min.	Temp. Rise. ° F.	Time Min.	Temp. Rise. ° F.
L_1	9.7	105	81	135	11	115	37	180	73	30	62	Failed at 600 lb. Total Temp. Rise 273°																	
L_2	7.4	100	79	75	5	155	9	160	130	Failed at 500 lb. Total Temp. Rise 223°																			
L_3	7.6	90	64	105	12	95	8	120	14	40	152	Failed at 600 lb. Total Temp. Rise 250°																	
L_4	7.3	115	69	70	8	85	3	115	11	55	145	Failed at 600 lb. Total Temp. Rise 236°																	
T_1*	32.5	100	67	55	3	50	0	50	0	75	0	60	2	60	0	70	2	60	2	80	1	65	5	105	20	125	129		
T_2	24.7	145	109	235	102	Failed at 300 lb. Total Temp. Rise 211°																							
T_3	32	170	106	90	12	105	10	70	3	80	6	50	5	50	1	45	3	25	90	Failed at 1000 lb. Total Temp. Rise 237°									

*Failed at 1400 lb. Total Temp. Rise 231°.

ilar to *T2*, which was furnished. They also assured me they had cured obstinate cases of hot bearings, where several varieties of tin mixtures had failed, by replacing them with a high-lead mixture. This ran very cooly from its first start and thereafter gave no further trouble.

SUMMARY

It is not my purpose to enter into any long or intricate discussion of the problems of bearing design, but in these days when forced and ample, even excessive, lubrication is daily becoming more popular, it would seem as if the conditions such as were used in the test could be closely approximated in most cases and thus the cheaper bearing be safely introduced.

If the experience of master mechanics of some of the largest steel plants is such as to find the high-lead bearing acceptable for the rough usage of heavy rolling-mill and the heaviest gas-engine practice known, it would seem at least worthy of a fair trial.

It is my own experience that a mixture similar to *T2* has stood the test for years of generator service at from 60 to 90 pounds dead-load unit pressures, with the possibility of a magnetic pull, due to an unbalanced air gap, doubling that pressure. It is also used with success in engine main bearings where the pressures withstood vary from 200 to 250 pounds per square inch and in crank-pin boxes where the momentary pressures at the point of admission of steam to the cylinder reach a maximum of 1400 pounds per square inch.

If a mixture of as poor a test record as recorded above, has so good a record in years of actual service under widely varying conditions, should not a mixture of a highly superior test record, with an initial cost of less than one-third of that of its rival, be given at least a fair opportunity to make a record by which it must stand or fall? It would seem so, and I will venture to predict that such will quite generally be the case in the near future and that under the policy of ample lubrication now gaining ground daily in power-plant service, the results will amply justify the experiment.

Compression in Steam Engines

By Armand Duchesne

The principal loss in the reciprocating steam engine is that due to the exchange of heat between the metal and the steam. In the ordinary case over 20 per cent. of the steam admitted is condensed to warm up the containing surfaces, and a large part of it is not reëvaporated until after the exhaust valve opens. Georges Duchesne did some original and notable work at Liége in measuring the variation of temperature of the cylinder surface and the author, his brother, tells of his own continuation of that work.

It has been demonstrated by the laboratory of applied mechanics of the University of Liège that the law of compression of steam in the engine is not the same as that of expansion, and it is not necessary, it appears to us, to search further for the loss of economy, due to the compression of the steam in the clearance spaces, discovered experimentally by Professor Dwelshauvers-Dery.*

There has been a collection of facts which have been brought to light at the laboratory of Liège, where I have the honor to labor under the orders of the learned professor, and in collaboration with my lamented brother, Georges Duchesne, which do not permit of any doubt upon this subject.

The genius of Hirn had led him to foresee a thing which we find at present very simple and very natural. He imagined that the temperature of the metal of the cylinder varied between limits much more narrow than those of the temperature of the working vapor, and the conclusion which he immediately deduced was that the vapor was dry at the end of the exhaust, since the hot metal had had the time to reëvaporate the film of water which had been deposited upon it. This probably appeared too simple and was not generally admitted, when Georges Duchesne gave a striking demonstration of the fact that it could not be otherwise, in such a way that only those who wished to remain ignorant of these proofs of the laws of physics who did not acquiesce in them.

Georges Duchesne had already determined the temperature of the metal during the exhaust of the steam,† and the comprehension of the phenomena depended only upon a knowledge of the properties of the saturated vapor of water. What would happen to several drops of water at the temperature of 110 degrees if they were placed suddenly under the receiver of an air pump where there existed a vacuum of one-tenth of an atmosphere? This is just what happens in the case of an engine operating condensing.

The hypothesis of Hirn was, therefore, demonstrated. The steam is dry at the end of the exhaust, and Georges Duchesne proved that it was even a little superheated.

An experimental verification of this fact would be of great interest, and we have been occupied for several years in obtaining it. The problem which we set for ourselves was to trace the diagrams of the temperature of the steam and of the metal for the two strokes of the piston forming a complete revolution. Our method has been already discussed,‡ but it has been modified, and we will describe it such as it is at present.

We needed evidently a thermometer which had no heat capacity, in order that there might be no lag, and we chose a thermo-electrical pyrometer, furnished with a platinum-silver couple, of which the elements had a diameter of 0.02 of a millimeter. This thermometer had a large number of junctures, which gave us consequently the mean temperature of all the steam in the cylinder. As to the walls, we used a pyrometer, made of two plates, one of silver and the other of platinum, of 0.002 millimeter thickness, applied to the walls of the clearance space in such a way that the junctures remained entirely free. In this way we are in command of two systems, one taking immediately the temperature of the steam, and the other the temperature of the walls. How could we register at each instant the temperature of the steam and the temperature of the metal?

By delivering the current of the pyrometer into a ballistic galvanometer during a determined time, one-tenth of a second for example, we have a deviation which, according to an established calibration, will furnish us the average temperature during this one-tenth of a second. This condition is realized by the fall of a weight, suspended by an electromagnet, the height of that fall being calculated to continue for the required time. This corresponds with a speed of 30 revolutions per minute to one-twentieth of a revolution of the engine. It is necessary, there-

*Revue de Mécanique, 1907, pp. 925 and 1260; Power, June 28, 1910.

†Revue de Mécanique, July, 1909.

‡Revue de Mécanique, Dec. 1909.

fore, only to bring about the fall of this weight at the commencement of each one-twentieth of a revolution to arrive at the average temperature during the successive twentieth.

In order to realize this we have divided the two strokes of the piston into subdivisions, which correspond to the twentieth of a revolution (Fig. 1), and an electric contact could be broken by the crosshead itself at each of the subdivisions, in such a manner that the weight during the entire time of its fall will send the current furnished by the pyrometer into the galvanometer during the twentieth of a revolution, corresponding to that division and giving, therefore, the average temperature during this twentieth. It will be seen, therefore, that we could obtain points on the curves of the temperature of the steam and of the metal for an entire revolution of the crank, and it was necessary only to make these diagrams correspond to the corresponding two strokes of the piston in taking account of the obliquity of the connecting rod.

It goes without saying that if the speed is other than 30 revolutions per minute, one can calculate what must be the hight of the fall of the weight, in

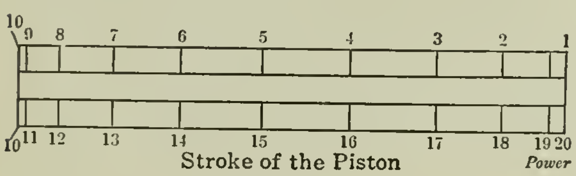


FIG. 1.

order that it shall continue through one-twentieth of the revolution of the engine. If the speed is only 15 revolutions per minute, the hight of fall of the weight should be calculated for a value of two-tenths of a second in order that it should correspond to one-twentieth of a revolution. Before undertaking specially the study of compression, we will describe an example of a test made without steam jackets, and which was made under the following conditions:

Expansion, commencement, 0.1; end, 0.95.

Compression, commencement, 0.9; end, 1.

It will be seen that the admission continued for one-tenth of a stroke of the piston, and that the compression was also one-tenth of the stroke.

The diagrams of the temperature are traced in Fig. 2, and we have added to these experimental curves those representing at each instant the temperature of saturation corresponding with the pressure shown by the indicator and the tables of saturated steam. It is seen at once that, excepting during the admission, the metal is always considerably warmer than the working fluid. The points of temperature of saturation are marked by small circles, and the diagram which unites them is traced in a dotted line. It is easy to prove that the steam is superheated well before the end of the exhaust stroke, with the result that at the commencement of the compression the degree of superheat attains 45 degrees.

During the expansion the two curves of the temperature of the steam experimentally determined and that of saturation taken from the tables correspond absolutely, and this suffices already to show us clearly that the fluid which is compressed is very different from that which operates during expansion. But we will show in that which follows the loss which is occasioned by compressing the vapor in the clearance space, when one exceeds a certain degree of compression.

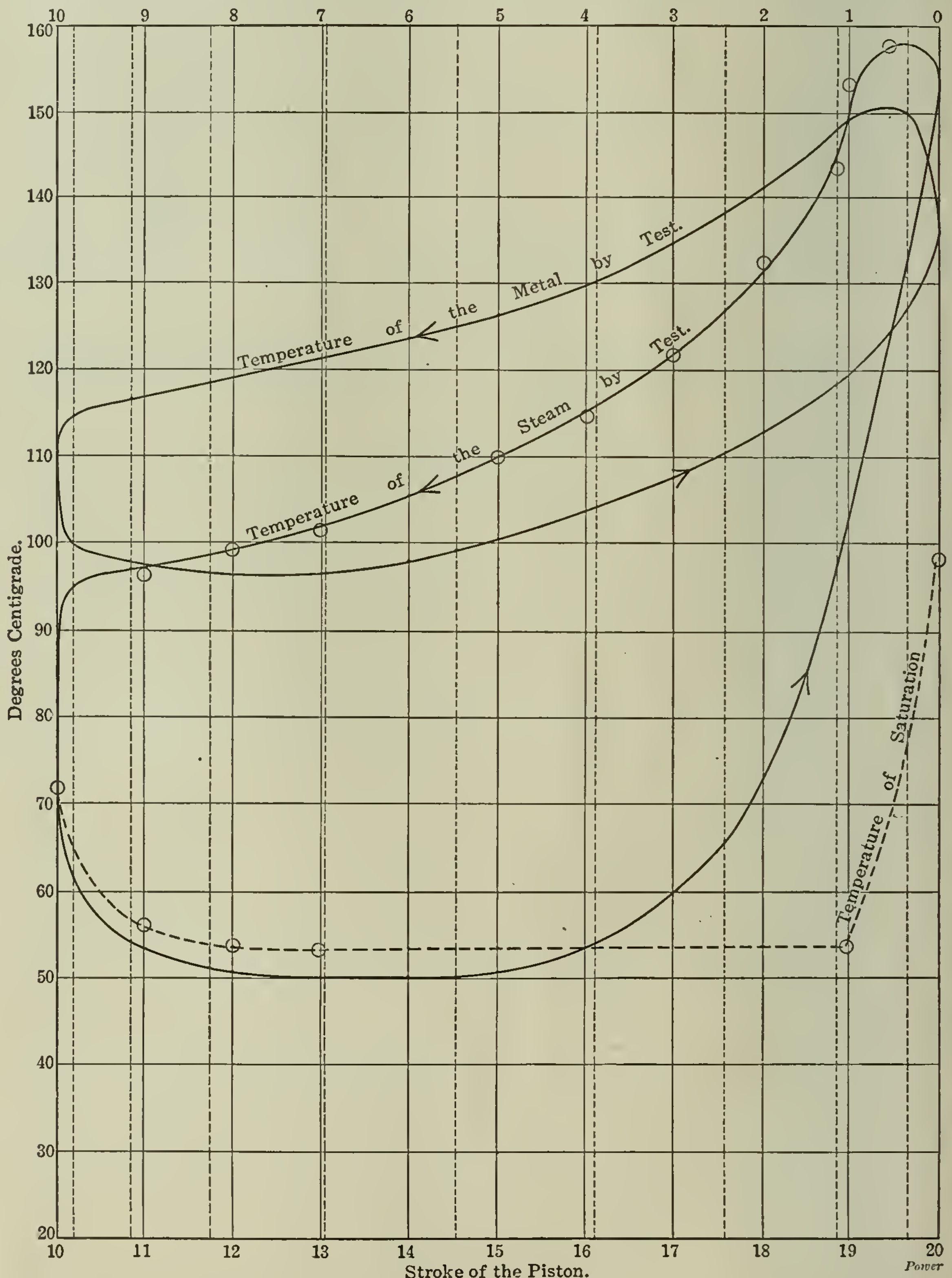


FIG. 2.

To this end we have arranged our engine to realize a high degree of compression—nine-tenths of the stroke. In order, however, to more nearly comply with ordinary conditions, this long compression diminishing the time of exhaust, we have so adjusted the engine that the cylinder would remain in communication with the condenser during the same time as if we had a compression of only three-tenths. This was necessary in order to be able to draw the conclusions which we were after, the assumption being made that during this long compression we should have thus about the same weight of steam M_c, as if the compression had been shorter.

In Figs. 3 and 4 is given only that which concerns the compression. First, in Fig. 3, the experimental temperatures of the steam and the cylinder wall, as a function of the path followed by the crank pin, and in Fig. 4 these temperatures refer to the path of the piston. There is given also in a dotted line the curve of the temperatures of saturation.

And now there exists no doubt that a perfect gas is being compressed, the temperature of the steam going up to 450 degrees, while the maximum temperature of saturation is above 140 degrees, and this demonstrates that the theorem of Zeuner cannot be applied to the case of the steam engines. We can, therefore, conclude at once that under the conditions in which we compress this steam it will require exterior work, considerably greater than that which it can produce, especially during the expansion, since at that time it operates under the form of saturated steam.

Let us try now to examine the loss of efficiency due to the compression in the case under consideration. We will suppose that the operation is adiabatic.** Let us take as the average specific heat of the superheated steam the figure 0.485, which we will suppose constant to the limit; that is to say, to the point of saturation. Leaving to one side the end of the curves, which show a sudden fall in the temperature of the steam and which will be explained later, we notice at $A A'$ that the compression has raised the temperature from 86.5 degrees to 450 degrees. Upon the assumptions which we have made this operation has required an external work equal to

$$425 \times 0.485 \; (450 - 86.5) \; M_c \, Kgm$$

This would be nothing if the equivalent heat of this work could be retained in the fluid to be utilized in the following cycle. But what happens in reality beyond the point $A A'$ is that the temperature of the fluid falls suddenly, the metal commences to cool the steam because the difference of temperature is enormous and the piston is moving very slowly; and if, under these conditions, certain portions of the metal remain cooler than the temperature of saturation, the cooling will produce condensation, and condensation means an exchange of heat extremely intense. It will be seen, therefore, that the heat which comes from the exterior work enters into the metal and will not be reimparted to the steam except in part during the expansion, but under unfavorable conditions of efficiency, since the temperature will be considerably lower than that at which the walls absorb the heat, and another part during the exhaust stroke, which is absolutely lost upon the efficiency.

Our remarks on the properties of the superheated vapor of water permit us to calculate M_c.

M_c [illegible]

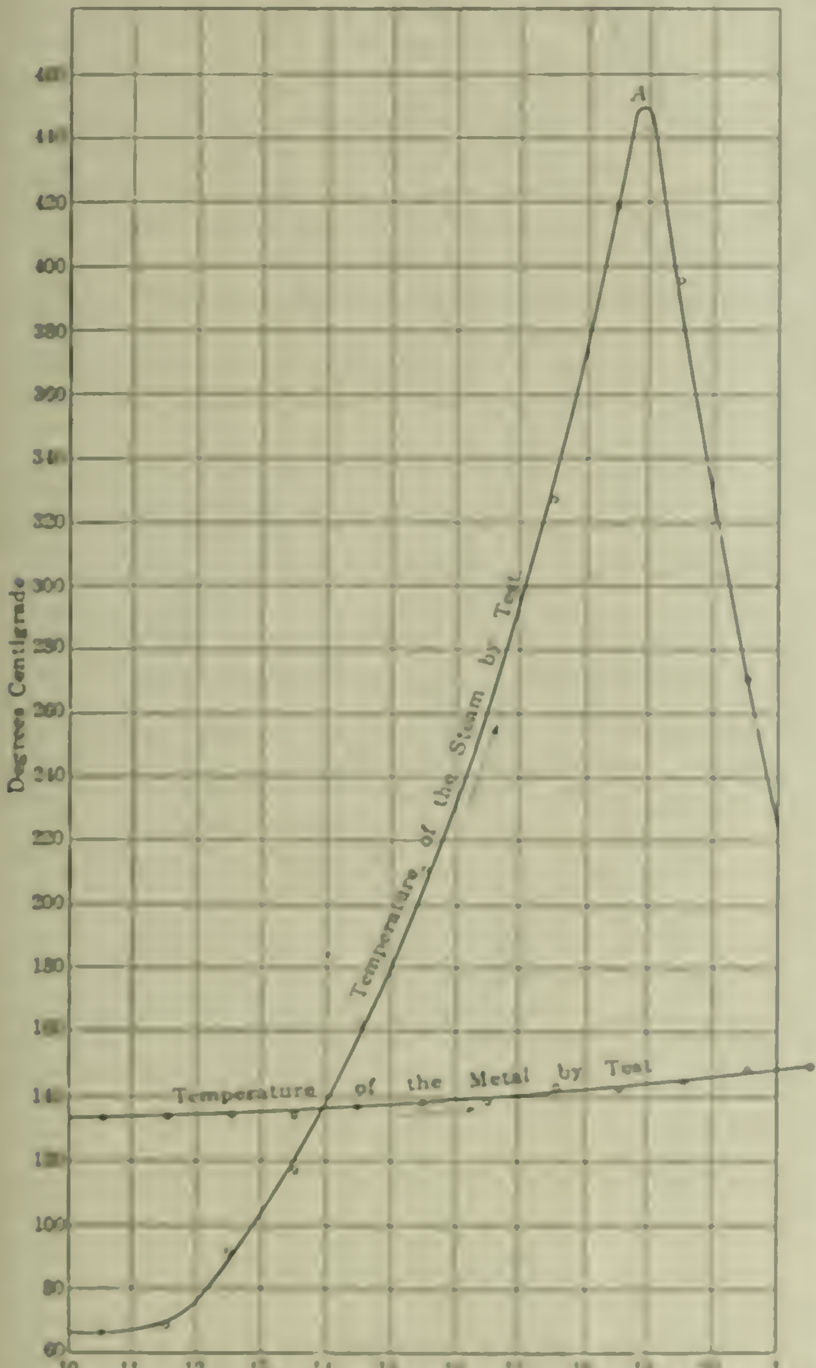


FIG. 3

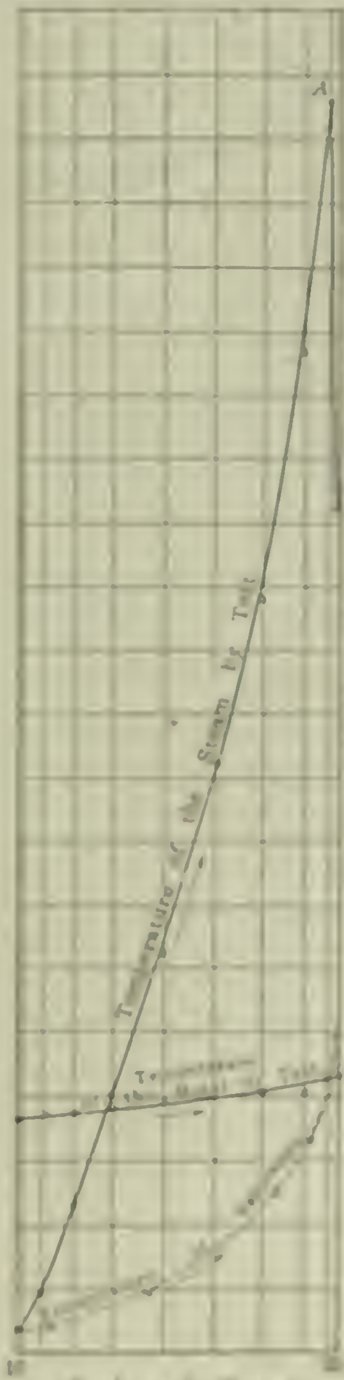


FIG. 4

According to the preceding, we find that the compression has produced work of which the heat equivalent is

$$0.585 \; (450 - 86.5) \times 0.00445 = 0.784 \text{ calorie}$$

of which the action of the walls will lose to us a great part of the benefit.

We have a verification of this figure. By measuring the area under the compression curve of the indicator diagram we should obtain the same results. By the aid of the planimeter we find that the mean hight of the curve of compression is 15.06 millimeters, the scale of the spring is 1 millimeter, or 496.1 kilogram per square meter. We have, therefore, during the compression a mean pressure of 7471 kilograms per square meter, the volume generated during compression being 0.04245 cubic meter. The work of compression measured up to the point $A A'$ will be 317.1430 kilogram-meters, which corresponds to

$$\frac{317.1430}{425} = 0.746 \text{ calorie}$$

This figure is sufficiently near to that (0.784) found above to assure us of the exactitude of our measurements.

If we calculate the work per stroke by measuring the area of the indicator diagram, we will find 713.200 kilogram-meters, which correspond to 1.678 calories. We may, therefore, conclude that the loss of energy due to the compression by the mechanism which we have described is an important fraction, and that the 0.784 calorie, found as above, has a marked influence for this amount of heat, 0.784 ... certainly not negligible as compared with the 1.678 calories, which represents the work developed upon one stroke of the piston.

But it may be said that we have chosen a compression of nine-tenths of a stroke, which would never be used in practice. Very true, but a long compression shows the influence much more markedly, and can we not deduce from it that we would reach the same results, but in a less marked degree, by a more feeble compression?

There will remain one point to be cleared up. For a given set of conditions Professor Dwelshauvers-Dery has found an increase of economy up to a certain degree of compression, and this is very simply explained if we consider a compression such that the temperature of saturation corresponding to the final pressure remains always less than the temperature of the metal. The effect will be that if at the end of the stroke the steam is somewhat cooled, it will not condense, but will remain superheated, and instead of producing a loss will contribute to diminish the initial condensation.

It is in this way that the measurements of the temperatures of the steam and of the containing surfaces permit the phenomena which occur during compression to be interpreted.

**In view of the fact that the steam is superheated, we will not depart widely from the truth in making this assumption.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Primer of Electricity

By Cecil P. Poole

The Compound-wound Dynamo

In the lesson of November 8 it was explained that the electromotive force at the brushes of a shunt-wound dynamo remains almost constant between no load and full load, but that the drop in the wires between the dynamo and the load makes it necessary to increase the voltage of the machine, when the load increases, in order to keep the voltage right at the load.

The series-wound dynamo, on the other

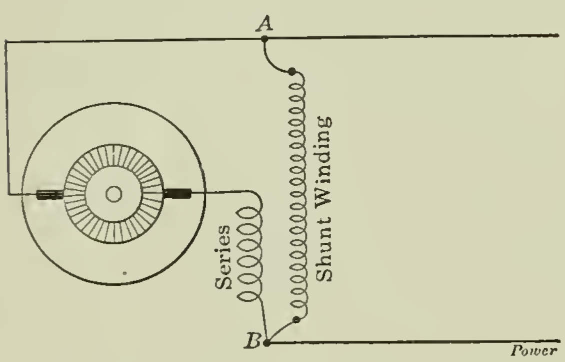


Fig. 82. Circuits of a Compound-wound Dynamo

hand, increases its voltage when the armature current increases, because the armature current passes through the field winding. This feature of the series-wound machine supplies just what the shunt-wound machine lacks for constant-potential work, but a simple series-wound dynamo cannot be used for this kind of work because its voltage varies too much with load changes.

Therefore, a field winding has been developed which is a combination of the shunt and series windings—in fact, there are two separate and distinct windings, one a shunt winding and the other a series winding, as indicated in Fig. 82,

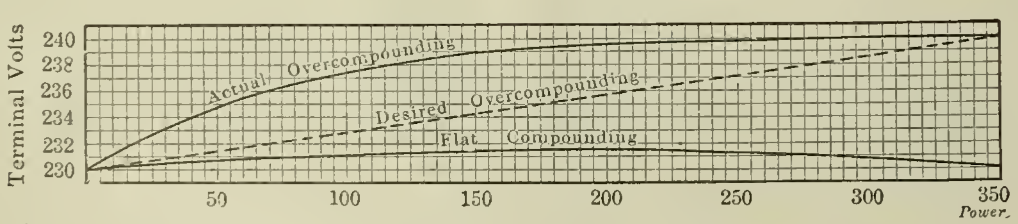


Fig. 83. Curves Showing Voltage at Different Loads

which is only an elementary diagram of the main circuits of a compound-wound dynamo, with regulating devices omitted. The shunt winding supplies the excitation necessary to generate the rated voltage and the series winding adds the excitation necessary to generate the extra electromotive force required to make up the drop in the dynamo and, if required, that in the wires of the external or load circuits.

For example, suppose the internal resistance of an 80-kilowatt dynamo were 1/35 of an ohm, the rated e.m.f. 230 volts and the full-load current 350 amperes. Then, at full load, the drop within the dynamo itself would be

$$350 \times \frac{1}{35} = 10$$

volts, and if it were not compound wound the voltage at the terminals would be only 220 volts at full load, unless the field excitation were strengthened.

In order to make the series winding strengthen the field excitation enough to make up the 10 volts lost in the windings, it would be proportioned so that with 350 amperes flowing through it, the ampere-turns would produce enough additional magnetic flux to enable the armature to generate 10 volts more than it would with the shunt winding alone. That is, the magnetism produced by the shunt winding would cause the armature to generate 230 volts and that produced by the two windings together would make it generate 240 volts.

In other words, if the machine required 8000 ampere-turns per pole to generate 230 volts and 8700 to generate 240 volts, the shunt winding would have to give 8000 and the series winding (at full load) 700 ampere-turns per pole.

A machine built in the way described—to give the same voltage at full load as at no load—is called "flat compounded," because a curve showing the relation between the load and the voltage at the dynamo terminals is practically flat, as shown by the lower curve in Fig. 83.

Most compound-wound dynamos, however, are "overcompounded"; that is, when full-load current flows through the series winding the field strength is increased *more* than enough to enable the armature to generate the extra voltage required to make up for the drop in the windings of the machine itself. This is done to make up partly or completely for the drop in the circuit between the dynamo and the lamps.

For example, suppose the drop in the external circuit supplied by the 80-kilowatt dynamo were also 10 volts at full load and the machine had to be over-

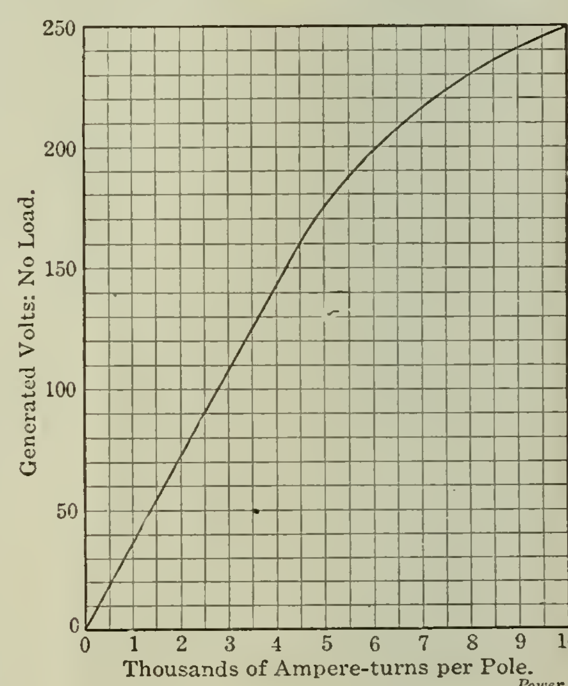


Fig. 84. Excitation Curve

compounded to cover that drop. Then, at full load, the armature would have to generate 250 volts in all, 10 of which would be used up in the windings and 10 in the line, leaving 230 volts available at the lamps. If the machine required 10,000 ampere-turns per pole to generate this 250 volts, the series field winding would have to supply 1650 ampere-turns at full load because the shunt winding, which supplied 8000 ampere-turns when the e.m.f. at its terminals was 230 volts, would supply 8350 ampere-turns when subjected to 240 volts, which would be the terminal pressure when overcompounded 10 volts.

As Fig. 83 clearly indicates, the compound winding does not do accurately what is intended, that is, maintain constant terminal voltage* with flat com-

*Terminal voltage is that at the terminals or circuit connections on the dynamo: *A* and *B*, in Fig. 82.

pounding or a rise in exact proportion to the load with overcompounding. In the case of the flat-compounded machine just described, the e.m.f. at the terminals, instead of being constant at all loads, goes up to 231½ volts when the load reaches 200 amperes, and gradually falls, as the load increases, to 230 at full load. In the case of 10 volts overcompounding the terminal volts increase rapidly with the load up to about half load and then increase slowly as the load increases, as shown by the upper curve in Fig. 83 marked "Actual overcompounding." What is desired is a regular increase in voltage, as indicated by the broken line.

The reason for this departure from constant voltage in the one case and a regular increase in the other is that the magnetism produced by the field excitation is not proportional to the excitation. This was explained in a previous lesson, and is illustrated by Fig. 84, which is the excitation curve of the 80-kilowatt machine now being considered. Referring to this curve it will be evident that the generated volts, which vary exactly with the field magnetism, increase exactly with the ampere-turns up to about 4500 ampere-turns; thus, 1000 ampere-turns produce 35.55 volts, 2000 produce 71.11 volts, 3000 produce 106⅔ volts, 4000 produce 142.22 volts and 4500 give 160 volts. Beyond this, the additional volts produced by each additional 1000 ampere-turns are less than 30 volts, instead of continuing at the rate of 35.55 volts per 1000 ampere-turns.

Fig. 85, which is the upper part of Fig. 84 plotted to a larger scale, shows more distinctly the relation between the ampere-turns and the generated volts of the 80-kilowatt machine, within the working range. This shows that 8000 ampere-turns of excitation enabled the armature to generate 230 volts; 8300 ampere-turns produced 235 volts; 8700 ampere-turns, 240 volts; 9000 ampere-turns, 243 volts; 9500 ampere-turns, 247 volts, and 10,000 ampere-turns produced 250 volts. If that part of the curve above 230 volts were a straight line instead of a curve, then the curves in Fig. 83 would be straight lines, so far as the machine followed them, but, as explained in a previous lesson, the machine would be unstable; that is, it would not stop at any particular voltage but would either increase to an infinite voltage and destroy itself or drop to no voltage at all and remain "dead."

For the reason just explained, it is impossible to get a straight-line excitation characteristic* from a dynamo. The curves shown in Fig. 83, however, are unusually bad and were selected because of that fact; they serve to illustrate the departure from a straight line better than curves taken from a well proportioned compound-wound dynamo would. The machine from which these curves were plotted was really a 240-volt shunt-wound dynamo.

The field magnet of a compound-wound dynamo would be "worked" farther down the curve shown in Fig. 85, say along that part from 220 volts up to 240 instead of from 230 up to 250. The difference in

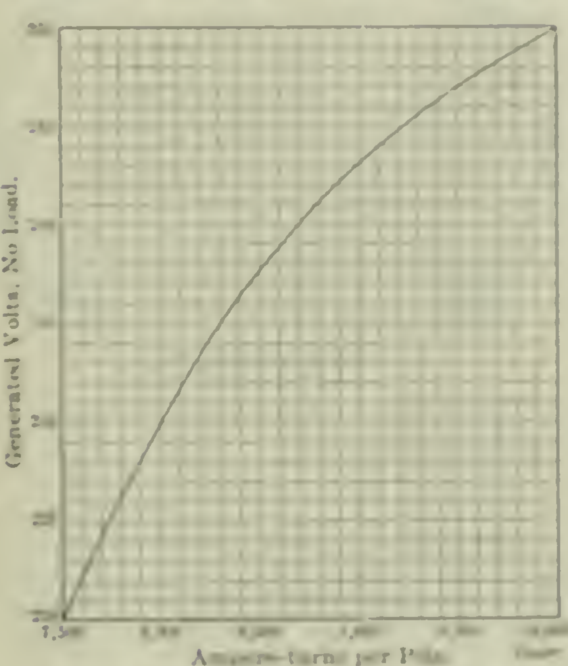


FIG. 85. UPPER PART OF FIG. 84

regulation is quite remarkable. For example, if the full-load drop of the machine were 8 volts and it were compounded for a 12-volt rise at the terminals —that is, the terminal voltage at no load to be 220 volts and at full load 232 volts, the following results would be obtained:

	Ampere-turns			Generated Volts	Drop	Terminal Volts
	Shunt	Series	Total			
No load	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]
Full load	[illegible]	791	8700	240	8	[illegible]

These results are deduced very easily. If the terminal voltage at full load is 232 volts and the internal drop is 8 volts, the total generated voltage at full load must be 232 + 8 = 240 volts. Fig. 85 shows that 7500 ampere-turns are needed to generate 220 volts and 8700 to generate 240 volts. The shunt winding must contain 7500 ampere-turns when 220 volts are applied to it; therefore, it will contain 7909 ampere-turns at 232 volts. The series winding must contain at full load the difference between the 7909 supplied by the shunt winding and the 8700 required; this difference is 791 ampere-turns. Without going farther into details it is sufficient to say that the terminal voltage of the machine at one-fourth, one-half, three-quarters and full load would be as follows:

Load	Generated Volts	Drop	Terminal Volts	Desired Terminal Volts
0	[illegible]	0	[illegible]	[illegible]
¼	[illegible]	[illegible]	[illegible]	[illegible]
½	[illegible]	[illegible]	[illegible]	[illegible]
¾	[illegible]	[illegible]	[illegible]	[illegible]
Full	[illegible]	[illegible]	[illegible]	[illegible]

Here, the greatest excess of terminal voltage over the desired voltage is 4 volts, as compared with 4½ volts excess in Fig. 83.

*A curve or line on a chart showing the relation between different features of operation is called a "characteristic."

LETTERS

Water in Transformer Oil

"You had more transformers burn out in your little district during the last three months than we had in any of the larger districts in the same time."

The foregoing statement by the superintendent of construction to the superintendent of the little district mentioned caused me to do some thinking and investigating. I was the engineer of the plant and had nothing to do with the line work, but my natural curiosity prompted me to find out why so many transformers burned out. First I sought the lineman who had charge of the transformers and asked him in a casual way why so many transformers had burned out lately. As the burnouts occurred in transformers set up last and usually after a rain, he thought it was the wet weather that caused the trouble, but could not understand why, as the rain did not affect the transformers when hung on the poles.

Continuing the investigation I went into the building where the transformer oil was kept. The supply was contained in a steel barrel or drum which was placed on a bench high enough so that the oil could be drawn into a can set on the floor, from this can, which the lineman usually kept full or nearly so, he would pour the oil into the transformer cases because this took less time and he often had a hurry call for a transformer. I took this can out and poured out slowly the oil that was in it, then I saw that there was a considerable quantity of water in the bottom of the can. Following this clue I discovered that the roof of the building where the oil was kept was leaky, and when it rained the can caught its share of the water, which was afterward poured into the transformer cases along with the oil. This impaired the insulation, ultimately producing short-circuits which burned out the transformers. The roof was repaired and the trouble ceased.

JAMES W. BLAKE.

New York City.

This is the season when the lecturer stands in the lantern's glare and fulminates upon everything from entropy to boiler-feed compounds for the benefit of the operating engineer. There is much to be gotten out of these lectures, and the opportunity to learn is not satisfied by the fact that the lecturer may have as a motive the exploitation of his wares. One cannot know too much about the things he may be called upon to use, and discussion and a chance to hear the other man will bring out points about those that one never thought of.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Elementary Lectures on the Gas Producer

By Cecil P. Poole

Fuel Bed Temperature

It is probably not clear to the student why the fuel bed in a gas generator does not become red hot all the way through, instead of being divided into "zones" as indicated roughly in Fig. 12. There are three reasons, each rather mixed up with the other; in the first place, the fuel bed is very deep—seldom less than three feet and usually from four to seven feet, according to the size of the generator; largely because of this, the principal reason exists, which is that not enough air goes through the fuel bed and into intimate contact with the particles of coal to burn it completely to carbon dioxide; the third reason is that the air is mixed with steam, as described in the first lecture last June, and this steam absorbs a lot of heat from the burning fuel in the combustion zone which would otherwise be transferred to the coal immediately above and raise the temperature of that zone.

This will be better understood, perhaps, if you will think over what happens when you pour water on a fire. If a little water be thrown on the fire it will be evaporated into steam and this will take heat away from the fire, dimming it considerably. If enough water be thrown on the fire all the heat will be absorbed and the fire will go out. The heat effect of putting steam through a bed of red-hot coal is the same, though the physical results are different. The steam is decomposed into hydrogen and oxygen and this process takes an amount of heat away from the burning coal equal to the heat that would be liberated by burning hydrogen to form the same amount of steam. This amounts to 62,000 heat units for each pound of hydrogen, or 6890 heat units for each pound of steam.

For example, each pound of carbon burned to CO_2 unites with 2⅔ pounds of oxygen, which is taken from 11½ pounds of air. The heat liberated by this combustion is 14,600 B.t.u. Now if, say, 9/10 of a pound of steam be admitted with the 11½ pounds of air, that will be decomposed into 1/10 pound of hydrogen and 8/10 pound of oxygen and the decomposition will absorb 6200 heat units of the 14,600 set free by combustion; this will leave only 8400 B.t.u., instead of 14,600, available for raising the temperature.

The coal in the second zone has to be heated by the heat from the fire in the first zone, and if the temperature there (in the second zone) is kept at 1900 degrees, each pound of coal will absorb about 400 B.t.u. in "sensible heat" (see the December 6 lecture). Therefore, if there were 8½ pounds of coal in the second zone for each pound of carbon burned in the fire zone, about 3400 B.t.u. would be absorbed in heating it up to 1900 degrees, so that instead of 8400 B.t.u. there would be only about 5000 available for heating the gases.

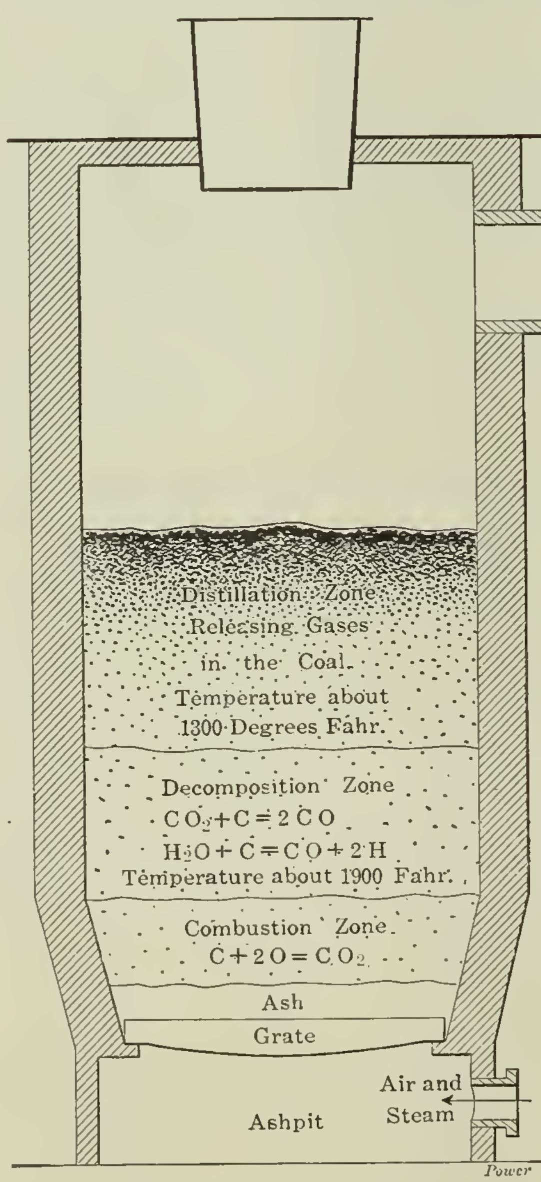


Fig. 12. Approximate Character of the Zones of a Fuel Bed When Steam Is Admitted with the Air

But in addition to the processes described there are two others which affect the generator temperature. The CO_2 formed in the fire zone "picks up" carbon in the second zone and is converted into CO; and the oxygen from the decomposed steam also combines with carbon to form CO. The first process absorbs heat and the second one gives out heat. For each pound of carbon united with CO_2 to form CO, there are absorbed 5700 B.t.u. and for each pound of carbon burned to CO with oxygen 4450 B.t.u. are given up.

Now, if we assume that all of the CO_2 formed in the fire zone is converted to CO in the second zone, that 9/10 pound of steam is admitted with the 11½ pounds of air, that all of the oxygen from this steam unites with carbon to form CO, and that 3 pounds of coal are heated to 1900 degrees in the second zone for each pound of carbon burned in the first one, the burning of that pound would produce the following results:

1 pound carbon burned to 3⅔ pounds CO_2 gives out	14,600 B.t.u.
3 pounds coal heated to 1900 degrees absorb	1,200 "
Leaving	13,400 "
3⅔ pounds CO_2 united with 1 pound carbon to form 4⅔ pounds CO absorb	5,700 "
Leaving	7,700 B.t.u.
$\frac{9}{10}$ pound steam decomposed to $\frac{1}{10}$ pound H and $\frac{8}{10}$ pound O absorbs	6,200 "
Leaving	1,500 B.t.u.
$\frac{6}{10}$ pound carbon burned to 1.4 pounds CO with $\frac{8}{10}$ pound of oxygen gives out	2,670 "
Net heat remaining	4,170 B.t.u.

The final products of these processes are 6.067 pounds of CO, 8.84 pounds of nitrogen and 1/10 pound of hydrogen, and the specific heat of this mixture is 0.267 B.t.u. per pound or 4 B.t.u. for the whole 15 pounds. Therefore these gases will be at a temperature theoretically $\frac{4170}{4} = 1042\frac{1}{2}$ degrees above that of the atmosphere when they pass from the decomposition zone to the upper part of the fuel bed. The green coal there will absorb considerable heat from the gases so that when they finally leave the generator their temperature may be as low as 600 or 800 degrees, Fahrenheit. Of the 3 pounds of coal heated in the second zone, about 1¾ pounds have been used to make CO and the remaining 1¼ pounds pass to the fire zone to keep up combustion.

Many conditions other than those mentioned affect the temperature, such as the heat absorbed by the ash and that radiated through the generator walls. The calculations just given are intended only to indicate the way in which the fuel-bed thickness and steam supply affect the temperatures of the fuel and products of combustion and gasification. In practice it is impossible to convert all of the CO_2 into CO, and a considerable amount is always contained in the gases finally delivered by the generator.

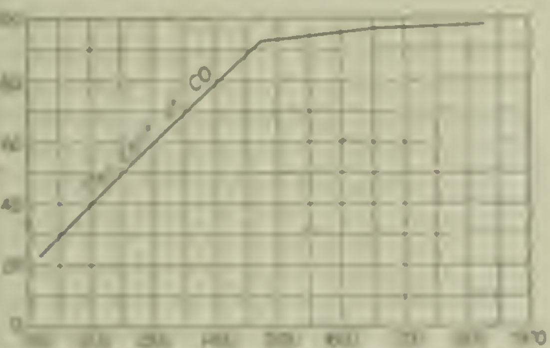


Fig. 14. Effect of Temperature on Production of CO

As the object of operating a producer is to make gases that will burn in an engine, and not to develop heat as a boiler furnace does, the less carbon dioxide it delivers, the better. Therefore, the aim is to completely burn just as little carbon as possible and to convert as much as possible of this back into CO, as described. It is necessary to make CO_2 in order to obtain the heat required to make CO; a fuel bed cannot be kept hot by burning all of the carbon incompletely, and it must be kept very hot to get the greatest proportion of CO in the outgoing gases. The conditions are contradictory to a certain extent. The quantity of CO_2 made in the fire zone must not be so great that much of it will go through the second zone unconverted; yet the second zone must be kept very hot in order to convert the greatest amount of CO_2, and in order to keep it hot a good deal of CO_2 must be made in the fire zone by complete combustion. The ideal fuel-bed depth and air supply are those that will burn just enough coal in the fire zone to heat the second zone up to that temperature at which the most CO_2 will be converted into CO. The deeper the fuel bed, the more coal must be burned in the fire zone to keep it hot and the more coal is burned to CO_2, the more steam can be admitted with the air without cooling the bed too much.

Boudouard, a French investigator, found that at 1112 degrees Fahrenheit, carbon dioxide passing through a bed of coal would combine with carbon to form 23 per cent. of CO, and at 1832 degrees the CO produced was slightly over 90 per cent. Fig. 14 was plotted from the results of Boudouard's tests. It shows that the percentage of carbon monoxide rose regularly with increasing temperatures up to 1475 degrees, beyond which point the increase was much less rapid. This chart indicates that the best temperature range for the second or decomposition zone is from 1800 to 2000 degrees.

As already explained, the temperature of the second zone depends on the depth of the fuel bed and the proportion of steam admitted with the air. Reducing the depth of bed will reduce the quantity of coal through which the CO_2 from the fire zone passes; the coal, therefore, will be heated to a higher temperature, and if the bed is too shallow it will increase in temperature until complete combustion occurs, unless the air supply is checked enough to prevent that. If that is done, the quantity of gas made will, of course, be reduced.

On the other hand, if the fuel bed is extremely deep the coal above the second zone may absorb so much heat from the rising gases that the temperature in the top part will fall low enough to allow some of the CO to be converted back to CO_2. This can happen either by the loss of the carbon "picked up" in the second zone or by the combination of CO with oxygen in steam which has been reformed or has escaped decomposition. In ordinary work this condition cannot arise because the generator is not high enough to contain any such depth of fuel.

It is asserted by some authorities that a slight conversion of CO to CO_2 occurs in the scrubber and gas passages due to the loss of carbon by cooling; this is said to account for the soot found in the scrubber water and the gas pipes, but the writer is more inclined to believe that that is merely coal dust swept from the upper parts of the fuel bed by the outgoing gases. However that may be, it is clear that the higher the temperature of a generator up to that which gives the second zone 1900 degrees, the larger will be the percentage of useful gases and the smaller the percentage of CO_2 delivered. Any temperature above that merely wastes heat by increasing the temperature of the outgoing gases and also tends to fuse the ash in the coal and form clinkers.

A New Diesel Engine in Small Sizes

The "original Diesel small motors" shown at the International Motor Boat and Motor Exhibition in Berlin and at the Brussels World's Fair this year indicate that the development of the Diesel motor has been extended to the broad field of small high-speed motors.

This new type of Diesel motor, which is built at present in sizes of from 5 to 30 horsepower with one to six cylinders, is primarily intended to meet the needs of small industrial plants, and for this reason the aim of the builders has not been to obtain the greatest possible reduction of weight, but rather to provide a strong machine adapted to use by unskilled persons. Nevertheless, the new machines are lighter than is usual in stationary-engine practice. For instance, the weight of the 30-horsepower engine complete for service, including bedplate, air tanks, fuel holder and exhaust head, amounts to 32 kilograms per brake horsepower; this is about one-tenth of the weight of the old stationary Diesel engine of like efficiency, but greater than the weight of the submarine-boat engine, which, at any rate, must be lightly built. For installation in ordinary vessels the "original Diesel" small engine is provided with a modified crank case and the heavy foundation plate is omitted entirely, so that the weight of the engine for marine service is less than that of the land engine.

The speed of the small engine is normally 600 revolutions per minute, at which the combustion is complete and the exhaust invisible and odorless. The

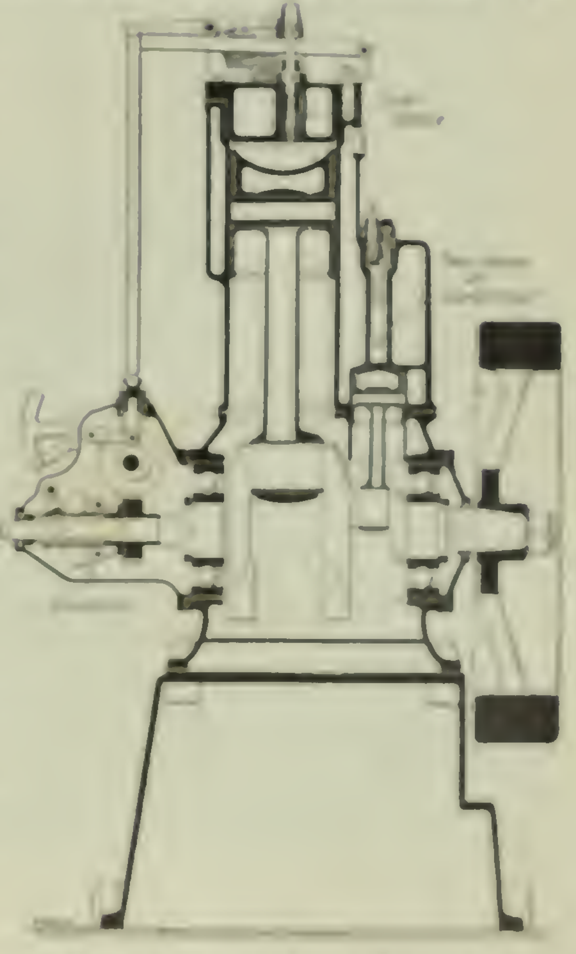


Fig. 1. Small Diesel Engine

speed of the engines built for marine service, however, can be varied from 200 to 1000 revolutions per minute. The stationary engine is kept within 10 per cent. of the rated speed by means of the usual centrifugal governor. The problem of reliably controlling the injection of the very small quantities of fuel required is said to have been solved in the "original Diesel" small motor in a very satisfactory manner.

The machine shows several differences from the usual form of construction, some of these being characteristic features that have been developed in modern automobile practice. The cylinder head contains all valves and valve mechanism, and it extends from the cylinder body, being packed by means of conical seat surfaces, metal to metal. Thus it has been possible to bring the larger piping, such as suction, exhaust and water pipes, to the cylinder instead of the cylinder head, and, consequently, the cylinder head is made very light and can be removed or replaced in a few minutes without dismounting clumsy piping or valve gearing. The arrangement of the valve-actuating levers on the cylinder head corresponds in general to that of the large types of Diesel motor; the cam shaft is, however, located directly above the crank shaft in an extension housing, as shown in Fig. 1, relieving the cylinder head still further of heavy parts. Fig. 2 shows a single-cylinder 5-horsepower Diesel small motor coupled to a direct-current dynamo.

For stationary service, in which constant speed is desired, the motor, as already stated, is provided with a governor, which is inclosed in the extension housing of the cam shaft and controls the length of stroke of the suction valve of the fuel pump. The marine engine is regulated by hand adjustment of the fuel pump.

Fuel-consumption tests at normal continuous loads have shown the exceedingly favorable result that the consumption differs only a little from that of the large engines. There have been obtained figures of 238 grams [8.4 ounces] consumption per brake horsepower-hour, so that 250 grams [8.8 ounces] may be taken as a guarantee figure.

According to data thus far obtained, the fuel costs for the Diesel small motors are only one-fifth to one-fourth of those obtained in gasolene-motor practice, and in marine service there is also the saving of fuel weight carried, which on the average is cut down to half of that required for the old motors. The radius of action of boats equipped with small Diesel motors, therefore, as affected by the fuel weight, is doubled.

As in the large engines, the fuels used are heavy oils of relatively "slow" inflammability; even with the most sluggishly inflammable oils, however, combustion is said to be so rapid that the indicator diagrams are indistinguishable from those of the large Diesel engine. The diagram shown in Fig. 3 was taken at reduced speed in order to avoid the distortions that would be caused by inertia of the indicator piston.

The inlet and oil-jet air is forced into steel tanks by the air pump, which, in its smallest type, is cast in one piece with the cylinder and is surrounded by the common water jacket. These steel tanks resemble the carbonic-acid flasks which for years have proved reliable. The ends of these tanks are shown projecting from the bed casting in Fig. 2.

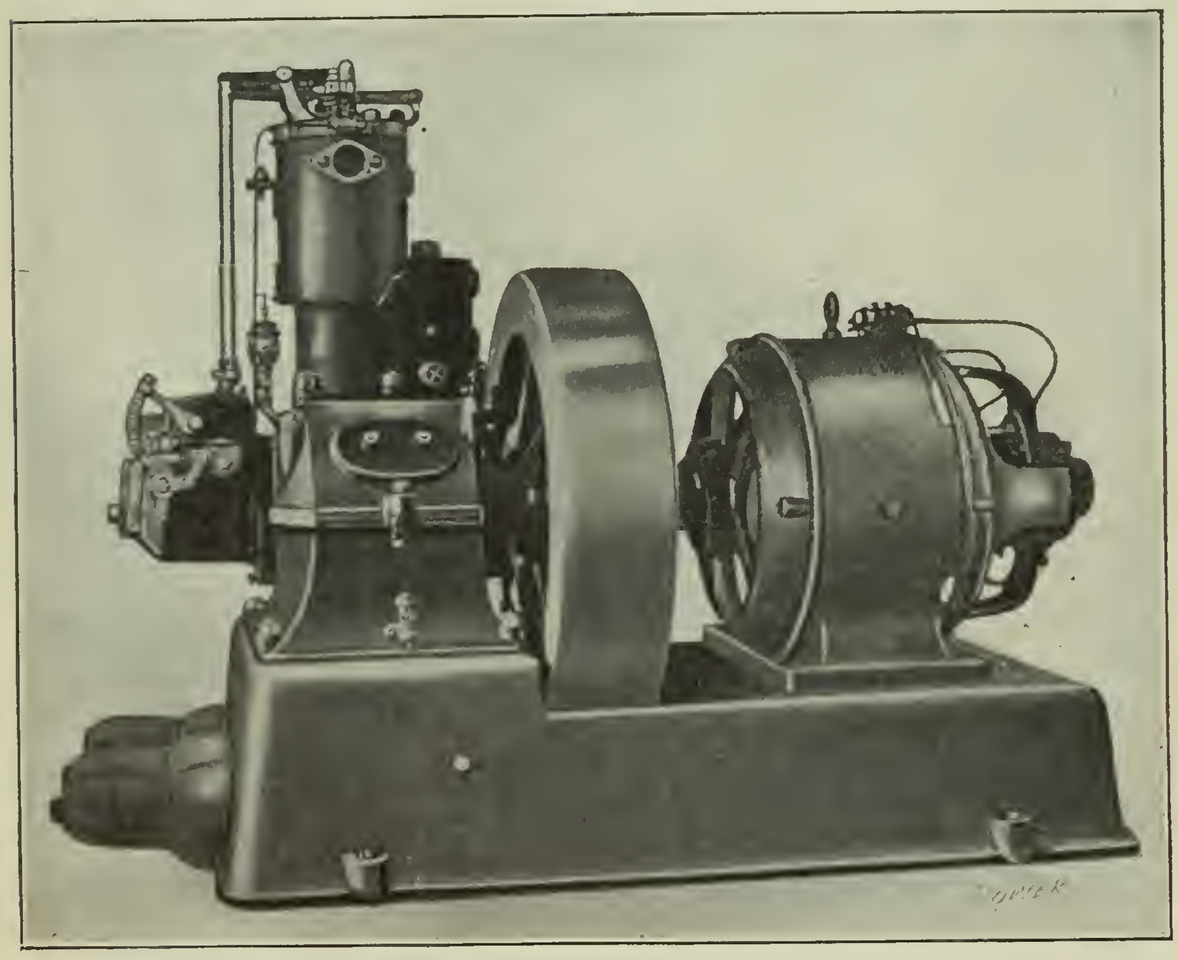


Fig. 2. Small High-speed Diesel Engine

The engine parts subjected to excessive stress, such as the crank shaft, crank pin, connecting rod and crosshead pin, are made of the best chrome-nickel steel; all bearings are ball bearings.

An improvement valuable in small service of all kinds is the automatic regulation of the air pump, which renders unnecessary any supervision of the air pressure in the various reservoirs. Since, also, the lubrication of the engine does not need special attention, this new small motor is a completely automatic machine.

These little machines are built by the Société Anonyme St. Georges, of Zurich, Switzerland. They are designated "original Diesel" small motors because they have been so named by Herr Diesel himself and their construction is carried out under his advice.

The Future of the Gas Engine

Dugald Clerk, the well known English authority, recently delivered a lecture at Manchester University on "The Phenomena of Explosions in Gas and Other Internal Combustion Engines." Mr. Clerk, in conclusion, expressed the opinion that so long as expansions remain as at present, no great further increase in the thermal efficiency of the internal-combustion engine can be expected. Increasing expansions mean increasing engine weight very largely to gain a small increase in efficiency. It is quite possible to design and construct an engine working with coal gas which would give an indicated thermal efficiency of about 50 per cent.; but such an engine would probably have a lower mechanical efficiency—probably about 80 per cent.—so that the brake efficiency would be only about 40 per cent. It is not likely, he said, that such an engine would be commercially successful, because the increased first cost would not be justified by the greater economy. Unless some other method can be adopted of increasing power by utilizing the exhaust heat, coal-gas engines are likely to remain at their present standard. The principle of compounding, it is true, might be applied to the gas engine, and longer ranges of expansion obtained; but such complication would be justified only in comparatively large engines.

So far as the small gas engine is concerned, a close approach has been made to a standard type. Practically all difficulties have been overcome, both from the engineering and the commercial standpoints. Small gas engines are now even more reliable than small steam engines, as may be proved by comparison of results given by various insurance companies. Scientific work is more vitally required in the case of the large gas engine, where the conditions as to temperature, pressure and unequal expansion due to heat are of the severest kind. Study of the various problems of volumetric heat, heat flow, radiation, incomplete combustion, dissociation, etc., are all required to produce better conditions of operation while maintaining or increasing thermal efficiency. Inventors of this generation may not succeed in producing sufficiently favorable conditions for commercial success in very large gas engines; but their work and that of the scientific investigator of the present will undoubtedly provide the engineer of the future with means of solving problems so far unsolved by the engineer of today.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Trouble with a Heating Plant

While putting in a steam-heating job of about 30,000 square feet of radiation, nearly all indirect, I ran across a problem that gave me some trouble to master, and the solution may interest some reader.

The building contained many wings and ells and as the several parts of it were built at different periods there are many changes of floor level; so that the steam main, all of which was run in the basement, had to rise, fall and rise again according to the various elevations of the basement ceiling. Altogether there are 1800 lineal feet of main steam pipe in the job, running from 10 inches at the boilers to 2½ inches in diameter at the extreme ends.

The boilers are located in the center of a court around which the building was built, and the main steam pipe ran in opposite directions from the boiler plant, feeding the north and south parts of the building.

The water line in the boilers was some 40 feet above the water line under the lowest radiators, so it was necessary to resort to the use of automatic feed pumps and receivers in order to return the water of condensation to the boilers. Two of these pumps were installed, one of them being kept as a reserve unit.

Accompanying is a diagrammatic sketch, Fig. 1, showing the general arrangement of the part which gave trouble and how it was piped.

Soon after starting to heat the buildings it was found that the returns would come back to the automatic feed pump in slugs. The pump would run very fast for a few minutes, filling the boilers to the top of the glass gage before it slowed down, and then run very slowly for a while. The trouble was located at the point *A*, Fig. 1. A steam gage and a water glass gage were put on at *B*. The gage showed that for some reason, never clearly understood, the pressure in the pipe *C* was so much reduced at varying intervals that the pressure in the radiators *X X X*, which was constant, forced the water lying in the return risers and in the main return pipe over the trap seal at *A*.

This made an artificial water line in the highest of the several sections into which the system is divided, as before alluded to, notwithstanding the pressure from the equalizing pipe which was run from the steam main to the top of the trap in the usual manner.

FIG. 1. ARRANGEMENT OF HEATING SYSTEM

All sorts of devices were tried to remedy this rush of condensed steam in the return pipe, but none of them did any good until the following plan was adopted.

There were on hand an old 2-inch steam governor and a 1½-inch flanged strainer which came from an abandoned reducing valve. With these to begin with, a device was made as shown in Fig. 2, in which the balanced valve of the old governor is set by the spring plate *F* at such a point as will allow the ordinary flow of condensation to pass. Whenever the reduction of pressure in pipe *A*,

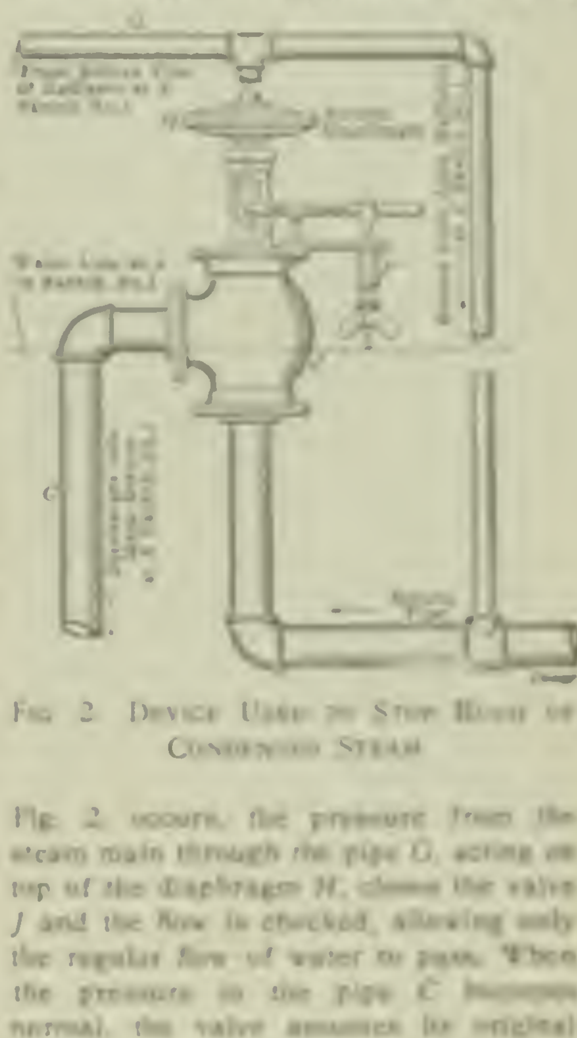


FIG. 2. DEVICE USED TO STOP RUSH OF CONDENSED STEAM

Fig. 2, occurs, the pressure from the steam main through the pipe *G*, acting on top of the diaphragm *H*, closes the valve *J* and the flow is checked, allowing only the regular flow of water to pass. When the pressure in the pipe *C* becomes normal, the valve assumes its original position and the regular flow of water continues.

There have been two of these valves in use for ten years and they have operated perfectly, the only attention required is the renewal of the rubber diaphragms once in about every third season.

I have never been able to understand just why the pressure was reduced periodically in the pipe *C* and I would like to hear from engineers having experience along this line.

T. H. De Saussure.

Milledgeville, Ga.

Simple Methods of Binding "Powers"

Each issue of POWER contains much valuable reading matter and information which ought to be preserved for reference. I have just completed a satisfactory job of binding the issues for three months in one volume. This makes a volume that can be easily handled, and a stronger and better job can be made than by making the volume of larger size.

To bind Power proceed as follows: First arrange the various copies according to their dates, and pile in three sections containing one month each. Then remove the covers and lift the ends of the binding wires and take off the advertising pages, after which turn down the ends of the wires again.

Next take the first and second issue of the first month and glue them together; then glue on the third issue and so on until the whole of the first month's issues are securely glued together. Proceed with the second and third month's issues in the same way, taking care to make as neat a job as possible.

Next take the first month's issues, which form one part of the volume and glue it to the second part, and to this glue the third part, which will complete the volume in the rough.

Then take a piece of strong cloth and cut it a size equal to the depth of the book and wide enough to stretch across the back, and lap one-half inch over on the front page and the same on the last page. Cover the cloth well with glue and stretch it across the back of the volume as tight as possible, as it is the cloth that gives strength to the volume and keeps the parts firmly held together.

Take a clean cover of Power and glue it in place, and the volume is finished. It is best to place the finished volume under a heavy weight for a few hours to allow the glue to set. The finished volume will look like an ordinary copy of Power, only it will be about one inch thick.

George E. Lambowin.

McKeesport, Penn.

Two Methods of Lacing Belts

Belts may be joined by lacing, riveting, sewing or cementing. A method of lacing a belt that may be relied upon is shown in Fig. 1.

First cut the ends of the belt square, using a sharp knife and try square. Then punch a row of holes exactly opposite each other in each end of the belt, using three holes for a 4-inch belt and five holes for a 5- and 6-inch belt. The number of holes in the row should always be uneven for the style of lacing shown.

A represents the outside of the belt and *B* the pulley side. The laces should be stretched as much as possible before using, and should be drawn half way through one of the middle holes, from the under side, as at *C*, and before proceeding see that the belt is not twisted, or, in the case of a crossed belt, that it has not been given a wrong twist. Then pass the end of the lace on the upper side of the belt through the hole *D*, under the belt and up through *E*, back again to *D* and *E*, through *F* and up through *G*. Then an incision is made in one side of the lacing which forms a barb that will prevent the end from pulling through. Then lace the other side of the belt in the same manner. This method may be used for belts up to 6 inches wide, but soft wire should be used instead of laces on belts smaller than 3 inches in width. If a lace is used on a small belt it makes

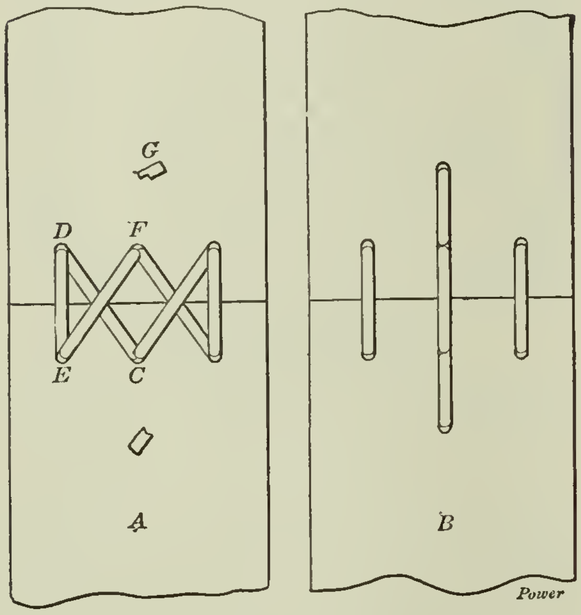


Fig. 1. A Reliable Method

the joint clumsy looking and the belt will travel unevenly over the pulley.

For belts wider than 6 inches the lacing shown in Fig. 2 is good. Two rows of holes should be punched. The number of holes in the row nearest the joint should exceed by one the number of holes in the second row. For 6-inch up to 7-inch belts I have always used four and three holes respectively. For larger belts make the total number of holes in

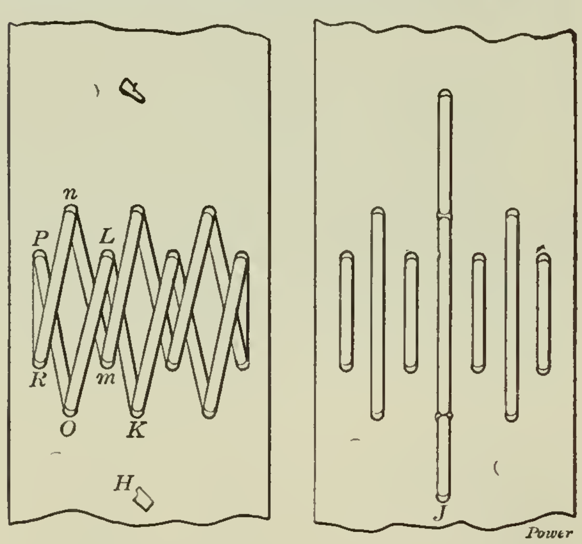


Fig. 2. Lacing for Large Belts

each end either one less, or one for each inch of belt width. I never care, with large belts, whether the number of holes near the end of the joint is odd or even. In a 10-inch belt, for example, nine and eight holes are used respectively. The outside holes of the first row should not be nearer the edge of the belt than ¾ inch, nor should the first row be nearer the joint than 1 inch. The second row should be at least 2 inches from the end of the belt. In Fig. 2, *H* is the outside and *J* the pulley side of the belt. Begin at one of the center holes, always in the outside row, as at *K*, and continue through *L*, *m*, *n*, *O*, *P*, *R*, *P*, *R*, *n*, *O*, *L*, *m*, etc.

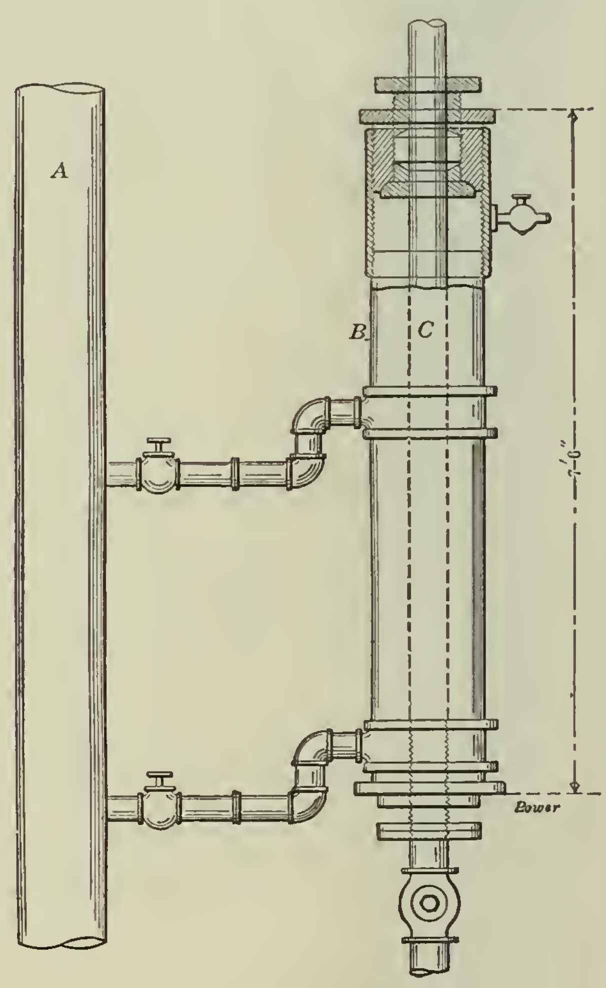
The lacing may also be started on one side instead of at the middle, and it should not be crossed on the pulley side of the belt.

William L. Keil.

Philadelphia, Penn.

Hot Water Reheater

Some time ago I had difficulty with the hot-water circulation in one of the buildings, due to the circulating pipe being placed about 6 feet below the lowest hot-water fixture, which is 12 feet below the main circulating pipe. This formed a trap and prevented the circulation of the water. There was also



Hot Water Reheater

danger that the line would freeze up in cold weather as the lower section was exposed to severe draft of cold air.

Therefore, I made a reheater on the riser pipe to the main, as shown in the accompanying sketch.

The steam is taken from a heating riser *A*, which is close by. The packing boxes of the pipe *B* are made of bushings which were filed out to fit the brass pipe *C*.

A swing check valve is placed below the reheater and at the lowest point on the brass pipe. This simple device reheats the water in the pipe *C* and establishes a satisfactory circulation.

George Peters.

New York City.

Patching a Second-hand Boiler

Some years ago the company I worked for traded their old boiler for a larger, second-hand boiler. After it was in place and all the pipe connections made, I filled it with water and built a fire, but before the boiler was warm, I noticed water dropping on the grates. Drawing the fire I found that the boiler was leaking at the first girth seam over the fire. This boiler was built, as shown in the illustration, and consisted of three sheets with single-riveted lap-joint seams. Securing a calking tool and hammer I tried to stop the leak, but was not successful.

After emptying the boiler I cut out a rivet and, holding a candle in the rivet hole, found that the under sheet was cracked in the rivet hole. Cutting out a rivet on each side of the first one, I found that the crack still extended beyond the remaining rivets. Considering this a job beyond me, I got a boilermaker to come and look over the boiler. He continued cutting out rivets until he got past the crack, which extended through twelve rivet holes.

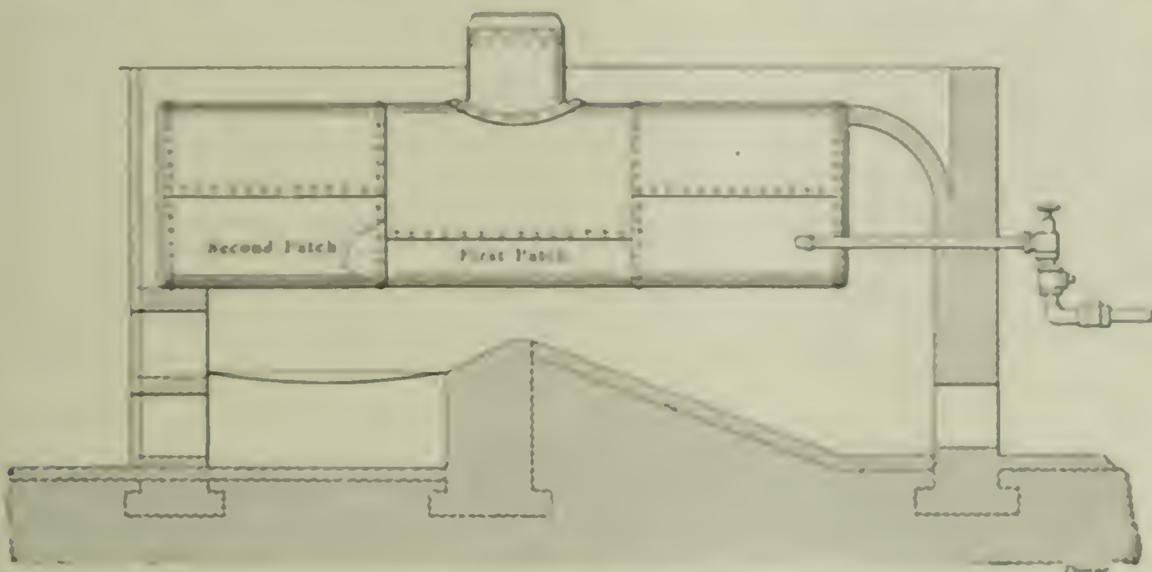
We then cut out a piece of plate back to the next girth seam, as illustrated, and put in a patch.

After this job was complete, I filled the boiler again and got up steam, when I found that the tubes were leaking at the back end. By means of a tube expander and a trip into the back end about twice a week, I managed to keep things going for a while, but I soon reached the limit with the expander as the tubes were rolled so thin that it was impossible to stop the leaks by further expanding. I also discovered that the back head was in two pieces and that there was a seam about 2½ inches above the top row of tubes. When the water level dropped below this seam, I had trouble with the tubes leaking.

It became necessary in order to keep the plant running at all to consume a lot more fuel than should have been necessary. Then the boss agreed to get a new set of tubes and I cut out the old and put in the new ones. I found it necessary, in order not to roll the new tubes too much at the back end, to insert thin strips of copper around the tubes to help fill up the holes which had previously been enlarged. After this job had been completed, there was no trouble for about 6 months.

One morning, when starting a fire, I noticed a wet spot on the firebricks but not being able to discover anything wrong I fired up, but did not neglect to keep my eye on this part of the boiler.

During the day I noticed that there was a thin spray of steam and water coming from the seam near where I had noticed the wet bricks, and at once let the steam pressure drop. I found that the first sheet was cracked through nine rivet holes. A section was cut out and a patch put on as shown. This disgusted the owner so much with second-hand boilers that he purchased a new boiler.



Patched Boiler

William G. Walters.

Stratford, Can.

The Way to Do It

Down at the big plant where they develop about 150 horsepower with 300 horsepower of boilers, with stationary grates and natural draft, they wheeled in one day a number of loads of screenings instead of the usual nut. The engineer in charge called the chief, and he in turn called Mr. Anti, the purchasing agent, who said that the screenings cost the company only the price of hauling and that they would burn them if they tried. He was taken at his word, but at about 4 o'clock in the afternoon every wheel stopped, and when the "big show" gathered at the power plant they found the engineer and fireman trying to dig out what was left of those screenings. Mr. Anti seized upon the occasion to introduce some observations with regard to the advisability of an engineer learning to fire during his apprenticeship, and how the sawmill of which he was president in the old country, never had as good coal as that. But here was where the worm turned, and the grimy engineer, wiping the sweat from his brow and handing the bar to the fireman said, "Do you know I have been figuring all the morning how to make steam with that stuff. How do you think it would work, Mr. Anti, if we were to lower the safety valve, close the quick return and feed it lightly on the crown sheet, with the crosshead wide open?" Whereupon Mr. Anti, whose dignity was sorely hurt at being led into a discussion with a common engineer, answered, "Why, any fool would have tried that at first. That's the way we used to burn it over in the old country."

A. Greenshaw.

Edmonton, Alta., Can.

Brine Foamed

When pulling ice from our tank, trouble was had with the brine foaming. The foam was very thick and resembled soap suds, and when it overflowed into the cans the water was spoiled for ice making.

Upon investigation it was found that too many cans were pulled before any were filled and put back in the tank. This allowed the brine level to fall to the top of the pipe *A* and air was drawn in at the open end, and this air caused all of the trouble.

Piping of Can Tank

Now, the men pull fewer cans at a time and there has been no more trouble with foaming brine.

Myron D. Place.

Foxboro, Mass.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Steam Boiler Economy

I have noticed several articles in recent issues of POWER on the subject of flue-gas analysis and CO_2 recorders. The main object of these seems to be that of inducing engineers to write of their experiences with CO_2 recorders and of what success or failure they have had with such instruments.

In view of the fact that flue-gas analysis is almost essential to high furnace efficiency, and that the largest part of the expense of operating a plant is concentrated in the boiler room, very few engineers are making any progress in the study of saving fuel and building up furnace efficiency.

I have tried to learn from several engineers who do not use CO_2 recorders or flue-gas analyzers, just why they have never given this subject more consideration and have most of their reasons embodied in the following answers:

One engineer says that not having sufficient knowledge of the chemical composition of flue gases caused him to lose interest in the economical combustion of fuels. He took an interest in steam-engine indicators because his plant was equipped with them, and likewise was familiar with all other instruments at his disposal.

Another says that lack of training in chemistry prevents the average engineer from understanding chemical analysis and he does not like to believe anything beyond his knowledge.

Another states that apparently his furnaces are giving full efficiency and all the available heat is utilized and to purchase the necessary apparatus would be a waste of money.

Still another says that the required information on the fundamental principles of flue-gas analysis has not been obtainable in the columns of POWER or in textbooks so that the average engineer could educate himself to the point where he would be adequately qualified to handle this work. The results of several tests have been published but nothing which would aid the man unfamiliar with this work to take the necessary elementary steps toward possessing himself with the ability to economically burn the fuels and consequently reduce the coal bills by virtue of the proper use of instruments. Progress in this direction has not been as rapid as we would expect for a problem of so great importance. Good results are, however, being obtained from some of the later models and coal is being saved in appreciable quantities and if engineers would write their experiences or ask for information, thereby benefiting all interested, the chance would be lessened for readers of POWER to return answers similar to the above when approached on the subject of CO_2 recorders and the economical burning of coal in their boilers.

CHARLES M. ROGERS.

Detroit, Mich.

The editorial in the November 22 issue on CO_2 records should have the effect of awakening engineers to a sense of what their duty is in this age of advancement. The day is past when an engineer was judged by his ability to shovel coal and employers are beginning to realize that the engineer is one of the most important men in their establishment. The other branches of mechanics (with the improvements of machinery of this age) are gradually falling away and the mechanic of the past is now just a link of a great machine. With the engineer it is different, for with the improvement of machinery and with the substitution of machines for manual labor his duties are increased by the responsibility for and care and management of these machines which come under his direct charge.

It is, then, up to the engineer to meet his duties and to educate himself so that when the demand is made he will have the ability to fill the position which calls for the assumption of increased responsibilities.

The engineers of Ontario, Canada, are probably up against a harder proposition than the engineers situated in any other part of America. The transmission of electricity by the government throughout the province of Ontario brings electrical energy from Niagara into direct competition with the steam plants. It is up to the steam engineer to demonstrate his ability and compete with this new form of power. In many establishments where heat is required and where the exhaust steam can be utilized for heating purposes, if the engineer can put up any kind of a showing with the steam plant, Niagara power will never get a foothold. Many large companies, after going into the matter thoroughly and taking into consideration the fact that the climate makes it necessary to heat the buildings during about seven months of the year, have installed steam plants and are generating their own current and using the exhaust steam for heating purposes, and have demonstrated to their own satisfaction that, after taking into consideration the heating of their establishment, the ledger comes out right by a large margin in favor of the steam plant.

Now a word along the line of the editorial. It is true that the great savings in the future are to be made in the boiler room. But, as the average engineer is not very proficient as a chemist, it will require considerable agitation to get him started along that line. I have been thinking of the subject for some time and on reading the editorial I commenced to look through the advertisements, but I am unable to see what I wanted there. POWER would certainly be conferring a favor on the engineers who are interested along this line, and would draw into interest those who are not, if it would enlarge on this subject and give us a lesson along this line every week, and also intimate to the manufacturers of recording instruments that a little printer's ink used judiciously would have a tendency to increase their business. If the engineers can be awakened to take an interest in this subject and also along the line of keeping complete records in every line in the steam plant, it will certainly increase their interest in the profession, and will benefit them financially and cut down the operating expenses to such a degree that we need not be afraid to enter into competition with any new development that may enter the field of industrial progress.

W. G. WALTERS.

Stratford, Ont.

Boiler Room Emergencies

One of the most common and least dangerous emergencies in boiler-room practice is the breaking of gage glasses. With the steam rapidly escaping into the boiler room, it is only necessary that the inexperienced fireman keep his wits about him. The lower gage valve should be closed first, thus stopping the flow of water, after which it is an easy matter to close the upper valve, from which steam only is emerging. Until time can be found to renew the glass, the water level can be determined by means of the try cocks. The upper cock should show dry steam, the lower water, and the middle one steam and water. Spare glasses should be, and usually are, kept on hand for such emergencies.

Another emergency to be met is that of finding the water either too high or too low. The boiler is in no danger from high water, but a wrecked engine is liable to be the penalty for such carelessness. The remedy for high water is to blow down the boiler. This, however, is not necessary if the engine has shown no signs of getting water, and it is known that no sudden load will be thrown on. Under such a condition it is only necessary to stop the feed pump until the water is down to normal.

To suddenly discover that the glass contains no water is an emergency which calls for quick action on the part of the attendant. If it is definitely known that the glass contained water only a very short time before, and that no sudden demand for steam has been made on the boiler, which could possibly have lowered the water sufficiently to expose any of the heating surface, and that the boiler has sprung no leaks, the attendant may feel reasonably safe in opening up the feed supply and raising the water level to normal. However, if there is any doubt as to whether or not the water has reached a dangerously low level, no time should be lost. The fire should be deadened, using ashes or green coal. The damper and ashpit doors should also be closed, and the furnace doors opened. If the boiler is in a battery, the pressure on all should be lowered as much as possible without interrupting the service, after which the boiler should be cut out, cooled off and inspected for burned plates. If no signs of overheating are found, it may be fired up and placed in service.

Another emergency which calls for very quick action is the sudden discovery that the steam pressure is considerably higher than it should be. This is not liable to occur in a well kept plant, or when the boilers are in a battery, where each is protected by its own safety valve. The present practice of equipping boilers with two safety valves further limits the probability of excessive pressure.

When, from any cause, the pressure in a boiler is found to be abnormally high, the first thing to be done is to deaden the fire, thus preventing a greater rise in pressure. The practice of drawing the fires is not to be recommended as it is sure to increase the furnace temperature. The better method is to smother the fires, as for low water. No valve connected with the boiler should be touched; this especially applies to the safety valve, before the boiler pressure has dropped to normal.

Perhaps the most severe emergency to be met in the generation of steam is the rupturing of any part of the boiler. Under this condition the attendant must be governed entirely by the circumstances and surroundings. Stopping the generation of heat and increasing the water flow are the two things most essential to be done, until the pressure is sufficiently lowered and the boiler cooled.

J. M. Row.

Fort Flagler, Wash.

Trouble with Water Column

I read with a good deal of interest the short article on "Trouble with Water Column" in the November 29 number. I lately had a similar experience to that described therein. I came to the conclusion, however, that the trouble was caused by the condensation of steam in the upper part of the column which caused the pressure to fall at that point and hence the pressure in the boiler, acting on the water in the column at the bottom forced it to the top of the glass.

To anyone who has experienced trouble of the kind I would recommend the following remedy. Make a box of either sheet iron or light wood and fasten or hang it in some way to the boiler front and thus inclose the whole column leaving only the glass exposed. Then, fill the box with, say, charcoal dust. Leave the glass in connection with the boiler both at the upper and lower end during the time when the boiler is banked. When steam is again raised, the trouble will be gone.

John Zetterlund.

Eskilstuna, Sweden.

The "Trouble with Water Column" described in the article under that head in the November 29 issue was undoubtedly caused by the filling up of the lower connection with mud or sediment. In many boilers trouble is caused in this way, to a greater or less extent. Last year the water columns on my boilers began to get a little slow. They were piped with 1½-inch top and bottom connections, with a ½-inch blowoff connection under the 1½-inch cross valve. The cause of the trouble lay in the small size of the blowoff line, which would not let the water move fast enough to dislodge the mud in the lower connection when blowing off the column. I removed the ½-inch line and substituted 1½-inch pipe in its place, and connected it to the main blowoff line. With this arrangement, when I blow off the column, the water passes through the lower connection with force enough to carry off any and all sediment that has found lodgment in the column.

[illegible]

Norwalk, Conn.

Exhaust Steam Regenerators

In the issue of November 8 there is an article by Charles H. Smoot under the above title. In one instance, the article seems to contain an inaccuracy. In the last column on page 1983 the statement is made that the efficiency of a well designed injector for boiler-feed purposes does not exceed 20 per cent.

When an injector is used only to lift water and the heat put into the water by the steam passing through the injector is wasted, it may be true that the efficiency cannot exceed 20 per cent. But when an injector handles boiler feed, all of the heat imparted to the water goes back into the boiler. In such cases the efficiency is very high, possibly 98 or 99 per cent. It seems to me that the set of similar conditions surrounding the use of the injector principle in a regenerator would permit a high efficiency to be obtained.

Karl [illegible]

Lowell, Mass.

Water Gage Connections

With regard to Mr. McGahey's letter in the December 13 number, I believe that I am right when I say that fully 90 per cent. of the engineers favor valves placed in the water-column connections. It has been said that a careless boiler attendant might close one of the valves for some reason and forget to open it again. Just so a careless boiler attendant might do any of a hundred other possible things, but it is the duty of the head to see that no careless boiler attendant is allowed on the job.

James E. Noble.

Toronto, Ont.

Experience of an Indicator Man

In the December 6 issue of Power, W. E. Hopkins makes a few comments on how easy it would be to get an even cut-off on a corliss engine, by stating that if the cutoff was equal, both steam valves would stop cutting off at once. Does he not know that if the dashpots both raised to the same height before cutoff took place that the engine would have the late cutoff at the head end? Mr. Hopkins certainly knows that the piston of any reciprocating engine travels faster in either direction in the head end of the cylinder than in the corresponding position in the crank end, after the crank pin is past the quarter mark on the crank-end side; and a thinking man can easily see that the steam valve on the crank end would have to remain open longer to get a steam line equal to the head-end steam line. The only way to secure this longer interval is to have the pot lift higher before cutoff takes place.

[illegible]

Emmetsburg, Iowa.

Installing Globe Valves

For a number of weeks past there has been a discussion on in the columns of Power as to the proper method of installing a globe or an angle valve.

For several reasons, the chief of which is that I believe it to be the only safe method, I am strongly in favor of having the pressure come under the disk, tending to open the valve and throwing the stress of the steam pressure on the threads of the stem, when the valve is closed.

About ten years ago I witnessed an incident which came near being an accident, and which convinced me of the danger of having the pressure come over the disk.

In the plant of which I am now in charge we had at that time six horizontal return-tubular boilers, all 66 inches in diameter. Nos. 1 and 2 were lap-joint iron boilers 15 feet long; the other four were lap-joint steel boilers 18 feet long. All of these boilers were fitted with 5-inch lever safety valves on the front nozzles, and 5-inch angle stop valves on risers from the rear nozzles. The stop valves were placed with the stems horizontal and the boiler pressure came above the disk, tending to hold it to its seat.

On No. 1 boiler the safety-valve lever was turned toward No. 2 boiler and reached nearly half way over the setting. There was a 1¼-inch steam pipe which came down between the front of boilers Nos. 1 and 2 and passed horizontally close to the end of the No. 1 safety-valve lever. This pipe was used for tube blowing and the steam blowers under the grates.

Now, we have great difficulty, out in the country here, in getting good men for night watching and boiler tending. Nobody wants the job at any price; we have almost to beg men to take the job. Importing men from the neighboring city is a dead failure; about three days is the average city man's stop on the job. Nothing doing, you know; and they come and tell you, "It's too lonesome here," and can they get their pay? So, generally, our night help on the boilers is pretty poor. At the particular time to which I am referring, our night men were particularly thick in the head.

One morning in January, 1900, the man on the fires in some way or other got the 1¼-inch blower pipe moved or sprung over the end of the No. 1 safety-valve lever, thus holding the valve tightly to its seat. The Nos. 1 and 2 boilers had been banked during the night and the stop valves closed. When the watchman had raised the pressure in these boilers to equal that in the line, he opened the stop valves, or supposed that he did, and as it was cold he started to build up some pretty big fires.

These two boilers were 20 years old and insured for 90 pounds pressure. They had had considerable repair work done on them at one time and another and were not considered to be very safe for pressures over 100 pounds. It was lucky indeed that the master mechanic, who had charge of the boilers at that time, got down earlier than usual that morning. When he got into the boiler house, the watchman told him that the No. 1 pressure gage was out of order; the pointer was loose, he thought. It was a 150-pound gage and when the master mechanic looked at it the pointer was where the 155-pound mark would have been if the scale had extended that high. He got a ladder to get at the gage, and then noticed that the pointer was vibrating stiffly and was evidently tight on the spindle. Just then his eye caught sight of the pipe over the safety-valve lever and he jumped up and tried the stop valve. From the feel of the valve he concluded that the disk was off the stem and that the boiler pressure was holding the valve closed. Then, he got excited and jumped for the safety valve, sat on the lever and sprung the steam pipe free and then got off and let her blow. She did; considerable. No, there was no water hammer, and the boiler did not go through the roof. It stayed right where it was and blew down to the regular pressure in a commonplace but noisy manner.

The fire was drawn, the pressure reduced and the valve bonnet removed. The disk had pulled off the stem, the stem collar pulling through the nut.

Now, if this valve had been put on the "other end to" with the boiler pressure under the disk, there would have been no dangerous trouble at all. It would not have been necessary to shut down the boiler to fix the valve at that time; it could have been left for a more convenient time. Of course, the stop valve was not responsible for the blocking of the safety valve; it was merely a coincidence that the safety valve was useless when badly needed. That steam pipe was moved before noon that day. All the stop valves on the other five boilers lost their disks in the same way a number of times after this, but as the safety valves worked, nothing exciting or dangerous happened.

As soon as I was given charge, I had all of these valves turned so as to bring the boiler pressure under the disks; and I never had any trouble with them. The No. 1 boiler was apparently not hurt by its experience of high pressure, for we ran it hard for four and a half years after the occurrence until the insurance company lowered the pressure to 50 pounds. Boilers Nos. 1 and 2 were replaced in November, 1904, with two 72-inch by 17-foot butt-joint steel boilers of the same make. The old boilers were 25 years old when replaced, and were cut up right away. We never sold an old boiler, as a boiler; it was always cut up for junk; if it was not safe for us, it certainly was not safe for anybody else.

Now, a globe or an angle valve with the pressure under the disk may fail in two ways. The threads on the stem or in the bonnet may strip, or the disk may split in two. In either case the valve would be open for the passage of steam and if the disk is whole and only the threads stripped, the valve may be closed by means of a lever over the top of the stem; the steam pressure will open it again when the lever is released.

When the pressure is over the disk, the valve may fail by stripping the stem or bonnet threads, by the stem pulling in two or by the disk coming off the stem, caused either by the stem collar pulling through the retaining nut or by the threads of this nut stripping or the nut backing out. In all of these cases of failure the valve would be closed to the passage of steam, and it would be impossible to open it under pressure except in the one case of the stem or bonnet threads stripping, in which case the valve may be opened by means of a lever under a collar or lathe dog on the valve stem. However, when the pressure comes over the disk, 75 per cent. of the failures are caused by the disk in some way coming loose from the stem.

In the December 13 number of Power, J. W. Parker speaks of two throttle valves in which water hammer had upset the stems, and says that he advised reversing the valves. I do not think that this advice was good, for if the water hammer was severe enough to upset the valve stems when acting from under the disk it would quickly drive the disk off the stems if it acted on the top of the disks, and then the valve could not be opened at all and he would be in a worse fix than the upset stems put him.

The inspection department of the Factory Mutual Fire Insurance Company would quickly make him change the fire-pump throttle so as to bring the pressure under the disk. They will not accept a gate valve on a fire-pump steam line; it must be a globe or an angle valve with the boiler pressure under the disk.

As to feed valves, they should be placed so that the feed-pump pressure comes under the disk, and an extra valve should be placed between the check valve and the boiler so that the check valve can be reground or the feed valve repacked while steam is on the boiler.

Never place a valve on the feed line in such a way that if the disk comes loose the pump pressure will close the valve and obstruct the feed line.

Angle blow-down valves may be the one exception that goes to prove the general rule, but in all other cases I want the pressure to come under the disk of a globe or an angle valve. Blow-down valves are constructed so as to protect the seating surfaces of the valve body and disk, and the position the valve is placed in depends a great deal on the method used to protect the seats from the cutting action of boiler scale. I heard of a case in one plant where they had lots of trouble getting the water out of a boiler, owing to the blow-down valve plug or disk coming off the stem.

BENJAMIN S. HANSON.

Broad Brook, Conn.

Liquid Discharging Device

Mr. Pagett's description of his invention for discharging liquids from barrels looks very much like a device that I made some years ago, to empty oil from barrels to the shop tank, only he has not given a very necessary dimension, that is, the size of the air inlet.

In making my device I figured on using 80 pounds air pressure, but as I did not think a barrel would stand that pressure I reduced the inlet for the air to 0.03 of an inch in diameter, figuring that the oil would run out of the 1-inch exhaust pipe fast enough to keep down the pressure, which it did, and the thing worked fine. I used it in the shop for several months, until one day the helper whose duty it was to look after the oil used it in a barrel of lard oil that was chilled. He put in the device and turned on the air and in just a minute the lard oil was all over the floor and the helper looked as though he was suffering from shock; I know that I was.

I have never seen my device from that day. It may have gone West. I would advise anyone who wants to use Mr. Pagett's invention to see that the inlet hole is something less than 0.03 of an inch in diameter for 80 pounds pressure and that there is a safety valve on the job.

J. J. SEIBERT.

Washington, D. C.

The Expansion Valve

In looking over the October 25 number of POWER, I came across an article by Mr. Reynolds in criticism of an article, in the August 30 number by Mr. Nash, regarding the expansion valve.

In reading the two articles one would conclude either that one of the gentlemen is not posted or that expansion valves differ greatly.

I will not attempt to tell anything about Mr. Nash's expansion valve nor yet about the one operated by Mr. Reynolds, but will tell you about one which I have in connection with an absorption machine which I am operating at present.

The best way of which I know to describe the action of ammonia in the brine cooler is to compare it to the well known action of water in a steam boiler, both under operating conditions. In fact, from a mere verbal description of a brine cooler and steam boiler it would be very difficult to distinguish one from the other.

By way of comparison, I will say that a steam boiler is a cylindrical shell with tubes or pipes extending from end to end and so is a brine cooler, though the pipes in the brine cooler are formed into coils.

The boiler is partly filled with liquid (water) and the remaining space is filled with gas (or steam).

The brine cooler is partly filled with liquid ammonia and the remaining space with ammonia gas. In the steam boiler part of the heat in the flue gases which traverse the tubes is absorbed by the water, a part of which passes into steam.

In the brine cooler part of the heat in the warm brine which traverses the tubes is absorbed by the liquid ammonia, a part of which passes into ammonia gas.

In the boiler the temperature of the flue gases is lowered and the water would soon cease to boil or give off steam if more heat was not supplied by replenishing the fire.

In the brine cooler the temperature of the brine is lowered and the ammonia would soon cease to boil or give off gas if more heat was not supplied in the form of more warm brine.

Water is a great absorber of heat. In fact, it comes pretty near holding the record. Its value as a heat absorber is due to its latent heat, that is, the amount of heat necessary to change it from the liquid to the gaseous state.

Ammonia owes its value as a heat absorber (or as a refrigerating medium) to its latent heat, which is the amount of heat necessary to change it from a liquid to a gaseous state.

A boiler filled with steam would absorb very little heat compared to what it would absorb if partly filled with water, and a brine cooler filled with ammonia gas would absorb only a small per cent. of the heat which it would if partly filled with liquid anhydrous ammonia.

If Mr. Reynolds will fill a test flask about half full of liquid anhydrous ammonia and expose it to the air, he will notice that the flask will frost from the bottom up to the liquid level, which goes to prove that the liquid absorbs the heat. For, if the gas absorbed the heat, it would frost from the liquid level to the top.

Now, to return to my expansion valve: only liquid ammonia ever passes through it, in the form of a coarse spray, and such is the case with all the expansion valves with which I have had any experience (with one exception). The exception was in connection with an air refrigerating machine where the refrigerating agent is not liquefied.

As a matter of fact, I keep my brine cooler two-thirds full of liquid anhydrous ammonia at all times. The expansion valve controls the amount of liquid fed but it has nothing whatever to do with the rate of expansion. That is controlled by the amount of heat supplied or, in other words, by the temperature of the brine, just as the steaming of the boiler is controlled within certain limits by the temperature of the fire and not by the feed pump or injector.

My brine cooler is fitted with gages which enable me to tell to a nicety just how much liquid ammonia I am carrying.

I often shut down with the brine cooler three-fourths full of liquid anhydrous ammonia, and in starting up only open the cold-gas valve between cooler and absorber and run this way until the liquid level in the cooler is somewhat lowered. I have often noticed that when running in this way with the expansion valve closed, the brine cools even faster than after the so called expansion valve is opened.

There has been considerable talk during the past few years about the "flooded system." It seems to me that a brine cooler operated in this way constitutes the important part of an ideal flooded system.

FRANK MIDDLETON.

Sedalia, Mo.

Underground Pipe Covering

Some years ago I was called upon to devise some means of protecting an underground steam pipe similar to that mentioned by W. P. C. in POWER for December 13. The pipe was 4 inches in diameter and carried steam at 90 pounds pressure. The pipe was about 200 feet long and up to the time of my investigation had been laid in a box made of planks and filled with ashes or other material that would form a suitable insulation. Trouble had been experienced and the pipe had to be taken up for repairs about every 3 to 8 months.

At times the trench would nearly fill with water; this caused condensation to take place so rapidly that a very severe water hammer was the result, especially when the steam was shut off, or when first turned on.

After looking the situation over, I selected some old 6-inch wrought-iron pipe with screwed joints. This pipe was connected up and tested with steam at about 20 pounds pressure, which was left on for an hour, so that we could be sure that no leaks existed. We then placed the 4-inch pipe inside the 6-inch and laid it in the box formerly used, packing ashes solidly about the 6-inch pipe. A trench just wide enough to accommodate the box was then made. A space of about 8 inches was left underneath the box, which rested on supports spaced about 10 feet apart.

One end of the 6-inch pipe was closed tightly about the 4-inch and the other end loosely so. This prevented a circulation of the inclosed air and formed a very satisfactory insulation. The entire arrangement proved so effective that I never heard from it afterward.

In many cases of underground steam-pipe work the trench is dug with a pitch toward one or both ends, for the purpose of draining the water into a catch basin, which is arranged with a float to automatically control a siphon or steam pump to remove the water. In some cases the float is connected to a signal which serves to call the attention of the person who has been assigned to the duty of controlling the water in the basin.

H. S. Brown.

New York City.

I noticed on the page of "Inquiries of General Interest," in the December 13 issue, a question by W. P. C. in regard to insulation for underground steam pipe.

It is the general practice among steam-distributing companies to insulate the pipe with a 4-inch thick wood covering, the inside diameter of which is 2 inches larger than that of the pipe.

The inside of the covering is lined with tin, and the outside is given a coat of asphaltum and tar paper to make it waterproof. This is laid on about 6 inches of broken stone in a perfectly drained trench, which is back filled with cinders.

If W. P. C. follows the above suggestions he will have a very satisfactory and efficient job. He will also realize a saving in fuel, for the loss by condensation will be less than with his present arrangement.

Fred. Glass.

Chicago, Ill.

Federal Laws

In the December 6 issue of Power, F. E. Albrecht cites his experience with license laws and adds that "he wishes he had let license laws alone and not bothered his head about them."

I would like to draw Mr. Albrecht's attention to the first-page editorials of Power for November 22 and December 13; they might help some. Also, I wish to point out the fact that engineers in other license districts and towns have had much the same experiences before getting satisfactory results with the license laws.

Apparently, if Mr. Albrecht and his associates had turned their efforts and money to use in getting a Federal license law started or passed, they might have secured some benefit for themselves and their Eastern brothers at the same time.

A good Federal law would do away with all conditions such as those of which Mr. Albrecht complains and, in addition, would place all engineers on an equal footing, both East and West.

There is a law providing for Federal inspection of locomotive boilers, up for consideration by Congress now. What were the various engineers' associations doing when that law was being drafted? Why did they not get busy and have that law extended to cover all stationary boilers within the United States and colonies?

Practically the same men could take care of the inspection work, and I am sure that there is greater need of Federal inspection of stationary boilers than there is of locomotive boilers. The latter are all overhauled and practically rebuilt every year, in the railroad shops, while stationary boilers are kept on operation just as long as they will hold steam and water, and are often operated for months at a time without ever being opened. Yet, there are thousands of lives in danger from explosions in stationary plants for every one in danger from locomotive-boiler explosions, to say nothing of the vast amount of property.

I am not decrying the bill; we need it, but it is only half a bill, only a waste of valuable time and money unless it is extended to include stationary boilers and made a partner to a measure providing for the proper examining and licensing of stationary operating engineers.

Why is it that we do not see or hear more about Federal license laws?

I have been talking and advocating them for five years, trying to get engineers and other men interested in pushing a Federal license law. But, while everyone agrees that it is what we should have, none seem to want to start it going or to help start it. Who started the locomotive boiler-inspection law? Locomotives have been operating in this country almost as long as stationary engines with no law to control them except the railroad rules, while the stationary engine has always been more or less controlled for years.

Wake up, brothers, and get to work; look a little further ahead than your own nose. When you think of a license law do not stop with the boundary line of your State, but reach out; try to help the man out West and down South. In other words, work for the good of all the engineers in this country, not for the few located just in your own town or State.

If every engineer in this country will do his share in this, we can have a Federal law so close on the heels of that locomotive boiler-inspection law that it will scare it. Think it over and act.

A. A. Blanchard.

Oak Harbor, O.

Boiler and Tube Failures

In reference to the numerous articles on boiler explosions and with especial reference to those on a boiler-tube failure, pages 2128 and 2131, in the issue of November 29, it may be pertinent to inquire whether the reduced thickness from No. 10 gage to nearly 1/32 of an inch at the point of rupture was due to an initial defect in construction, or to internal or external corrosion. If to one or both of the last two, which was the greater inducer, and why? It has been for many years my belief that if we could unite copper with iron and steel after the manner in which gold-plated ware is made on a commercial basis, which I think may be done, the product might be good for boiler shells, tubes, steam and other pipes, etc.

Possibly this might be done to some extent in the manufacture of seamless tubes, and tend to increase the efficiency in economy in steam plants. While the days of the all-copper fire box, staybolts, etc., are doubtlessly past, maybe that copper-plated ones may supersede the ones at present in use. Though much has been said and written by professors and theorists on the forms, construction operation and explosions of boilers and the relative effects of punched, drilled and reamed rivet holes; lap and butt joints, single- double- and triple-riveted, as compared with the initial sheet before being bent and formed, but little has been said of the effects of the strains set up by the forming process. If anything has been said in condemnation of the location of the seams joining the upper to the lower half of the sheets of horizontal boilers, I have yet to learn of it. Why is this seam universally regarded as being the weakest part of the boiler shell situated at a line naturally subjected to the greatest amount of frictional effects by reason of the active elevation of the surface of the water and also the point most susceptible to the effects of corrosion?

Would not these considerations then lead us to the logical conclusion that, if but a single line of joint be used, it should be placed in a position least subject to these effects—at the very bottom of the boiler—even though it would there be subject to strains due to the weight of the water in addition to the pressure to which the upper half of the circumference is subject?

If a diagrammatic chart were constructed of a boiler made practically perfect in all its parts as now constructed and operated; depicting its changes at numerous equidistant points circumferentially and longitudinally; from the first application of heat and at regular points in the increase of the rate of heat absorbed, up to the working pressure desired, when at rest and operating the motor, I think the chart would be curious and, possibly, instructive. If applied also to individual tubes and heads in like manner, probably even still more curious effects would be shown, many parts are fatigued, like overworked men, while others have comparatively easy times.

John W. Payler.

Detroit, Mich.

POWER

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Contents

Overpressure on an Old Boiler

In the Pittsfield boiler explosion is the first instance of an explosion of a boiler which was entirely under the jurisdiction of the Massachusetts district police, and it should not be difficult to place the responsibility for this calamity.

In all of the preceding explosions since the inspection laws of this State went into effect, the boilers have been insured by some commercial inspection and insurance company, and the State inspectors have had little to do with them beyond the examination of reports filed at the State house.

In this instance the boiler was examined by a State official who fixed its operating conditions. A man also examined by a State official was given permission to operate boilers and engines on the supposition that he was duly qualified for such work.

This safe boiler was put in the hands of the qualified man and exploded, on the very first day of its service, snuffing out the lives of twenty human beings.

It is not known what pressure caused the calamity, nor is it possible to approximately estimate it, but it is probable that it was far in excess of that fixed by the inspector. The boiler may have been safe for the pressure allowed, but it is highly probable that the pressure was carried beyond the safe limit by a misunderstanding on the part of the man of the paramount importance of the fact that safety valves and pressure gages should agree.

Profit Sharing Plan of the Brooklyn Edison Company

The recent action of the Brooklyn Edison Company in announcing a profit-sharing and pension system has evoked both favorable and adverse criticism; the optimist regards it as a substantial recognition of the employee's right to share in the profits of labor, while the pessimist can see in it only a scheme to keep the men in a state of virtual serfdom under the guise of pretended benevolence. In spite of whatever grounds these extremists may find for basing their contentions, the plan is to be commended more than condemned.

The avowed purpose of the plan as set forth in the company's announcement to its employees is "a recognition of faithful and efficient service and the encouragement of thrift and investment in the securities of the company." Reading between the lines shows the first part of this statement to be a purely business proposition: the company in return for a bonus expects to receive better service, to make the employees feel a personal interest in the company, thereby eliminating one great source of waste, and to retain their employees for longer periods of time, in this way doing away with the bother and loss in efficiency through continually breaking in new men.

The terms stipulate that those who have been with the company two full years shall receive a percentage of their wages for 1910 equal to one-fourth of the rate of dividends paid on the capital stock of the company during the past year; those who have been with the company three, four and five years shall receive, respectively, one-half, three-fourths and the full rate of dividend. This money, however, cannot be withdrawn by the employee within three years, except in special cases; but instead is deposited to his credit with the Brooklyn Edison Investment Fund, he receiving only the interest upon the dividend. Expressed in dollars and cents this would be as follows:

Assume that a fireman has been in the employ of the company for three years. His wages amount to $910 per year and if the rate of interest on the capital stock is eight per cent. (a fair estimate based upon the figures of past years), his share of the profits would be $36.40, but as this is turned over to the Investment Fund, he would receive only the interest which, at five per cent., would amount to $1.82 one year from this January. A watch engineer under the same length of service would have $58.24 placed to his credit and would receive $2.91. At the expiration of six years of service the fireman would be entitled to withdraw $163.80 and still have $72.80 to his credit, which latter sum he would receive annually thereafter. This would be equivalent to an increase in weekly wages of $1.40.

Although these figures may appear insignificant, their fairness, after five years of service, cannot be questioned. If a man's labor be considered as part of the working capital of the company, and providing he receives equitable wages, his share in the profits is obviously a percentage of his yearly wages equal to the rate of dividend paid on the capital stock of the company.

Flywheel Rims

It may not be too late to suggest that there is still room for improvement in the design and construction of the rims of large flywheels. That there has been progress in the past ten years is generally admitted, but there still seems to be a lack of knowledge on the part of some builders, of the essential weakness of the old-fashioned joint for wheel rims.

That this weakness is not confined to flange joints is evidenced by the sample of a large wheel on the engine of a plate mill which was examined some years ago and found to have a safety factor of only two. That is, an increase in speed of about 40 per cent. would have wrecked the wheel. This engine and its flywheel were built by a firm of national reputation and were in other respects of a high standard of workmanship, but the keyed joints of the wheel rim had only a small fraction of the strength of the rim itself.

In order to clear up any misunderstanding on this important feature of engine design, it may be well to state a few facts which have been determined partly by calculation but largely by direct experiment on smaller wheels.

A thin, comparatively wide, cast-iron rim such as is used on belt wheels, is subjected when in motion to tension along its circumference caused by the centrifugal force, just as a boiler shell is subjected to tension due to the internal pressure.

If the rim is unrestrained by the arms, as is the case in some wheels having the arms free to slip in the rim sockets, this tension in pounds per square inch of rim section will be expressed very nearly by the fraction, $v^2 \div 10$, for cast iron, where v is the rim velocity in feet per second.

Assuming the tensile strength of soft, gray iron to be 16,000 pounds per square inch, $v^2 \div 10$ would equal 16,000, and v would equal 400 feet per second, the bursting velocity.

Numerous experiments have verified this conclusion and have further shown that in wheels with whole rims, as ordinarily designed, the influence of the arms is negligible. The effect of arms which rigidly connect hub and rim is to restrain the rim from expanding, cause it to assume a wavy outline and to induce contrary bending moments at the arms and at points midway between the arms. This action causes stresses of tension, compression and shear which combine with the tension already existing to produce complicated resultant stresses. These are further complicated by the stretch of the arms themselves and by the initial stresses due to cooling strains. An ordinary cast-iron pulley having six or more arms will, however, burst at about the speed above indicated.

The introduction of rim joints changes all this, especially if the joints are between the arms. The addition of flanges or bosses and the introduction of heavy bolts or links for fastenings very much increase the local centrifugal force and therefore increase the bending moment at that point.

It is as if we had a plate girder, spanning a gap between two abutments and designed to carry a certain uniform load, and should proceed to cut it in two at the center, fasten it together by bolts located near the top flange and then put a large concentrated load at the point of weakness. We would naturally expect failure.

To illustrate the enormous force sometimes exerted by concentrated weights, we may consider a wheel twenty feet in diameter running at two hundred revolutions per minute or about one-half its bursting speed. The centrifugal force of a one-pound bolt in the rim at this speed would be about one hundred and forty pounds. A cast-iron double flange on such a wheel might weigh two or three hundred pounds and would exert a pressure of fifteen or twenty tons tending to rupture the joint.

For the same reason, balance weights inside the rims of high-speed pulleys are always a source of danger.

Experiments have shown that wheels having flange joints between the arms sometimes burst at less than half the speed attained by whole-rim wheels.

Now, whatever factor of safety is adopted in determining the safe speed of such wheels, this fact must be remembered:

A flywheel requires a certain interval of time to attain a dangerous speed and the larger this interval, the better for all parties concerned.

The racing of a flywheel is usually due to temporary disarrangement of the governor and depends upon the difference between the full energy of the steam and the load which the engine happens to be carrying at the time. If the flywheel is so designed that the bursting speed is three times the normal, there will ordinarily be ample time to close the throttle and prevent an accident.

Furthermore, it is known that air resistance and friction are considerable at high speeds and exert a marked retarding effect. If a wheel has radial ribs upon the faces of arms or rim the air resistances may be sufficient to prevent the attainment of dangerous speed.

Granted that any wheel will burst at some speed, it must be admitted that the wider the margin between the normal and the bursting speeds, the less the danger of accident.

It requires less courage to close the throttle when the engineer knows there is a respectable factor of safety in his flywheel.

Graft

The frank expression of such opinions as that of Amos Skeg in our issue of December 20, to the effect that "sales people and not the engineer or the employer are the ones to benefit by a too critical view of what constitutes a bribe," is not calculated to accelerate the movement for the abolition of graft. The picture of an employer conspiring with his engineer to get more out of the seller of supplies than the face of the bill calls for is not flattering to the employer and is degrading to the employee, who, to put it in its most charitable light, has received his master's permission to accept tips like any menial.

Where are the high ideals of the professional engineer?

No Boiler Explosions in Montana

Although last year was one of the most disastrous in the matter of boiler explosions, Montana's record shines out bright and clear, for during the entire twelve months not a single boiler explosion occurred. J. H. Bailey, State boiler inspector, is proud of this record. During the year three inspectors traveled 23,306 miles to examine internally and externally 2021 boilers.

In those inspections 2382 defects were noted, 1819 of which were considered dangerous, and suitable repairs were ordered made. Eleven boilers and seven mud drums were condemned as unfit for further service and pressure was reduced on 43 boilers.

The man who mistakes a mark on the gage glass for the water line, can be classed with the man who knocked the milk pitcher off the table, mistaking it for the cat, or tried to hang his coat on a nail only to find that it was a housefly.

The average man refuses to buy a clay pipe with a piece broken off the stem, but breaks off the stem to suit himself. This seems to be the case with the engineer who buys nicely finished brass unions and mars them all up with a stilson wrench.

Do not be hasty in prophesying failure, as things are sometimes practical that do not look so. It is often easier to make a thing work than to try to convince your boss to the contrary.

The engineer gets into trouble with two kinds of appliances: one is imperfect, and sticks; the other is too perfect, and sticks.

Reliability of both men and machines consists in their working when your back is turned.

Boiler Explosion in Pittsfield, Mass.

By F. L. Johnson

An incorrect steam gage leads to screwing down on the safety valve, causing an overpressure, which blew the boiler into more than fifty pieces, some of them no bigger than a man's hand, and threw pieces of boiler and engine weighing hundreds of pounds an eighth of a mile.

The Morewood Ice Company's plant at Pittsfield, Mass., was the scene of a disastrous boiler explosion at 9:45 on the morning of December 29, when 12 men were instantly killed and 20 or more injured, 5 of whom died later. The boiler was of the locomotive type surmounted by a 10x18-inch slide-valve engine which was scattered with parts of the boiler in all directions.

The barrel of the boiler was 36 inches in diameter, built in two courses of [illegible]-inch charcoal-iron plates, and was 7 feet between the heads, in which there were fifty-three 2[illegible]-inch tubes. Both the longitudinal and round-about seams were double riveted. The fire box, water leg and crown sheet were slightly over 5/16 inch thick. The crown sheet was supported by crown bars and the sides were supported by [illegible]-inch staybolts, pitched 4[illegible] inches.

During its many years of service, the fire-box portion had been subjected to a varied course of repairs, one being a strip of [illegible]-inch steel plate going around three sides.

As near as can be learned, the boiler was approximately 40 years old and had been in intermittent service in various parts of the State from Holyoke to Pittsfield. It was picked up at a bargain four years ago at Springfield, near where it had passed several years doing duty in a small sawmill and had carried a working pressure of 125 pounds. During the ice harvest the boiler was used from 10 days to two weeks and lay idle the rest of the year. There were in the boiler house when the explosion took place about 20 men, not one of whom is alive to give any information of what was going on immediately before the failure. It is reported that the boiler was inspected last March by one of the Massachusetts State inspectors who ordered some minor repairs and fixed the working pressure at 70 pounds, and ordered the purchase of a new steam gage and safety valve.

Fig. 1. Main Part of Fire Box

In accordance with the orders of the State inspector the repairs and changes suggested when the boiler was inspected in March were made before the boiler was put under steam. These consisted of a new water glass, a [illegible]-inch steam-gage connection conforming to the rules of the Board of Boiler Rules, a new steam gage and a new safety valve. Also a thorough cleaning of all bricks, dirt and ashes from inside and around the fire box.

Steam was raised for the first time this season on the day before the explosion, and the safety valve blew when the steam gage indicated a pressure of only 35 pounds. The tension on the valve spring was increased and the gage taken to a local plumber for testing and repairs, after which it was replaced on the boiler.

One man who had left the boiler house just before the failure reported that the gage showed a pressure of 40 pounds when he left and that steam was blowing from several places about the boiler.

Fig. 2. Cylinder of Engine

It was not a lap-seam failure and with the exception of the single riveted joint at the smoke-box end, nearly all of the ruptures tore through solid metal. It was not a case of tearing along the lines of least resistance but more as if the explosion was caused by a charge of dynamite.

Some slight idea of the force expended may be gathered from a study of the direction of and the distance to which various parts of the boiler and engine were thrown. The fire box was torn from the barrel and, like a pasteboard box, crushed and hurled backward against a corner of one of the ice houses, while the engine cylinder sailed off to one side, landing about 200 yards away on the hill side, dropping the piston and slide valve on the way. One side of the fire box and a part of the head landed diagonally about 100 feet away. The middle course, with rags of iron torn from the fire box, went nearly 500 feet in a direction opposite to that taken by the engine cylinder, cutting off the tops of several trees on its way.

About 50 feet in front of the boiler were two trees growing closely together, between which the flywheel end of the crank shaft dropped on its course southward. The other end of the shaft, with the connecting rod and the crosshead from which the piston rod had been pulled, shearing the 2[illegible]-inch taper key, fell about 25 feet to one side. The front course was torn from the head and fell in several pieces quite near, while the front head went fully 100 feet directly forward.

The safety valve, which was found about 50 feet away, was taken by the chief of police to one of the plants of the Pittsfield Electric Company, where it was

FIG. 3. MIDDLE COURSE THROWN 500 FEET

FIG. 4. PART OF MIDDLE COURSE WITH PART OF WATER LEG

subjected to a pressure of 154 pounds per square inch, which failed to open it. No additional pressure was put on the valve at this time. Later it was taken to the laboratory of the Stanley works, where it was subjected to a dead-weight test of 161 pounds without opening. It was finally forced open by the application of a water pressure of 225 pounds after which it popped repeatedly at pressures ranging from 210 to 220 pounds.

While the failure was almost instantaneous in all parts of the boiler, it is probable that the initial rupture started in one of the water-leg sheets where the feed-water pipe entered, as near this point the metal was eaten away to about one-third of its original thickness. There was no evidence of low water and the fusible plug taken from the crown sheet is in good condition. It was a case of overpressure caused by an incorrect steam gage which led to the screwing down on the spring of the safety valve.

Proportion of Nitrogen in Flue Gas

BY JULIAN C. SMALLWOOD

In view of the occasional publication of improbable, if not impossible, results from flue-gas analyses as made from apparatus such as the Orsat, it seems worth while to call attention to the significance of the proportion of nitrogen. The amount of this constituent of flue gas, in the case of coal combustion, is always nearly 80 per cent. if the accompanying results are valid. The reasons for this are as follows:

The proportion, by volume, of the oxygen to the nitrogen in the atmosphere is approximately 21 to 79. If pure carbon were used in the furnace, no matter how much air were admitted, these same proportions of oxygen to nitrogen would be found in the flue gas. For example: if just enough air for complete combustion were used and if, under these circumstances, the combustion were complete, the reaction would be

$$79\ N_2 + 21\ O_2 + 21\ C = 21\ CO_2 + 79\ N_2,$$

the right-hand member representing the flue gas, in which there are twenty-one molecules (that is, volumes) of oxygen, in the CO_2, as in the air.

The effect of the nitrogen, oxygen and hydrogen in the coal actually burned is to alter the proportion of oxygen to nitrogen originally existent in the air. But the amounts of these elements in the coal are small; therefore, the proportion of 21 to 79 is approximately realized in actual flue gas. If anthracite coal is

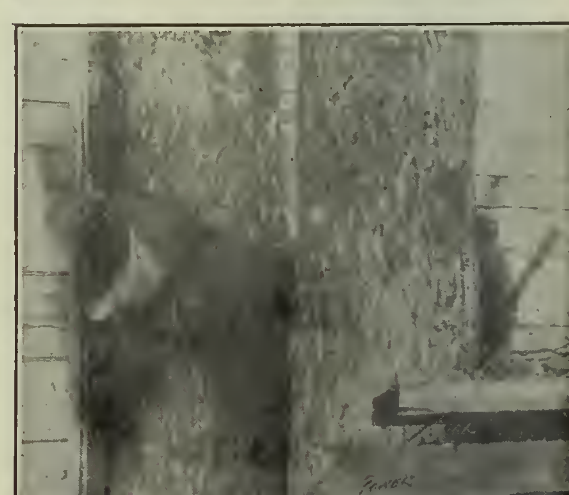


FIG. 5. PART OF CRANK SHAFT IN TREE CROTCH

used, the effect of its constituents in altering the proportion is slight; but with bituminous or semi-bituminous coals it is more marked, on account of the comparatively large amounts of hydrogen and oxygen. Part of the hydrogen may be considered to combine with the oxygen of the coal to form water, which does not appear in the flue-gas analysis. What is left of the hydrogen combines with oxygen from the air, and this tends to reduce the proportion of oxygen apparent in the flue gas. The nitrogen in the coal also has this effect, since it increases the total nitrogen, but not so much as would superficially appear. Coal containing 2 per cent. by weight of nitrogen would add to the flue gas a very much smaller percentage by volume, nitrogen being a heavy gas. Furthermore, the flue gas is formed by the combination of several pounds of air with each pound of coal; the proportions of the coal's ingredients when in the flue gas are less than when in the coal.

Since the ratio of oxygen to nitrogen remains the same and since the oxygen appearing in CO occupies the same volume as free oxygen, it follows that the percentage of nitrogen as shown by the analysis will be approximately the same as in air; namely, 79. If CO is present, the percentage of nitrogen will be reduced, because this gas occupies twice the volume of the free oxygen entering into its composition. But as the CO is usually only a fraction of 1 per cent., if present at all, its effect to lessen the percentage of nitrogen is not marked. Free hydrogen, on the other hand, is measured as nitrogen and tends to increase its apparent volume, but it, too, is likely to be present in very small quantities.

The foregoing facts may be demonstrated by calculating the reactions for various combustions of a coal high in hydrogen and nitrogen and comparatively low in oxygen, to show the resulting percentage of nitrogen in an extreme case. Such a coal is represented by the following analysis:

Carbon, Per Cent	Hydrogen, Per Cent	Nitrogen, Per Cent	Oxygen, Per Cent	Sulphur, Per Cent
[illegible]	[illegible]	2	[illegible]	1

Following is the flue-gas analysis which theoretically would result from such a coal. The calculations for the reactions neglect the SO from the sulphur and complete combustion of hydrogen is assumed.

	CO_2, Per Cent	O_2, Per Cent	CO, Per Cent	N, Per Cent
With [illegible] per cent. excess air	12.5	[illegible]	0	[illegible]
With no excess air (complete combustion assumed)	[illegible]	0	0	[illegible]
With [illegible] excess air (incomplete combustion assumed)	[illegible]	[illegible]	[illegible]	[illegible]

These results show, as would be expected, that the greater the excess air the more nearly does the percentage of nitrogen approximate to 79. Also, it may be observed that, although the CO decreases the percentage of nitrogen, the ratio of total oxygen to nitrogen is the same as in the case of complete combustion with the same amount of air. When anthracite coal is used, the percentage of nitrogen is between 79 and 80. It is not likely to exceed 81.2 even in the case of bituminous coals, and every excess of this figure renders the results questionable.

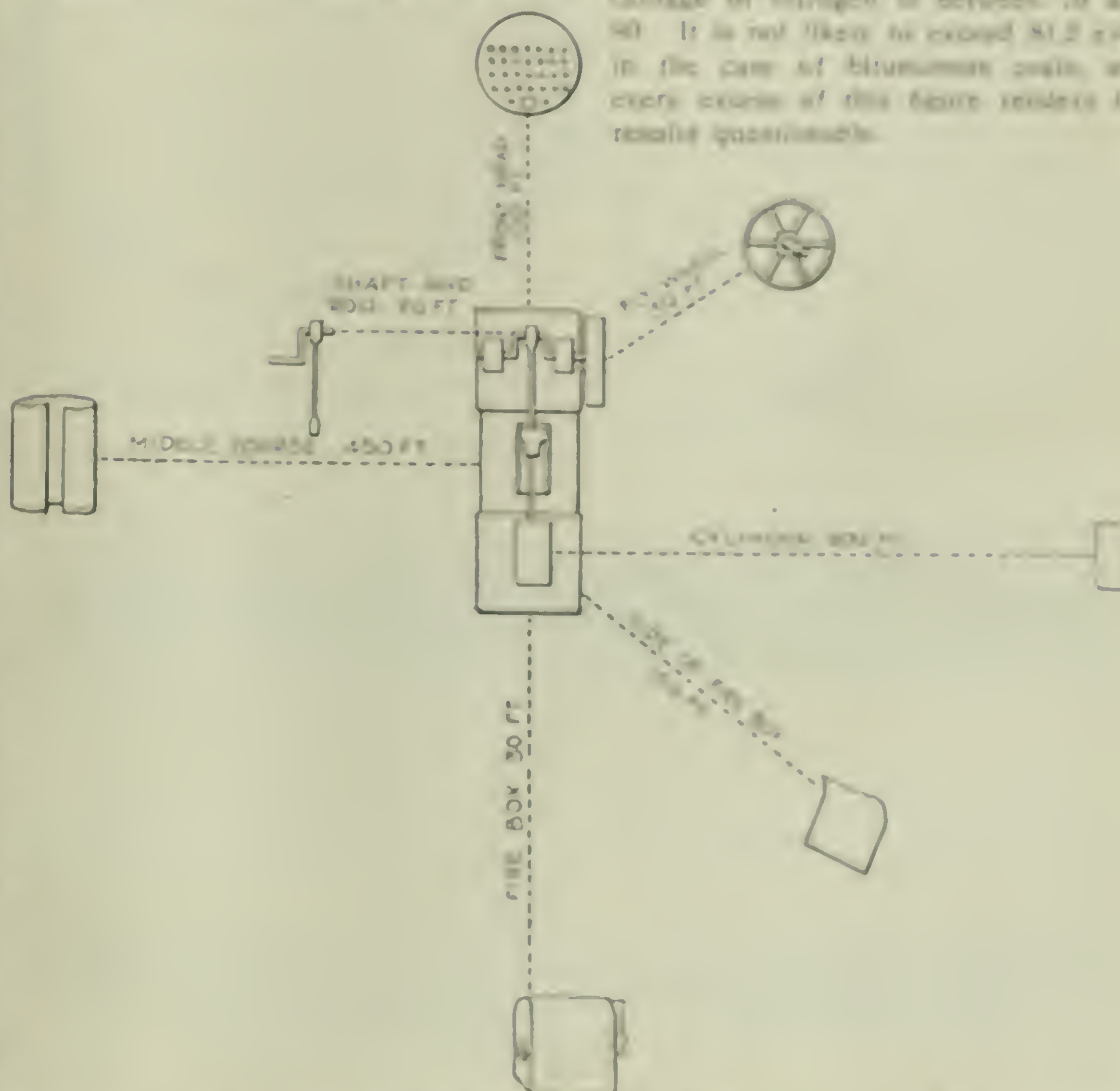


FIG. 7. PATHS TAKEN BY THE VARIOUS BOILER AND ENGINE PARTS

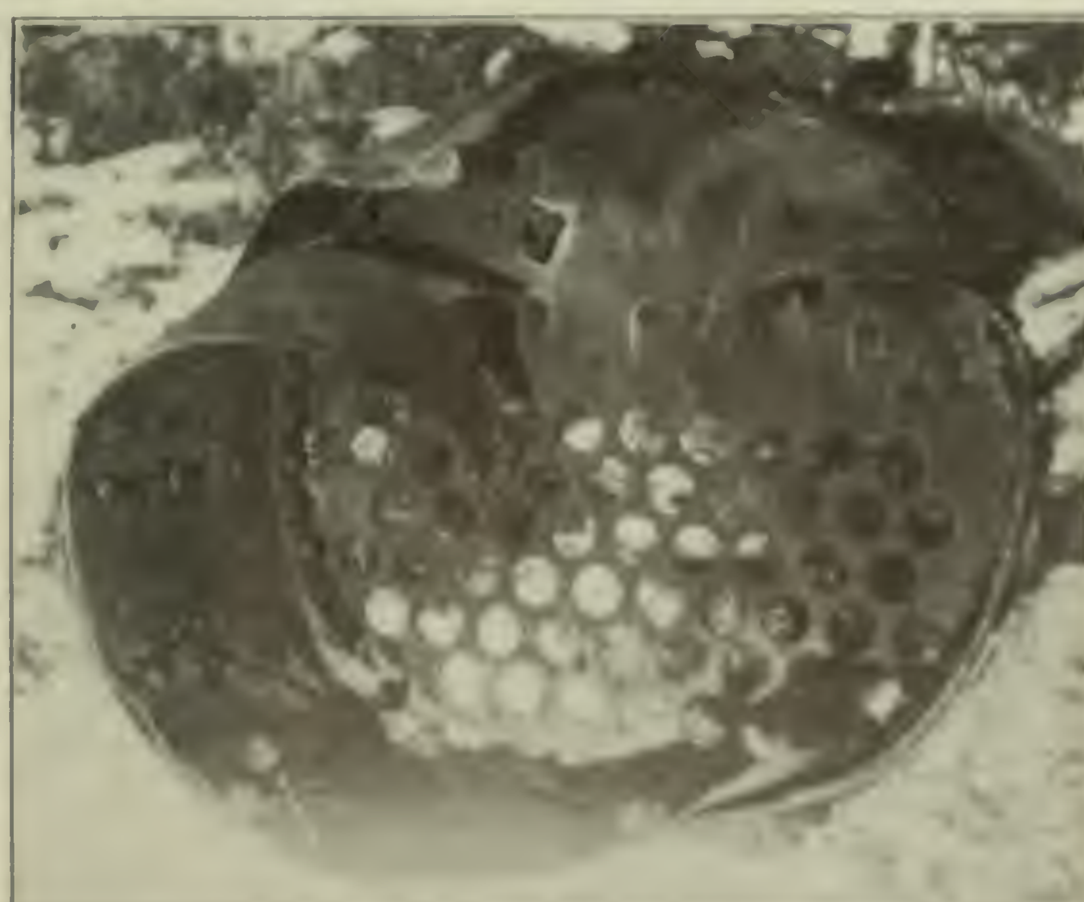


FIG. 8. FRONT AND REAR VIEWS OF FRONT HEAD AND SMOKE BOX

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Compound Gage

What is a compound gage, and for what purpose is it used?

A. C. G.

In a compound gage the dial is graduated to indicate pressures both above and below that of the atmosphere. From the zero mark the numbers read on one side the pressure in pounds above the atmosphere and on the other inches of mercury or pounds pressure below the atmosphere or vacuum. It is used wherever the pressure is liable to be either above or below that of the atmosphere, as is the case of the pressure in the receivers of compound engines.

Most Economical Vacuum

With a compound-condensing engine, how can I tell whether a 25- or a 27-inch vacuum is the more economical?

V. M. E.

By noting the hight at which the governor revolves. Other things being equal, the engine is using the least steam when the governor is highest.

Low Water

What should be done in a case of low water in a boiler carrying 100 pounds pressure?

C. L. W.

Smother the fire immediately with green coal. Close the ashpit doors. Open the damper, allowing cool air to draw through the furnace and tubes. Leave the engine running until pressure is reduced to the lowest possible point. If the feed pump is running let it run as long as it will. When the pressure will no longer run the engine or pump, it may be still further reduced by opening the gage cocks and the water-column drain valve. When the pressure has been reduced to near the atmosphere, water may be let in to the usual hight, and a search made for leaks or signs of overheating. If none appear, the fire may be started and the boiler put into service.

Incrustation and Corrosion

What is the difference between the corrosion and incrustation of steam boilers?

C. A. I.

Corrosion is the rusting or eating away of the iron or steel of the boiler, either internally or externally. It may be caused by air, water, acid, sulphur, etc. Incrustation is the covering of the surface with the solid matter left behind when the water passes away as steam and occurs only on the inside of the boiler.

Initial Condensation

What is initial condensation?

I. E. C.

When steam enters the cylinder at the beginning of the stroke it comes in contact with the piston, cylinder head and wall, which are cooler than the entering steam and as steam cannot exist in contact with anything cooler than itself, a part of it is condensed. Initial means at the beginning and as the steam is condensed at the beginning of the stroke, it is called initial condensation.

Rotary Engine

What is a rotary engine?

R. E.

A rotary engine is one having no reciprocating parts, the force of the steam being expended directly in producing rotation without the intervention of piston, connecting rod or crank.

Vacuum Breaker

What is a vacuum breaker, and for what purpose is it used?

C. V. D.

A vacuum breaker is an appliance attached to a jet condenser which automatically admits air to the exhaust pipe or condensing chamber of a condensing engine when water rises above a predeterminated hight in the system, destroying the vacuum and preventing water from entering the cylinder.

Complete Combustion

What conditions will cause practically complete combustion in a boiler furnace?

C. F. C.

There must be a high-furnace temperature, sufficient air intimately mixed with the fuel and distilled gases and room enough for the gases to burn without the flame coming in contact with the heating surfaces.

Loop in Steam Gage Pipe

Why is there always a loop in the pipe connecting a steam gage to its boiler?

L. S. G.

It is placed there to form a trap for water so that steam may not come in contact with the spring and by its heat affect its temper.

Lead Joints in Water Pipe

How are the lead joints in cast-iron water pipe made?

J. W. P.

The lengths of pipe are laid in position with the small or spigot end of one length accurately centered in the large or bell end of the next and held central by blocks of wood underneath and at the sides.

The annular space between the bell and spigot is then filled with tarred rope yarn which is calked in until the bell end is filled to within a half inch of the end.

A dam is made around the joint, usually a strip of tuck packing held by a clamp and melted lead poured into the space between the dam and the packing. Afterward, the lead is solidly calked. The packing makes a water-tight joint and the lead holds the packing in place as would a gland.

Compound Engine Cylinder Ratio

How can the proper cylinder ratio in a compound engine be found when the steam pressure, vacuum and load are known?

C. E. R.

The proper cylinder ratio in compound engines is a debatable question. A ratio which will give an equal number of expansions in each cylinder is found by assuming the probable initial pressure in the high-pressure cylinder and the terminal pressure in the low; then divide the initial pressure by the terminal and the square root of the quotient will be the proper cylinder ratio.

The life of the rubber hose of the flue blower can often be doubled by arranging the steam pipes so as to avoid short bends of the hose, also by remembering to turn on the steam before uncoiling the hose, as it is stiff and brittle when cold.

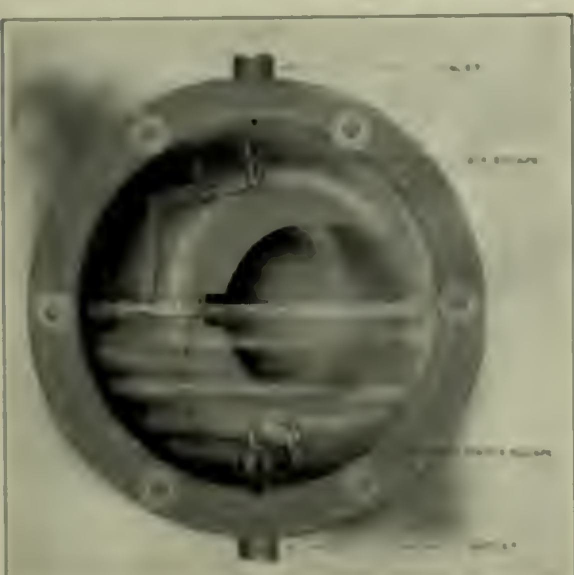
New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Combination Air and Water Trap

This trap is designed to handle both water and air from steam pipes, radiators, separators, etc. The trap does away with air cocks and air valves, and the escape of air is automatically taken care of. The accompanying illustration shows the interior construction of the trap, which consists of a casing, two needle valves, a float and lever connection.

The trap operates as follows: The trap being attached and the connection opened, the float is at the bottom of the chamber with the air escape open and the water escape closed. The pressure will then rise in the trap, and should the system be air bound the air will escape through the air valve. The steam will follow, and with it the water, which will



Sectional View through Trap

accumulate in the bottom of the float chamber, raise the float and gradually close the air escape. Further raising of the float after the air escape is closed will open the water escape and water will be discharged.

To compel the operation of the trap at the neutral point when both valves are closed, the bottom valve and its seat are not ground to a tight fit, thus permitting enough water to escape to insure continuous action of the trap when but very little steam is being condensed in the piping or other apparatus to which the trap is attached. The capacity of this trap is large, and it will successfully pass quantities of dirt and scale, due to the construction of the water valve, which is without wings or guides, and the seat, which has but small bearing surface and is removable.

This trap is made by the Atkins Brothers Company, Springfield, Mass.

Rolin Adjustable Interchangeable Grate Bar

This grate is so designed that four different air spaces can be obtained with

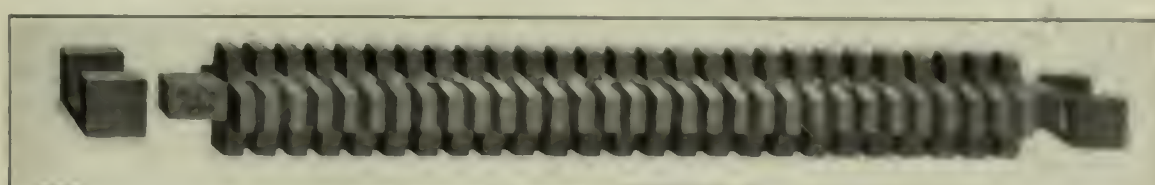


Fig. 1. Section of Bearing Bar

the same set of bars. It consists of three revolving bearing bars, one of which is shown in Fig. 1. This bar is made with

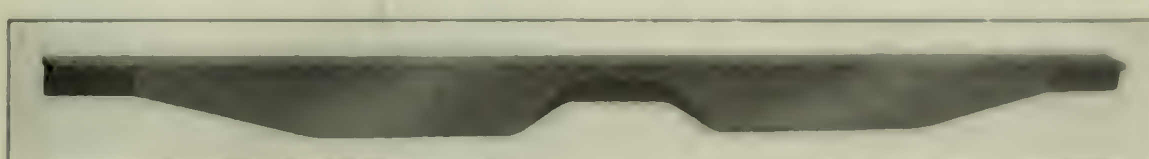


Fig. 2. Section of Grate Bar

four sets of projections, each set being differently spaced. On these revolving bars, the surface bars, Fig. 2, are placed and as the end and central bearing surfaces are made tapering, the surface bar will fit into the slope of the revolving bar to a greater or less degree according to the spacing of the projections. Fig. 4 shows how this is done.

Whenever it is found desirable to change the size of coal and to decrease or increase the width of the air space between the bars, it is only necessary to lift the grate bars from the grooves they are resting in, and turn the bearing bars until the desired groups are on top, when the grate bars are replaced. By this means a [illegible]-inch air space can be obtained for barley or rice coal; [illegible]-inch air space for pea or stove coal; [illegible]-inch for nut coal, and [illegible]-inch, [illegible]-inch and [illegible]-inch for all grades of bituminous coal.

Fig. 3 shows the grate in position under a boiler.

The surface bars are the only part that

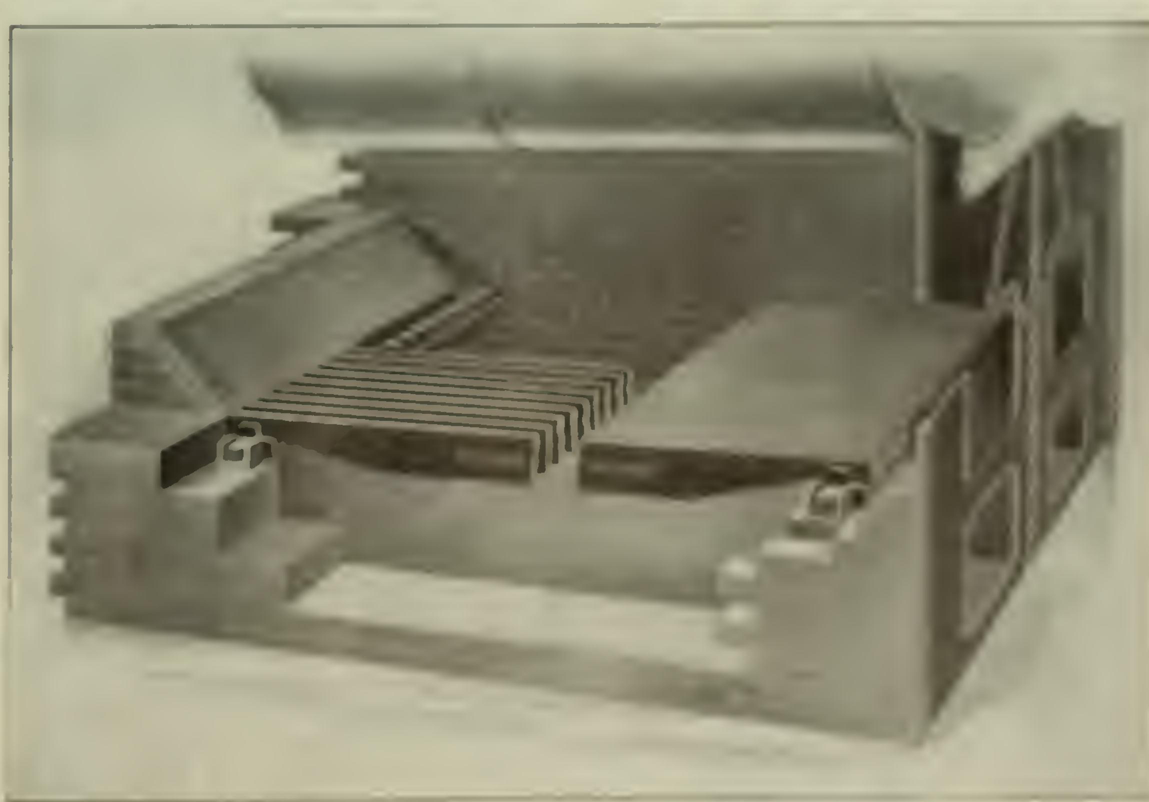


Fig. 3. Grate Bars in Position Under a Boiler

will require renewal, as the bearing bars should last the life of the boiler. This grate is made by the Standard Grate Company, 1213 Filbert street, Philadelphia, Penn.

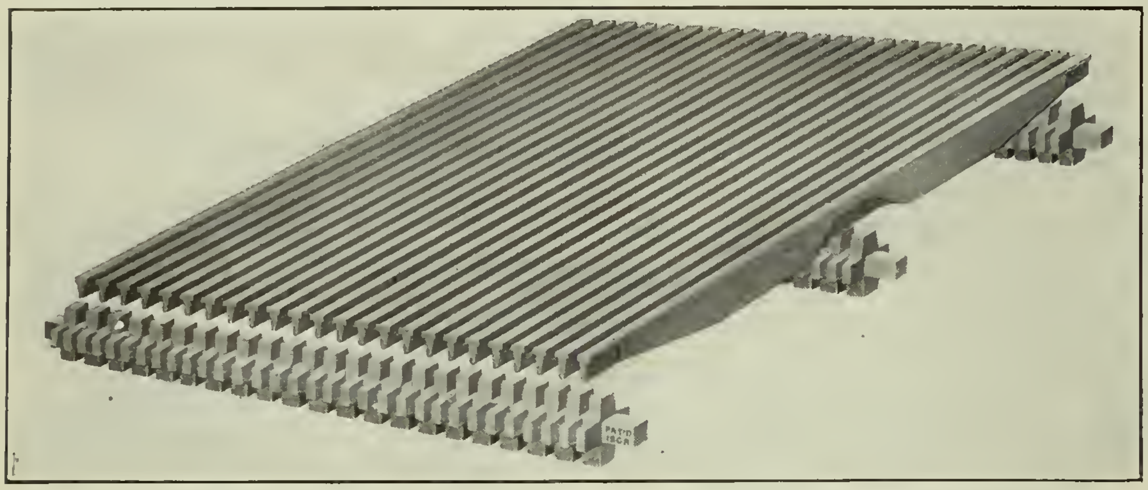


FIG. 4. SURFACE BARS AS SPACED BY THE BEARING BARS

OBITUARY

With Geheimen Kommerzienrat Dr. Ing. h.c. Rudolf Ernst Wolf, of Madgeburg, passed away on November 20, 1910, one of the most important and sympathetic personalities in German industry.

He was born July 26, 1831, the son of Wilhelm Wolf, professor in the Madgeburg Gymnasium. His father intended to give him a university education, but this did not suit the boy's inclinations, and his proficiency in ancient languages left so much to be desired that his father came to doubt whether he was able to study at all. "I don't want to," the lad replied, "I wish to become a machinist." Such a desire was then unheard of in educated circles, since the "black trade" was not considered respectable. But after he had delivered his mind, the parental opposition was soon overcome, and Wolf entered, April 12, 1847, the Maschinenfabrik Buckau as a simple apprentice. After two and a half years of practical instruction in this old-time shop which has given their rudinentary knowledge to so many able engineers, he attended, from October, 1850, to October, 1852, the provincial trade school at Halberstadt. After that he found a place in the Wöhiertschen Maschinenfabrik, of Berlin, where, under the leadership of H. Gruson, the then director of the firm and later founder of the celebrated Grusonwerk in Madgeburg, he was occupied especially in building locomotives. In 1855 he entered the factory of G. Kuhn in Stuttgart-Berg, where at the youthful age of 24 years he filled the office of chief engineer. Here for six years he was engaged in various kinds of work, till he decided to start a factory for himself, since he felt that he had sufficient force and experience to stand on his own feet. On June 15, 1862, he began work in the machine and boiler shop which he had erected at Buckau, and from the beginning constructed his locomobiles (portable steam engines), whose fundamental principles of construction were original with him. They contained removable tubular boilers with cylindrical fire boxes; the working cylinders were live-steam jacketed and connected with the steam dome itself. Thus he was the founder of modern German locomobile construction and developed the engine to its present important position. Among the radical improvements which he introduced were

RUDOLF ERNST WOLF

the method of compounding and the use of highly superheated steam.

R. Wolf had early recognized the importance of specialization in machine construction, and had therefore made his shop a special one for locomobiles and locomobile boilers. The greatest possible simplicity of organization and working methods, with concentration of all mental, manual and machine forces upon a single object, enabled him soon to turn out engines of high economic and constructive perfection. Already at the locomobile competitions at Madgeburg in 1880 and at Berlin in 1883, those of Wolf surpassed others, including the English ones. Today Wolf locomobiles show as good economy as eight pounds of coal per effective horsepower-hour.

Among the various products that, during its long existence, have been turned out by the Wolf shop, are rotary pumps and screw propellers, known as Buckau screws and intended for river steamers. The line of threshing-machine locomobiles has been supplemented by threshers themselves.

With Wolf appliances there have been drilled the deepest bore holes in the earth, those of Schladebach in the Saxon province, and of Paruschowitz in upper Silesia, which are 1748.4 and 2002 meters deep. Wolf has also been building stationary boilers and engines and machinery for a variety of industrial purposes.

In 1862, Wolf began with six workmen, and three officials, and built an 8-horsepower locomobile of six atmospheres working pressure, which did forty years' good service and now stands in the technical museum at Munich. Today the Wolf Works employ 3300 officials and workmen, turning out a large number of locomobiles, various in form and size, up to more than 800 effective horsepower and as high as 15 atmospheres working pressure. Beside the old works in Buckau, a new plant has been erected at Madgeburg-Salbke.

Wolf was not only a fine engineer, but a good salesman and a competent organizer. He understood the work of the shop from his own experience and could direct its details with great sagacity. He was popular with his men and solicitous for their welfare. In respect to pensions and various other means of social benefit among them, he far exceeded the requirements of the paternal German laws and long anticipated them. He was a man of public spirit and activity, and received official honors.

Edwin Ford, engineer of the Harlem hospital in Brooklyn, recently passed away. Mr. Ford was past financial secretary of Robert Fulton Association No. 57, National Association of Stationary Engineers, also member of the Municipal Engineers Local No. 319, International Union of Steam Engineers, and past senior warden of Washington Lodge No. 1, Free and Accepted Masons. He was a hard worker for the engineer and seemed to take great pleasure in doing anything within his power to aid the cause.

PERSONAL

John I. Rogers announces that having resigned one year ago from the Midvale Steel Company, of Philadelphia, to take up professional practice, he has since that time engaged in consultation and design, and has now opened a New York office at 165 Broadway. He will make a specialty of the design and operation of the most modern plants, furnaces and machinery for steam hammer, hydraulic press and drop forging; tire, wheel and other special rolling; hot- and cold-metal working; machine shops and power plants, iron and steel manufacture.

As a result of a Civil Service rule recently inaugurated in Kansas City, E. H. Lane was appointed a member of the board of examining engineers.

NEW PUBLICATIONS

Next best to knowing a thing one's self is to know where to find it. Next best to being able to retain in one's memory all the data and information which come to one's attention is to put it where it can be found. Many engineers keep card indexes of such data, and Edward Wray has conceived the idea of compiling such information as is likely to be of value to engineers and issuing it upon leaves of the standard 3x5 size, printed upon one side only, for filing in a standard index card set. He has associated with him a dozen editors expert in different lines, and issues the sets monthly in a little cover under the name of *Data*. The publication office is at 92 La Salle street, Chicago.

Will Hold Convention Soon

The Institute of Operating Engineers has created a renewed interest in its work by the issuing of the prospectus containing the proposed plan and scope of its work. Several branches are now in process of formation throughout the country and the work has already been adopted in the extension courses at Teachers College, Columbia University. A working agreement has been entered into between the Institute and the Williamson Free Trade School, whereby the graduates of the latter will receive a certificate of the journeyman grade in the Institute of Operating Engineers. Employers are also getting interested in the institute to such an extent that over seven desirable positions have been offered its members. Prominent educators who are interested in industrial education are taking great interest in the work of the Institute of Operating Engineers and are lending their aid and counsel in its formation. It is expected that the first convention will be announced in the very near future.

An industrial exposition to commemorate the fiftieth anniversary of the kingdom of Italy will be opened at Turin in April of next year. It is situated on the outskirts of the city on both sides of the River Po and includes an area of a million square meters, of which 280 square meters will be covered by buildings, making it one of the largest expositions yet held.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

GASOLENE ENGINE. George [illegible], Bakersfield, Cal. [illegible]

EXPLOSION ENGINE. Guy E. Price, Detroit, Mich. [illegible]

INTERNAL COMBUSTION ENGINE. [illegible], Boston, Mass. [illegible]

TWO-CYCLE EXPLOSION ENGINE. [illegible], Iowa. [illegible]

SINUSOIDAL WAVE CURRENT APPARATUS. [illegible], Hammond, Ind., assignor of one-half to Frank S. Betz, Hammond, Ind. [illegible]

FOUR-CYCLE INTERNAL COMBUSTION ENGINE. Robert Miller, New York, N. Y. [illegible]

WIND MOTOR. John [illegible], Chicago, Ill. [illegible]

ROTARY ENGINE. [illegible], Boston, Mass., assignor of one-half to [illegible], Boston, Mass. [illegible]

CURRENT MOTOR. [illegible] and [illegible], [illegible]. [illegible]

PRIME MOVER. Frank J. [illegible], Detroit, Mich., assignor to [illegible] Engineering Company, Detroit, Mich., a corporation of Michigan. [illegible]

INTERNAL COMBUSTION ENGINE. [illegible], Warren, Penn. [illegible]

BOILERS, FURNACES AND GAS PRODUCERS

STEAM BOILER. John A. [illegible], Roanoke, Va. [illegible]

STEAM GENERATOR. Robert L. Thompson, Elgin, Ill. [illegible]

POWER-PLANT AUXILIARIES AND APPLIANCES

BOILER CLEANER. [illegible], St. Louis, Mo. [illegible]

GAGE. Frederick C. Blanchard, Bridgeport, Conn., assignor to the Ashcroft Manufacturing Company, Bridgeport, Conn., a corporation of Connecticut. [illegible]

STEAM TRAP. John M. [illegible], N. Y., assignor of one-half to [illegible], Chicago, Ill. [illegible]

HYDROCARBON BURNER. William [illegible]. [illegible]

FLEXIBLE PIPE JOINT. Warren A. [illegible], [illegible] Highlands, Mass., assignor to the [illegible] Manufacturing Company, Boston, Mass., a corporation of Maine. [illegible]

PIPE HANGER. William H. [illegible], New York, N. Y. [illegible]

FURNACE ARCH. William [illegible], Scranton, Penn., assignor to McClave-Brooks Company, Scranton, Penn., a corporation of Pennsylvania. [illegible]

VALVE. Edward O'Malley, Jackson, Tenn., assignor, by direct and mesne assignments, to O'Malley-Beare Valve Company, Chicago, Ill., a corporation of Delaware. [illegible]

VALVE. Edward O'Malley, Jackson, Tenn., assignor by direct and mesne assignments, to O'Malley-Beare Valve Company, Chicago, Ill., a corporation of Delaware. [illegible]

HIGH AND LOW WATER ALARM. [illegible], Canada. [illegible]

COOLING TOWER. [illegible]

STEAM BOILER SUPERHEATER. [illegible], New York, N. Y. [illegible]

VALVE GEAR. [illegible]

VALVE-SEATING ATTACHMENT. [illegible]

DRAFT REGULATOR. [illegible]

ENGINE VALVE. [illegible]

[illegible] CLEANER. [illegible]

STEAM TRAP. [illegible]

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., [illegible]; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., [illegible]; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., [illegible]; sec., T. C. Martin, [illegible], New York.

AMERICAN SOCIETY OF NAVAL ENGINEERS

[illegible], Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., [illegible], New York; sec., [illegible]. Next meeting to be held [illegible], 1911, [illegible].

WESTERN SOCIETY OF ENGINEERS

Pres., [illegible]; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., [illegible]; sec., [illegible], Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesday.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Pres., [illegible]; sec., William M. Mackay, P. O. Box 1818, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., [illegible]; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio.

AMERICAN ORDER OF STEAM ENGINEERS

[illegible], Philadelphia, Pa. Next meeting at [illegible], June, 1911.

NATIONAL MARINE ENGINEERS' BENEFICIAL ASSOCIATION

Pres., [illegible], New York, N. Y.; sec., [illegible]. Next meeting [illegible], 1911.

INTERNATIONAL COMBUSTION ENGINEERS' ASSOCIATION

Pres., [illegible]; sec., [illegible], Chicago. [illegible]

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

[illegible]. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

[illegible], Ohio State University, Columbus, Ohio. Next meeting, [illegible], 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., [illegible]; sec., [illegible], New York. Next meeting [illegible], May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

[illegible]. Next meeting at [illegible], 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

[illegible]

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

When you were a small boy did you ever go swimming with the other "kids" in some fresh-water pond and, when emerging, find a big, black, ugly looking leech fastened onto you?

"Blood-suckers" we used to call them and we remember that they were about as repulsive a worm as ever made a small boy shiver.

Compared with them a mosquito is a respectable sort of parasite. He, at least, comes at you in a business way. You know which is head and which is tail, and that is more than can be said of your leech.

There are leeches in the business world and, after their fashion, they are quite as ugly and quite as repulsive and, when allowed to get busy, quite as destructive as the old original "blood-sucker."

Their first business in life is to remain unnoticed. Nature seems to have provided them with the instinct that makes them efface themselves as much as possible.

Their next business is to find some big and conspicuous concern manufacturing some conspicuously good article and to fasten onto them for reputation.

Their third business is to find the "easy marks" who will provide their nourishment.

These leeches of the business world are better known to you and us as "substitutors."

Do you know that there are large manufacturing concerns in this country whose whole business is to turn out substitutes for well known, trade-marked brands of goods?

Imagine it—big, wide-open *counterfeiting* factories!

Can you think of anything more crooked and despicable than that?

Yet these industries are made possible because there are enough dishonest dealers in the country to take their goods and enough indiscriminating buyers to accept the counterfeits.

Take it right in your own business, for instance—say some-engine room supply such as grease, oil or packing.

The fake manufacturer's agent says to the dealer, "Here, Mr. Man, you are selling so many pounds of Smith's Packing (mentioning a well known, old established, thoroughly advertised brand), and you are getting about 20 per cent. profit on it. Now, look at this stuff. Same trade-mark, nearly, isn't it? Same kind of a box; same stuff to all intents and purposes, what? Well, I'll sell you this so that you can clean up 35 per cent. on it and nobody will be the wiser."

The dealer can't resist the temptation or doesn't want to. Next time you send for Smith's Packing you get the substitute, and because you don't investigate the name and trade-mark closely enough you accept it as the real thing.

You use it and the next thing you know you find the stuffing box leaking badly. Out comes the offending packing and from that day on Smith's Packing is on your black list.

Unless he hears of your particular case Smith has no come-back—no chance to "show" you—no square deal.

Unconsciously, you are a party to the fraud.

Moreover, in the long run, you are the victim. You put up your good money or recommend that your concern put it up, and you get an inferior article, one which doesn't give the results you expected or one which actually works harm.

These business leeches have no reputation to live up to. They create nothing, they build up nothing. They are destroyers. Their whole function in life is to sustain themselves on a big manufacturer's reputation and a buyer's credulity, through a dealer's avariciousness.

The manufacturer who is everlastingly printing his claims—advertising—must live up to them, deliver the goods, or fail.

Your safeguard in buying is the trade-marked, advertised article.

But, when you buy, *get what you ask for.*

In your hands lies the remedy for the whole rotten practice.

Exercise your prerogative *every time.*

POWER

NEW YORK, JANUARY 17, 1911

Do you recollect the first time someone took you to a circus? You were a boy then, but the memory of the event will always be bright.

Some events in life are difficult to forget, and some are remembered with the keenest pleasure.

A truth known the wide world over is that the man who helps another gets more out of the act than the one helped. There is nothing to compare with that satisfied, full, "under the belt" feeling that creeps over a man when he has helped another to do something worth while, and the act of giving a helping hand to another has often resulted in the formation of a life-long friendship.

And the other fellow—well, he can't do much or say much, but he does a whole lot of thinking, and with him you are "IT."

There is some satisfaction in being appreciated, even if it is by the man who is running the little forty-horsepower plant.

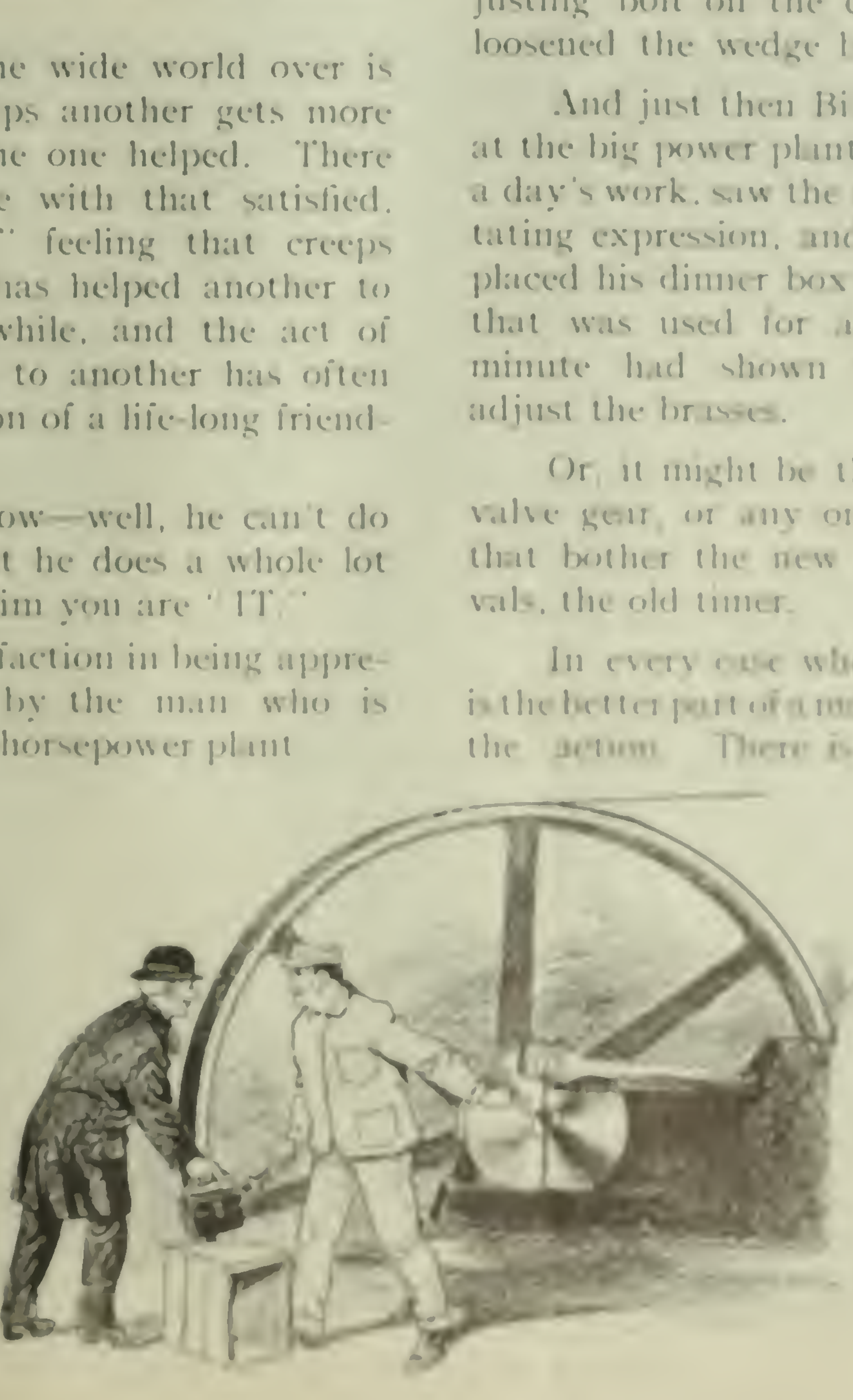
There are thousands of engineers, many holding "high up" positions, who are not above giving a lift to the little fellow—glad to give him the boost that is just necessary to enable him to get on his feet and toddle along alone.

Some engineers may recollect the time when they were new to the game, when they didn't know whether they were playing hide and seek or blind man's buff, and sometimes felt as if both games were on at once. They didn't know whether the top or bottom adjusting bolt on the crank rod tightened or loosened the wedge back of the brasses.

And just then Bill Somebody from down at the big power plant, on his way home after a day's work, saw the puzzled, undecided, hesitating expression, and, guessing the trouble, placed his dinner box on the old wooden box that was used for a tool chest, and in a minute had shown the way to properly adjust the brasses.

Or, it might be the crosshead shoes, the valve gear, or any one of a thousand other that bother the new beginner and at intervals, the old timer.

In every case where assistance is given it is the better part of a man's nature that prompts the action. There is no expectation of obtaining anything in return and nothing is wanted. It is one of the characteristics that go to make up the average engineer—and it pays, sometimes, in dollars and cents, but most often in the knowledge that a fellow man has been helped to help himself.



Hudson Manhattan Power Station

By F. R. Low

Boiler-room practice in a plant which produces current at less than 0.42 of a cent per kilowatt-hour and makes a thousand pounds of steam with 12.5 cents worth of coal. It is enabled to do this by the use of No. 3 buckwheat. The article describes the furnace and methods by which this is successfully done, notwithstanding the varying load.

The station at Jersey City which furnishes power for the operation of the trains in the McAdoo tunnels under the Hudson river is called upon to supply a load fluctuating momentarily from 8000 to 16,000 kilowatts and swinging from 1500 kilowatts in the early morning hours to 13,000 on the morning and evening peaks. Current is supplied by two 6000- and two 3000-kilowatt generators, driven by Curtis turbines to supply steam for which eight Babcock & Wilcox boilers of 900 rated horsepower each have been installed. Some of the dimensions and proportions pertinent to this article are as follows:

Water-heating surface per boiler, sq.ft.	9,128
Grate surface per boiler, sq.ft.	190
Water-heating surface per square foot grate surface, sq.ft.	48.05
Total rated boiler horsepower	7,200
Total rated capacity of generators, kw.	18,000
Maximum sustained capacity of generators, kw.	28,000
Boiler horsepower per kilowatt, rated	0.40
Boiler horsepower per kilowatt, maximum	0.26
Water-heating surface per kilowatt, rated, sq.ft.	4.06
Water-heating surface per kilowatt, maximum, sq.ft.	2.61
Grate surface per kilowatt, rated, sq.ft.	0.084
Grate surface per kilowatt, maximum, sq.ft.	0.054

While this is a generous amount of boiler and especially of grate surface for the present demands upon the station, the character of the service is such that no interruption is admissible and no chances could be taken of being found short of steam-generating capacity. Furthermore, it was believed by John Van Vleck, its designer, that a station thus of necessity liberally supplied with grate surface could be run upon No. 3 buckwheat, although none of the large power stations in this vicinity are being so run today and it is doubtful if it is being done elsewhere by a plant carrying a load of this magnitude and with this degree of variation.

Some difficulty was at first experienced in doing this, but a proposition was submitted by the McClave-Brooks Company, of Scranton, Penn., in which they agreed to burn No. 3 buckwheat, without the formation of clinker, to keep the boilers running at the required capacity, with a low per cent. of carbon in the ash, and to burn 35 pounds of this coal per hour per square foot of grate surface with not over 2.5 inches water pressure of air in the ashpit.

In accordance with this agreement the

Fig. 1. Turbine Room of Hudson-Manhattan Plant

furnaces were reconstructed, as shown in Fig. 6. Each furnace has three arches, so spaced that the area between them is sufficient to allow the products of combustion to pass through under slight compression, and placed sufficiently high above the fire to allow the complete combustion of the gases before they are discharged through the openings between the arches upon the cold tubes.

The grate used is what is known as the McClave No. 4. It is arranged in front and rear sections, both of which dump toward the middle, so that the ashes, clinkers, etc., fall naturally into the center of the hopper, into which the ashpit is extended; see Fig. 3. This grate has been especially designed for the burning of small grades of anthracite, allowing the necessarily strong undergrate draft to be used without disarranging the fuel and throwing it about in ridges and mounds all over the surface of the fire bed. To this end it has a uniform mesh of [illegible] of an inch not only on the surface of each bar but also on the surface of the bars adjacent to the sides of the longitudinal carrying bars which span the space from the edge of the dead plate to the bridgewall.

The grate bars are made with sectional removable tops or caps, having [illegible]-inch air space arranged as in Fig. 3. Into the shanks of these caps are cast soft-steel lugs which are bent under the bottom of the carrying bar, thus preventing any change in the location of the cap and insuring a uniform mesh all over the grate surface. The body portion of the bars is over 2 inches below the top level of the caps and is, therefore, not likely to warp or burn out from the fire on top of the grate. The bars overlap at their ends, as shown in Fig. 3, necessitating the use of the center tie *A* when the front and back of the grate dump in opposite directions. They may be brought into contact where they then overlap, or an opening may be left between them, by placing stops in front to arrest the throw of the stub levers at

Fig. 2. Front of Boilers Which Are Hand Fired

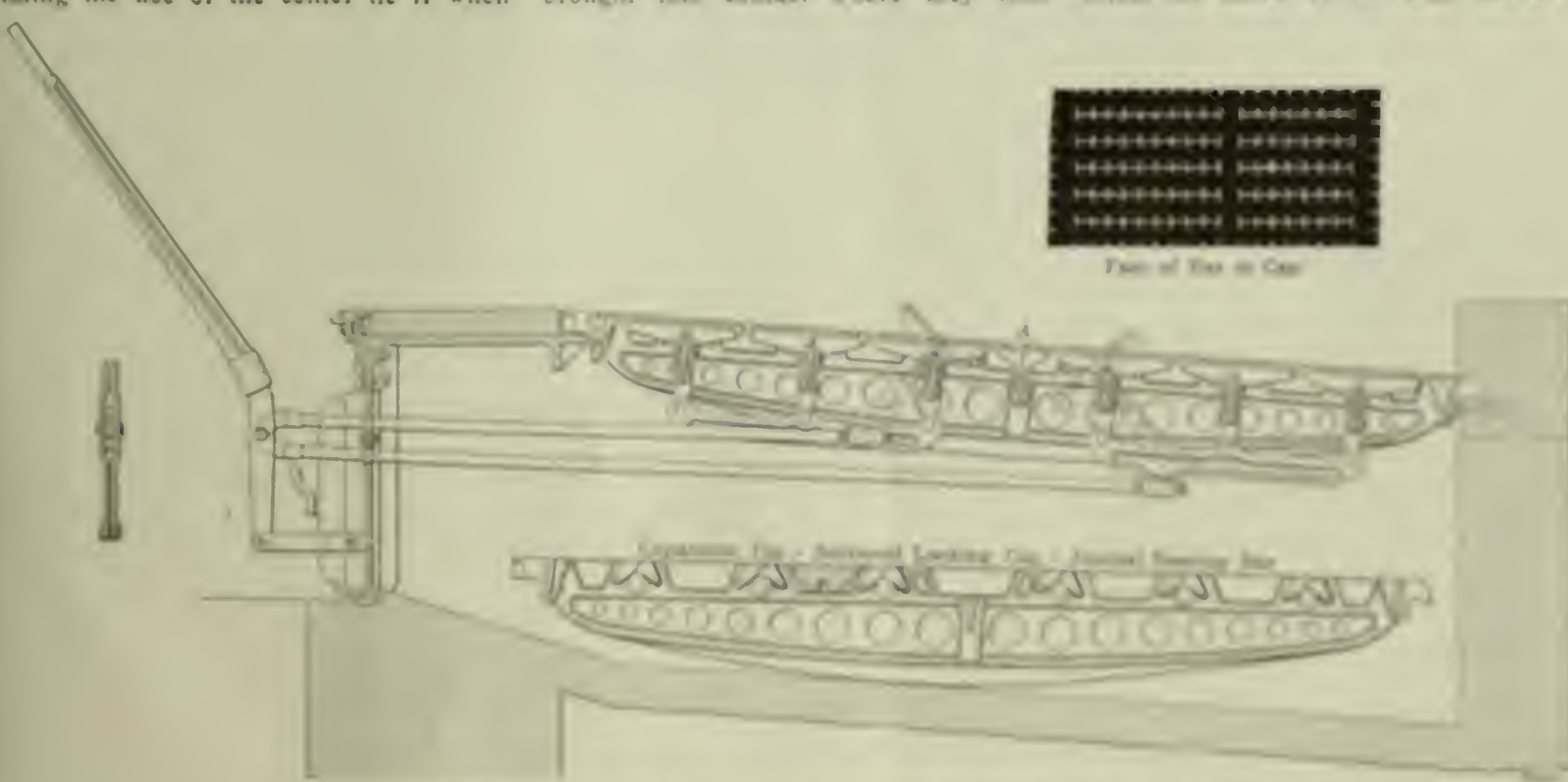


Fig. 3. The McClave No. 4 Grate Installed under the Boilers

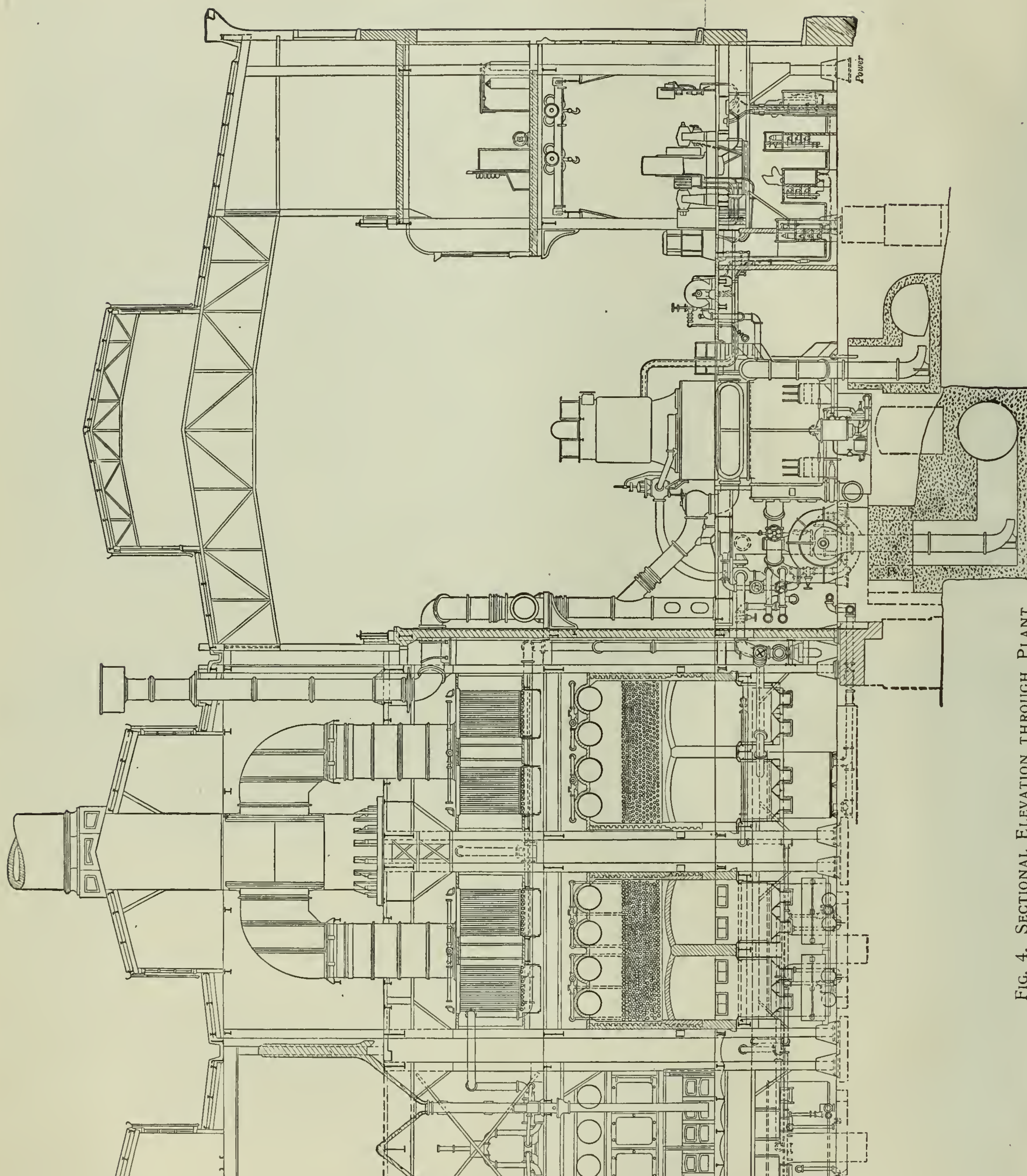


Fig. 4. Sectional Elevation through Plant

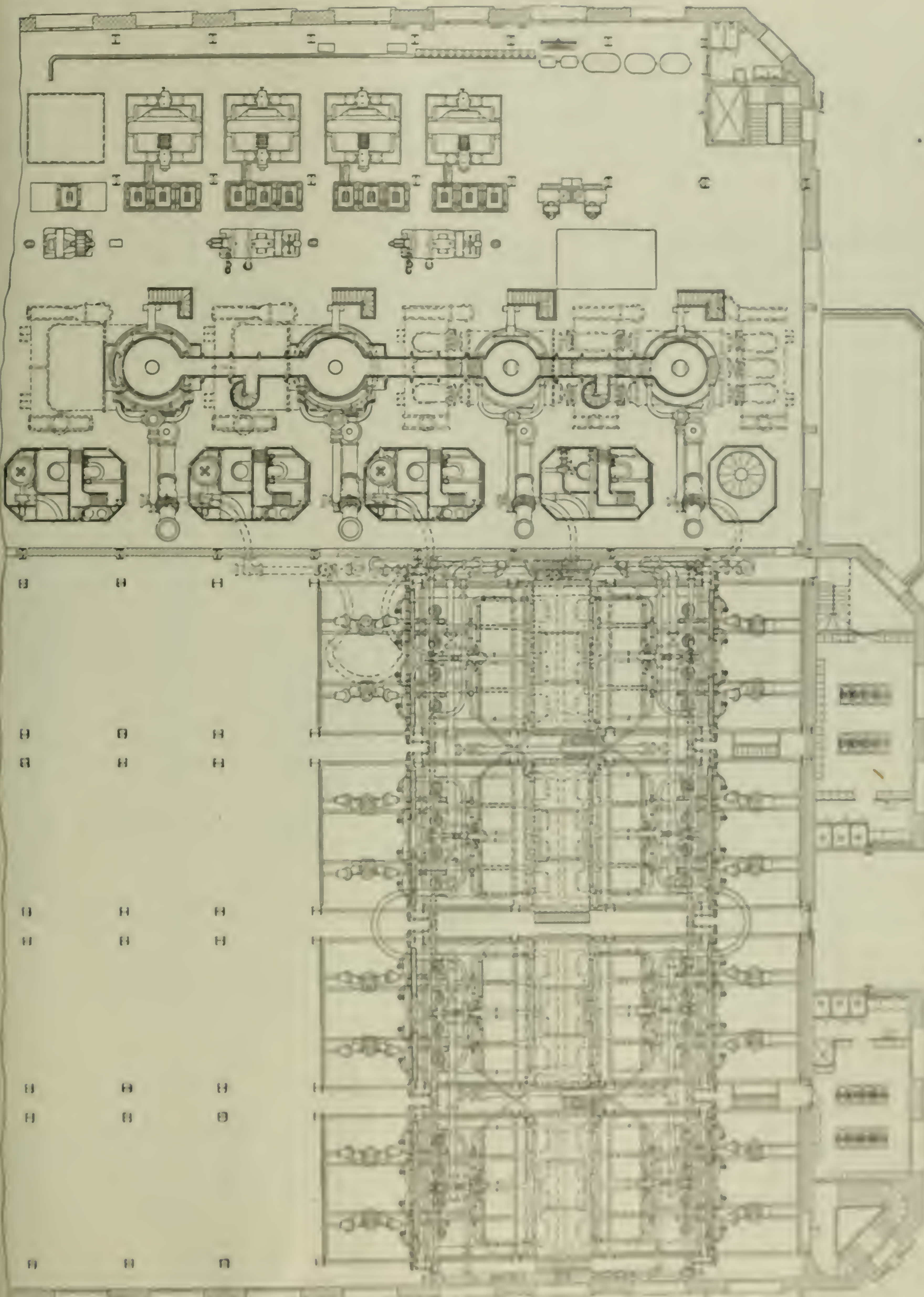


Fig. 5. Plan View of Plant, Showing Arrangement of Boilers and Turbine-room Equipment

the right point to secure whatever space is desired.

The dead plate is protected with firebrick. The ledge on which the front edge of the grate rests is dropped several inches below the general level so that there may be always a considerable depth of fire at the front edge of the grate to resist the too liberal admission of air in the clear and having three sections of grates and three fire doors, as shown in Fig. 4.

When the fire is to be cleaned, the unconsumed fuel is pushed back onto the back half of the grate and the front half is dumped, after which the live coal is pulled forward onto the clean part and the rear section dumped. All of the untop part live coal. The cleaning is done between the peaks. The air pressure used is from ½ to ⅝ inch of water in the ashpit with a light load, and with ⅛ inch suction in the furnace. After the fire gets to be 4 or 5 inches thick it is blown with about 2 inches of pressure in the ashpit, which gives a balanced condition in the furnace. When the fire is

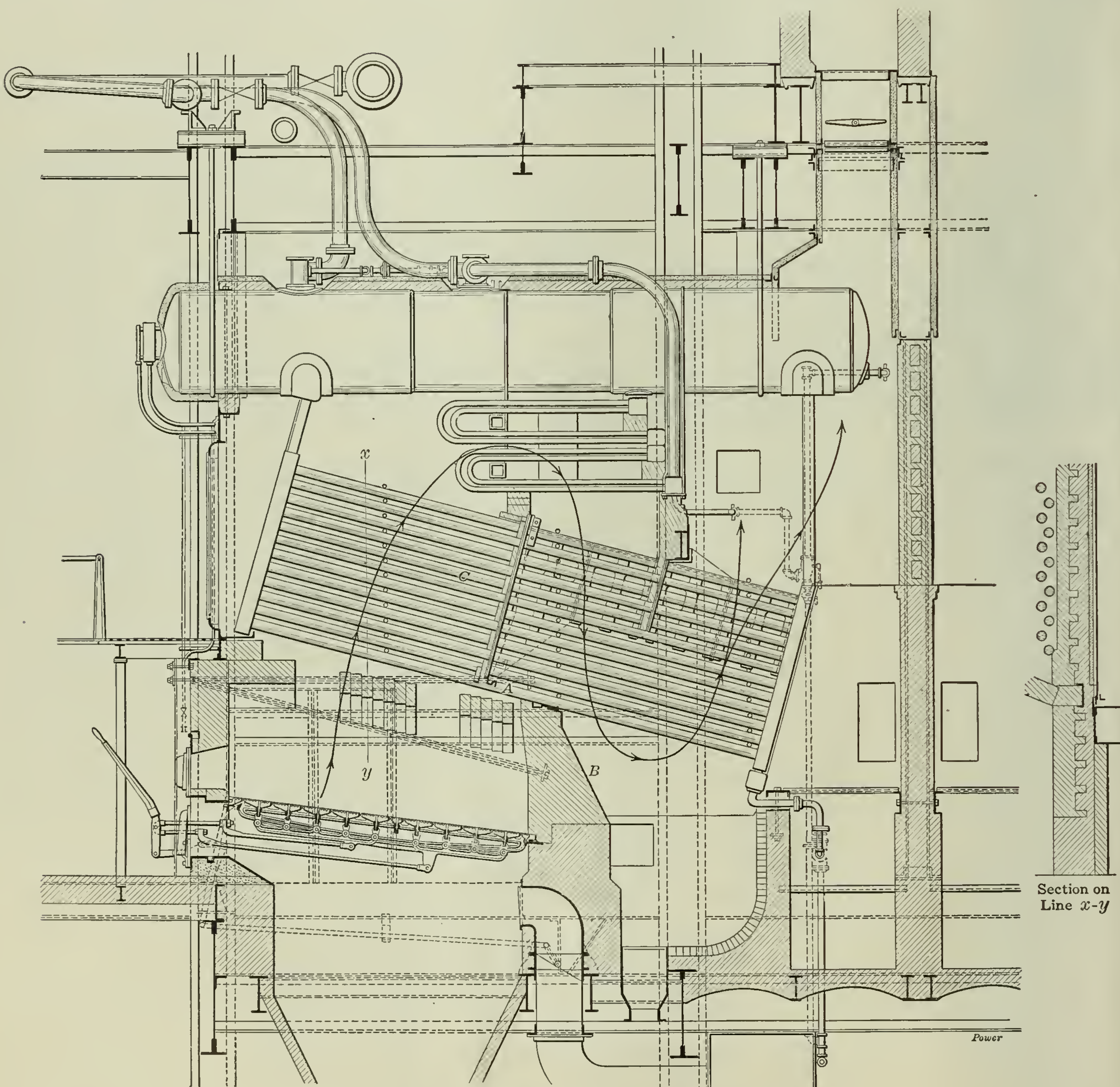


Fig. 6. Vertical Section through Boiler Setting

at this point without allowing the fuel to pile back into the doorways.

The grate is 10 feet in depth from the dead plate to the face of the bridgewall, made up as shown in Fig. 6 of five rows of bars dumping backward, the center tie and four rows of bars dumping forward. Each boiler is served by two furnaces separated by a division wall supporting the arches; each furnace being 10 feet deep by 9 feet 6 inches wide

consumed fuel is then distributed over the entire grate and fresh fuel added, all of which may be accomplished in less than two minutes. This is done separately for each furnace. Starting with this, perhaps 2 inches of live coal, the fires are allowed to build up until in the course of six to seven hours they will have attained a thickness of some 12 or 14 inches, two-thirds of which will be ash and only the at its thickest a blast of 2½ inches is used. The average rate of combustion is 25 pounds per square foot of grate and the maximum 36 pounds. At this average rate of combustion they are able to carry the load with five boilers in active operation with one banked in reserve for emergency.

In the report of the Committee on Power Generation presented at the recent meeting of the American Interurban Railway Engineering Association, C. E. Roehl mentioned the fact that practice is tending toward the reduction of the number of square feet of grate surface served by one fireman, and in turn increasing the rate of combustion which is expected of this fireman. In order to maintain a reasonable economy in the operation of a plant in which the hourly peak load is approximately two and a half times the average day load, it is absolutely necessary that the number of boilers in operation be kept down, so that the normal rating of the boilers will be approached during the light load of the middle day and night. Experience in this station shows that it is possible, roughly speaking, to obtain 1200 kilowatts from a fireman for a period not exceeding two and a half hours, and that the average fireman is as able to do this when shoveling this coal upon, say, 200 feet of grate surface as when shoveling the same amount of coal upon 100 square feet. It would, therefore, seem quite feasible to operate a boiler containing 200 square feet of grate surface with one man during the period of light loads, during which that man will develop, say, 700 kilowatts, and continue the same boiler in operation through the peak loads served by two firemen. During the peak load each of these men would have to work harder than the one alone during the light loads, as more than twice the light load output would be obtained by the two men, or 2400 kilowatts. At present, this practice is approached as nearly as operating conditions will permit and has proved quite effective, those of the surplus hands that it is nec-

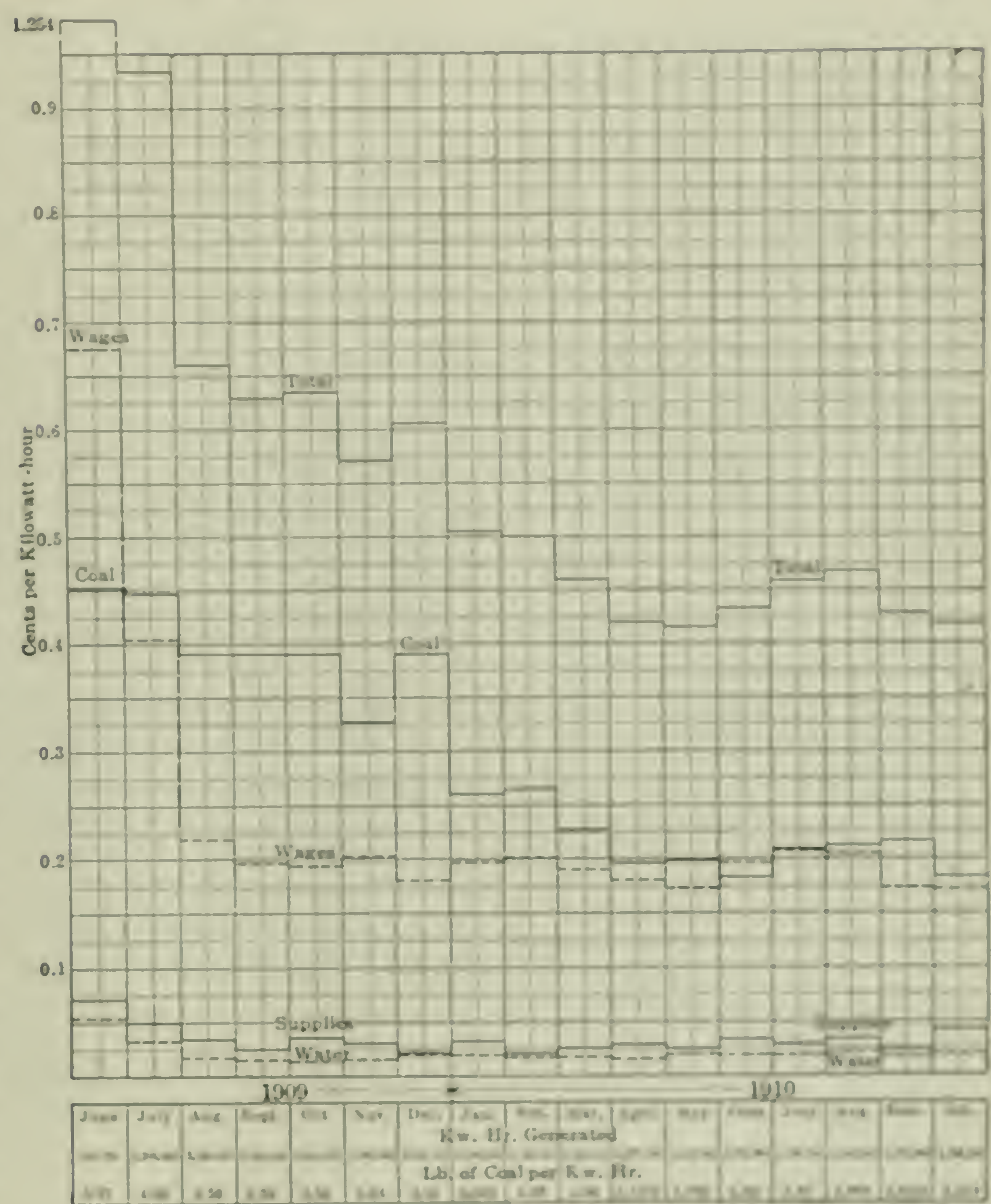


FIG. 7. COST OF POWER PER KILOWATT-HOUR

REPORT OF THREE TESTS OF A CERTAIN GRADE OF NO. 3 BUCKWHEAT COAL BURNED UNDER A [illegible]-HORSEPOWER BABCOCK & WILCOX BOILER, AT THE JERSEY CITY POWER HOUSE OF THE HUDSON-MANHATTAN RAILROAD COMPANY.

		Test No. 1	Test No. 2	Test No. 3			
				1st Watch	2d Watch	3d Watch	Total
1	Date of test	[illegible]	[illegible]	[illegible]			
2	Duration of test, hours	[illegible]	72	[illegible]	[illegible]	[illegible]	[illegible]
3	Weight of coal as fired, lb	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	Percentage moisture in coal	[illegible]	[illegible]				[illegible]
5	Weight of dry coal, lb	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	Total ash and refuse, lb	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
7	Percentage total ash and refuse in dry coal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	Total combustible consumed, lb	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	Total weight of water fed to boiler, in pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	Equivalent water evaporated into dry steam from and at 212° F., lb (including injection)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	Factor of evaporation	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	HOURLY QUANTITIES						
12	Dry coal consumed per hour, lb	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	Dry coal consumed per square foot of grate surface per hour, lb	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	Water evaporated per hour, lb	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	Equivalent evaporation per hour from and at 212° F., lb	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	Equivalent evaporation per hour from and at 212° F. per square foot of heating surface, lb	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	AVERAGE PRESSURES, TEMPERATURES, ETC.						
17	Steam pressure by gage, lb per square inch	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	Temperature of feed water	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	Draft under grate in inches of water	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
20	Amount of injection at boiler [illegible]	[illegible]	[illegible]				[illegible]
	HORSEPOWER						
21	Horsepower developed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	Horsepower, builders' rating	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
23	Builders' rating developed, per cent	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	ECONOMIC RESULTS						
24	Water apparently evaporated under actual conditions per pound of coal as fired	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	Equivalent evaporation from and at 212° F. per lb of coal as fired	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	Equivalent evaporation from and at 212° F. per lb of dry coal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	Equivalent evaporation from and at 212° F. per lb combustible	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

essary to keep on during the periods of light load being used in cleaning fires and doing the odd jobs that can best be done at that time. In this way the services of the firemen are used at their utmost efficiency and, as the load increases, an extra fireman can be put on who will simply work the hours of peak loads, receiving extra compensation in return for his split watch. This will probably give a lower operating cost for the boiler room than having the extra fireman stay during the entire watch at his normal rate of wage, as he can waste more coal in the hours when his services are not needed than the extra compensation given him for his split watch.

The pressure carried is from 180 to 185 pounds with 125 degrees of superheat. Each boiler has a separate Green economizer which heats the feed water to 240 or 250 degrees. The water is passed first through closed heaters, supplied with steam from the auxiliaries, and there is also an open heater at work in the construction plant for which the station also supplies power from which a considerable quantity of hot water is returned.

In addition to the railroad load there are nine air compressors taking steam equivalent to about 1000 kilowatts. The turbines require 13.5 pounds of steam per kilowatt-hour of themselves, and 17.5 including the auxiliaries.

The cost of operation has been running down steadily since the plant was started, as shown by the chart in Fig. 7, and has reached the remarkably low figure of less than 0.42 of a cent per kilowatt-hour for current at the switchboard, including the cost of water, supplies, wages and coal. The No. 3 buckwheat costs about 43 per cent. less at the conveyer siding of the station than No. 1 buckwheat coal. One of the units is fitted with a Venturi meter, Richardson coal scales, Westover CO_2 recorder, etc., and produced upon test the results in the accompanying table, the test being made with No. 3 buckwheat and with the alternate method of starting and stopping, as recommended by the Boiler Testing Code Committee of the American Society of Mechanical Engineers.

For the data and information contained in this article we are indebted to E. T. Munger, general manager of the Hudson & Manhattan Railroad Company.

Vacuum for Reciprocating Engines

In a recent paper upon the economical working of reciprocating marine engines, Mr. Morison contends that it is advantageous to run at as high a vacuum as possible. Mr. Weir takes issue with this assertion and places the maximum economical vacuum at 25 inches with triple- and quadruple-expansion marine engines.

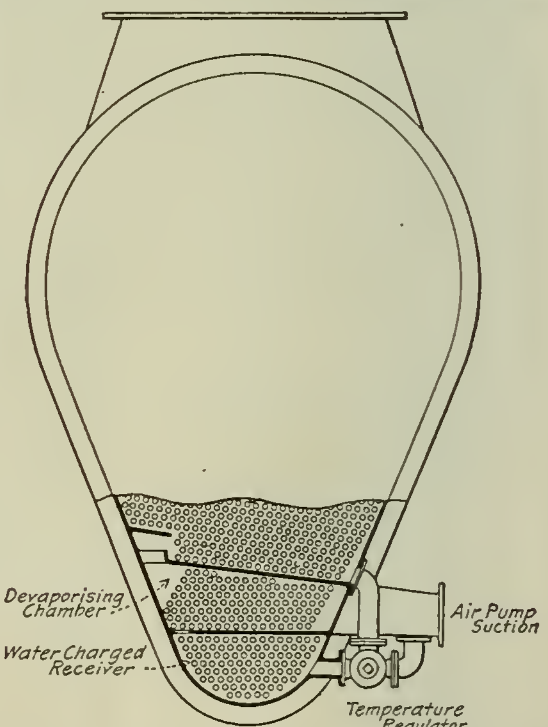
In a paper read before the Northeast Coast Institution of Engineers and Shipbuilders on November 25, D. B. Morison, whose words upon the subject of condensers have come to have more than ordinary importance, attributed the usual practice of carrying a low vacuum with triple- and quadruple-expansion marine engines to the fact that it produced a high temperature of air-pump discharge water. This practice is associated with the assumption that any vacuum above 25 inches in the condenser is a source of waste, while a few inches less works no difference as the feed water becomes just so much hotter.

In support of the contention that the power increases and the steam consumption per brake horsepower decreases with approximate uniformity up to the highest vacuum that can be reasonably carried on a steamship, Mr. Morison quoted the result of some investigations by Mr. Willans which showed that with a central-valve compound engine, the consumption per brake horsepower decreased with an increase of vacuum, at the rate of 1 per cent. per inch up to 27 inches vacuum. Referring to land practice, tests by Messrs. Belliss and Morcom showed that in a triple-expansion high-speed engine, the increase in steam consumption per brake horsepower was at the rate of 1.77 per cent. per inch of decrease in vacuum, from 28 inches down to 21.5 inches.

It was pointed out that the first essential in any condenser is a disposition of the surfaces such as will result in the greatest over-all efficiency; but the mere fact that a condenser has a large surface per horsepower is no criterion of its condensing capacity, because much of this may be ineffective. It is the treatment of the air in a condenser which is so vital to its efficiency, and from this point of view that condenser is the best which provides the air pump with air at maximum density.

Air-pump efficiency is a governing factor in any condensing plant, and in ordinary reciprocating engines the quantity of air leaking into the system is considerable. Tropical sea water also has a highly prejudicial effect on air-pump capacity by reason of the smaller difference in temperature of the water flowing through the tubes and that of the aërated vapor outside the tubes in the lower part of the condenser. This fact is largely responsible for the great fall in vacuum that invariably takes place in the tropics. Marine engineers accept its evil consequences as inevitable; but they are by no means inevitable, and can be overcome in an extremely simple manner. Many steamships trading in the tropics cannot carry more than 20 to 22 inches vacuum; but if the condensers were designed to carry 27 inches vacuum in the tropics and the engines were properly proportioned, together with adequate arrangements for feed-water heating, the saving would amount to about 10 per cent.

The air-withdrawing capacity of any reciprocating air pump depends upon the difference between the vacuum that can be produced in the pump barrel on its suction stroke and the vacuum in the condenser. It would obviously boil as soon as the pump buckets commenced the suction stroke, and the resultant vapor would impair the inflow of air from the condenser. Therefore, an air pump can be rendered flexible in air-withdrawing capacity by regulating the temperature.



SECTION OF CONDENSER, SHOWING WATER RECEIVER AND DIAPHRAGM

There are several devices on the market for accomplishing this. The condenser herein illustrated contains a divided receiver in its base, which is always completely filled with water of condensation. At a distance above this water receiver is a diaphragm which catches the water of condensation formed in the condensing chamber above it. There is a pipe connecting the top of the water-collecting diaphragm and water receiver, and in the pipe there is inserted a two-way cock; one way leads to the air-pump suction pipe and the other to the water receiver. If there is a clear way between the water-collecting diaphragm and the water receiver, all the water of condensation passes through the receiver and is reduced in temperature before it passes into the air pump. If, on the other hand, there is a clear way between the collecting diaphragm and the pump, all the water of condensation passes at a maximum temperature into the pump. The temperature of the pump and, therefore, its air-withdrawing capacity, is under complete control by the partial or full use of the temperature regulator. An extended experience has demonstrated that this simple apparatus will raise the vacuum in the tropics from 1½ to 3 inches, and often more, depending upon the amount of air prevailing; at the same time the air-pump discharge water is kept at the highest temperature consistent with the maintenance of the highest available vacuum in the condenser.

The air pump will withdraw air in maximum quantity only when the condenser delivers that air to it as free as possible from water vapor; therefore the interdependence of an air pump and condenser is obvious. The action of the one so influences the action of the other that both must be correctly designed if the available results must be realized.

Feed water in any steamship can be heated to the pumping limit by the available auxiliary exhaust steam, so that to ignore the economical possibilities of a high vacuum in the main engine and to work at a low vacuum in the condenser, with the sole object of obtaining a high temperature of air-pump discharge water, and then to throw away heat by deliberately discharging exhaust steam into the condenser because the feed water is already too hot to absorb it, is a system that involves considerable loss to the ship owner throughout the life of a ship.

Mr. Weir's Reply

In the December 9 number of *Engineering*, W. Weir takes issue with Mr. Morison, stating that after a careful perusal of the results of Mr. Willans' investigation he was unable to find any evidence that in a marine engine the steam consumption per brake horsepower decreases at the rate of 1 per cent. per inch of vacuum over 25 inches. Furthermore, Messrs. Belliss and Morcoms' figures show that from 21.5 to 25 inches the total economy was 1.3 pounds, or 2.8 per cent. per inch, while from 25 to 27.0 inches, the total economy was 0.3 pound, equivalent to 0.78 per cent. per inch—a very notable difference. He also charges an important omission in considering these latter figures in the fact that the reader is left to assume that the figures given represent the actual difference in economy, whereas they must be corrected for the cost of obtaining the relatively high degree of vacuum.

As regards the power required for the air pump, this can be omitted, as it will be practically the same for a 25-inch vacuum as for 28 inches, but for the latter condition, twice as much circulating water must be pumped as for the former. Figures are quoted to show that with the best type of high-speed engine for utilizing low terminal pressures, the actual saving in water consumption with vacuums over 25 inches may be 1.47 per cent. as a maximum. This, however, is more than counterbalanced by the extra power required for circulating water, together with the thermal loss due to the low hotwell temperature. A hotwell temperature of 124 degrees associated with a vacuum of 25 inches easily prevents the absorption by the feed water of all the steam from the auxiliary apparatus in the plant.

Features of Plant at Kodak Park Works

By A. R. Maujer

The features of the plant at Kodak Park works which are of more than ordinary interest are tallest chimney in New York State, motor driven boiler-feed pumps and a system of oil storage which reduces the waste of oil to the minimum.

The large steam-power plant which serves the great manufactory, Kodak Park Works, of the Eastman Kodak Company, located at Rochester, N. Y., where photographic film, paper and dry plates are manufactured, possesses some features of more than passing interest.

Chimney

Perhaps the most conspicuous object about any steam-power plant is the chimney. In this instance the chimney is especially conspicuous due to its great hight and fine design. It is 366 feet high, the tallest chimney in New York State. The object in making the chimney so high was, not so much to secure a strong draft as to carry off the acid fumes from the plate-coating departments and discharge them into the atmosphere at such a hight that they become well diffused before they can sink back to the ground level. The chimney is built of radial brick and contains an acid-proof brick lining throughout its entire hight. The inside diameter of the chimney is 9 feet. The present boiler capacity is approximately 5000 horsepower. Owing to an enlargement of the works an addition of about 3000 horsepower is to be made to the boiler equipment. To take care of this additional boiler capacity another chimney of the same hight but having an inside diameter of 13 feet has just been completed. This increases the capacity by 125 per cent. Both chimneys were erected by the Alphons Custodis Chimney Construction Company.

Electrically Driven Boiler-feed Pumps

Another interesting feature is the two electrically driven boiler-feed pumps. The pumps are of the Deming triplex single-acting type. The larger one is 9x10 inches in size and the smaller one, 7x8 inches. The speed at which they can vary is from 20 to 40 revolutions per minute; under normal conditions they operate at speeds of 25 and 30 revolutions per minute respectively. The larger pump is driven by a 35-horsepower Three Rivers Electric Company motor, the smaller one is driven by a 10-horsepower Rochester Electric Company motor. The pumps are designed with a double gear-and-pinion drive which tends to make the torsion in the crank shaft uniform and cause the pumps to run smoothly and efficiently. The motors have field control for varying the speed. The ratio of variation is 2 to 1. The pumps are provided with relief valves on the discharge pipes having outlets to the floor. When a rise in pressure causes the relief valves to open and thus indicate that there is trouble somewhere in the system, the discharge of water onto the boiler-room floor quickly attracts attention and the pumps are slowed down. The pumps have just been fitted with automatic pressure-regulated electric controllers so that the speed of the motors will be regulated according to the pressure. A set of steam pumps having the same capacity as the electrically driven pumps is maintained as an emergency equipment.

The smaller of the electrically driven pumps has been in continuous service for three and one-half years and the larger one for two. During these periods neither has gone out of service through accident or sudden failure. The average temperature of the water handled by the pumps is 210 degrees Fahrenheit; the boiler pressure against which they pump is 140 pounds. After passing through the pumps, the feed water goes through economizers and thence to the boilers. The larger of these pumps was illustrated in the September 27, 1910, issue of POWER.

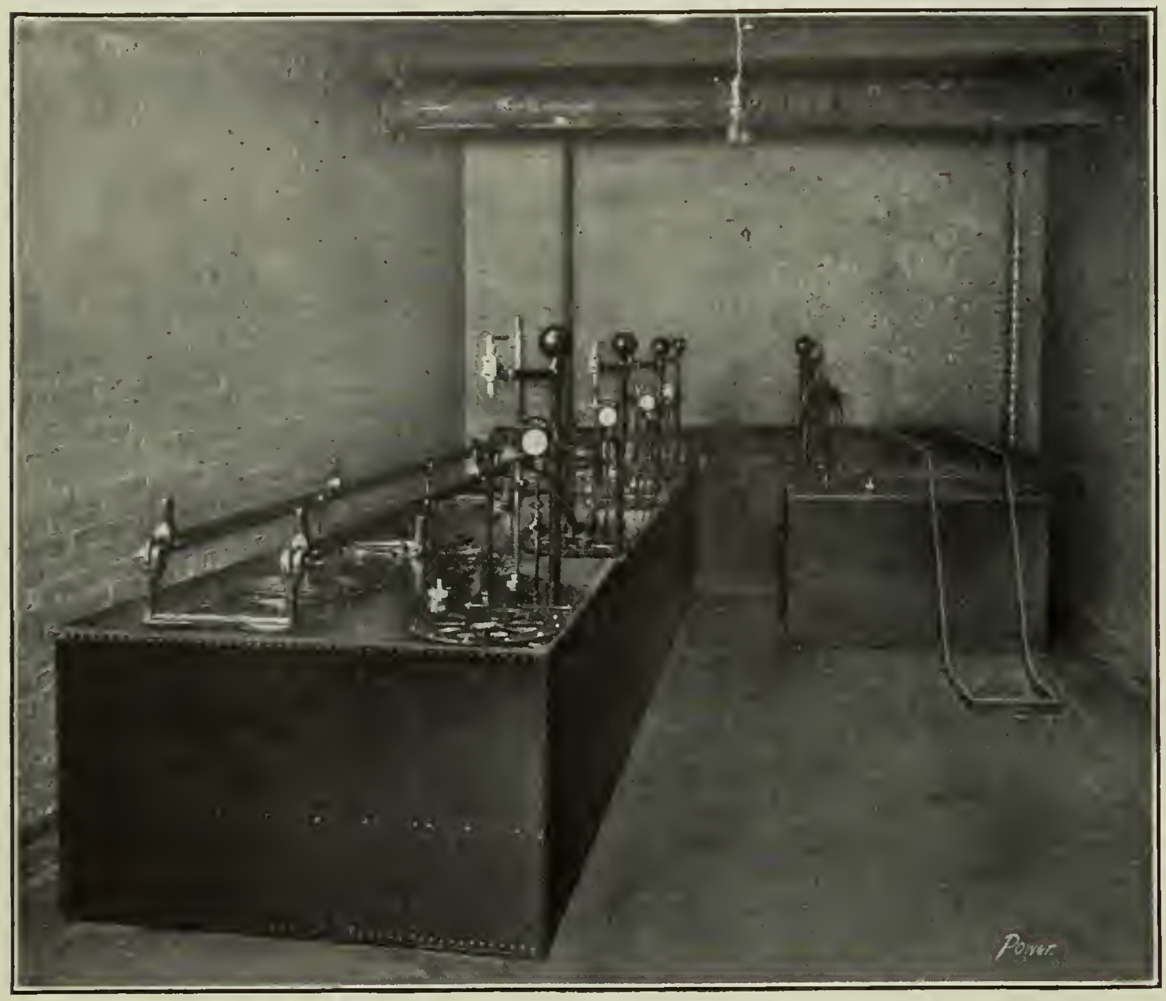


FIG. 1. OIL-STORAGE VAULT

OIL-STORAGE SYSTEM

Opening into the engine room is a brick and tile-lined vault which contains six self-measuring oil tanks manufactured by S. F. Bowser & Co. A view of the interior of the vault is given in Fig. 1. The vault is kept locked and oil may be obtained only by presenting a written order from the head of a department. Some such arrangement is highly desirable in a plant of this size and type where there are numerous departments in which various oils are used. If a rather close check were not maintained, the yearly expense for oil would undoubtedly be far above what it reasonably should be.

Each month a report is made out on a card of the form shown herewith. Thus the consumption of each department for

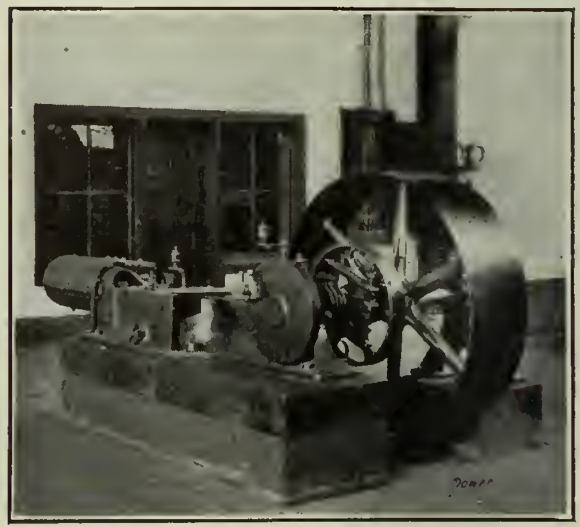


FIG. 3. THE ORIGINAL EQUIPMENT

each montn is placed on record in a convenient manner.

The arrangement of the tanks in the storage vault is convenient for filling the tanks and drawing the supplies. A barrel is rolled onto the cradle which is hinged to the barrel track. A tackle suspended from the ceiling is attached to the ring in the cradle, the end of the cradle is hoisted up and the barrel rolled off onto the track and around to the proper tank into which it is emptied through the manhole.

Oil is drawn from the tank by a plunger hand pump. One full stroke of the plunger discharges one gallon from the spout. A rod alongside of the plunger rod carries a number of adjustable stops. By turning this rod so that when the plunger is lifted, a projection on the

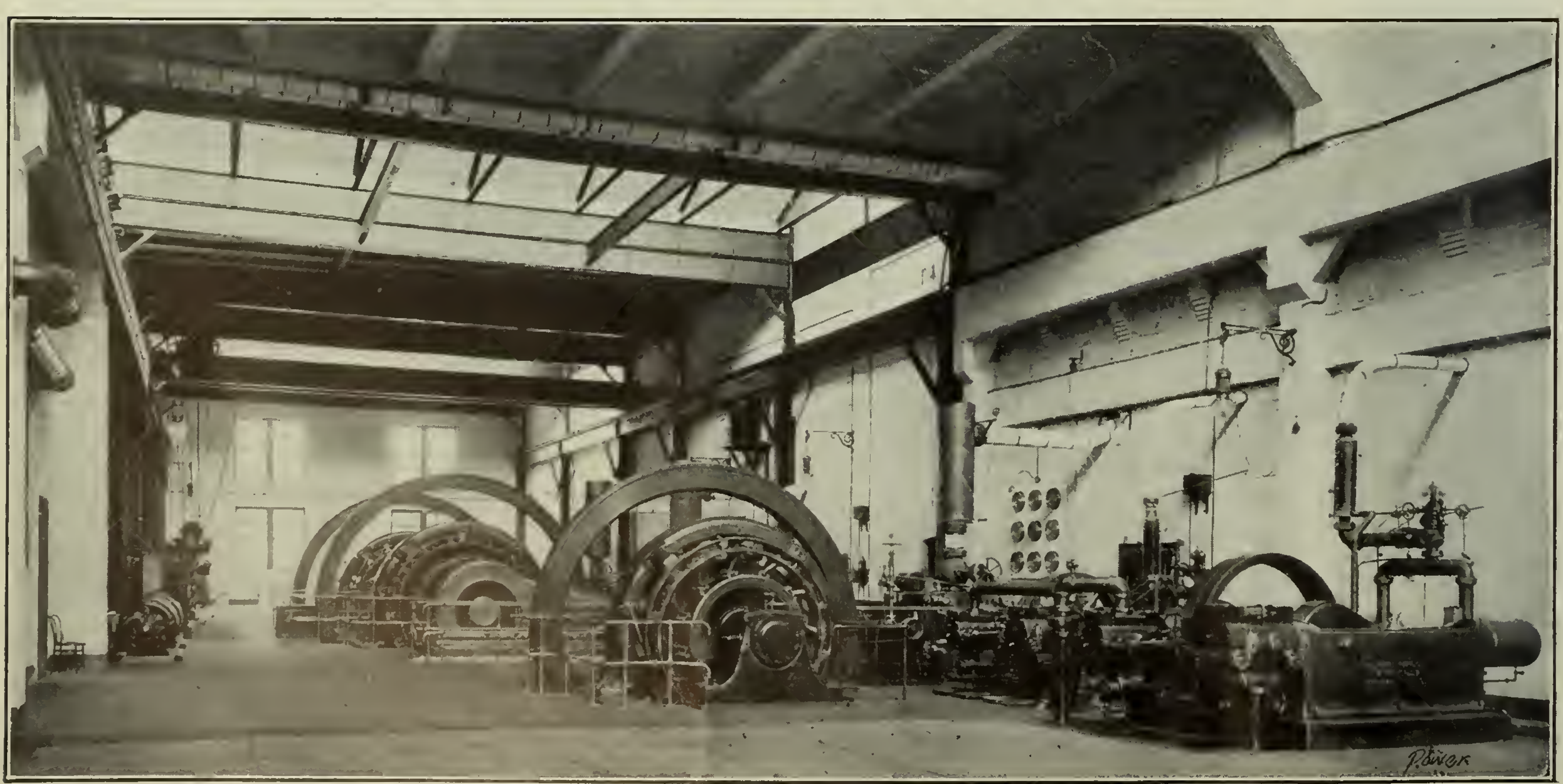


FIG. 2. VIEW OF GENERATING ROOM, SHOWING PRESENT EQUIPMENT

plunger-rod comes in contact with a given stop, the stroke of the plunger is limited and only a given fraction of a gallon is discharged. A registering device at the side of the pumping mechanism records the number of gallons successfully drawn.

A marked metal gage rod is provided in each tank so that the amount of oil still remaining in the tank can easily be ascertained at any time. Each tank has a capacity of 280 gallons. Two tanks contain cylinder oil, two contain engine oil, one contains kerosene and one, oil for the ice machines.

Original and Present Equipment

A general view of the engine room is shown in Fig. 2. The present equipment consists of two 500-kilowatt Crocker-Wheeler generators direct connected to Rice & Sargent Corliss engines, one generator of the same make but of 300 kilowatts capacity driven by an Allis-Chalmers Reliance engine and two Ingersoll-Rand duplex two-stage air compressors, one having a capacity of 530 cubic feet of free air per minute, the other, 710 cubic feet.

Because of the increase in the amount of power required, the capacity of the present equipment will be increased by the installation of a 1000-kilowatt generating unit, built by the Crocker-Wheeler Company. This unit will be driven by a 31 and 48 by 48-inch horizontal cross-compound noncondensing Corliss engine built by the Robert Wetherill Company.

In a separate building there are two York compression and six Isbell-Porter absorption ice machines of a combined capacity of 1020 tons per 24 hours. The refrigerating equipment will be increased by the installation of one 400-ton York compression machine, furnished by the York Manufacturing Company.

A relic of the small beginnings from which the present vast plant has grown is present in the engine room in the shape of the first steam engine used by George Eastman in the manufacture of cameras and supplies. The engine is shown in Fig. 3. It is 8 by 14 inches in size and ran at 275 revolutions per minute. The engine was built by the Buckeye Engine Company about 1885. It was used continuously until two or three years ago.

Some Testimonial Letters

More or less importance is credited to testimonial letters, according to the knowledge the reader has of how they were procured. Usually the party desiring a letter of this sort makes the request from several users of the device in question, and naturally selects the best for publication.

Some of these letters are indeed humorous when the literal meaning is taken. For instance, a certain water-purifying company recently sent out carbon copies of letters from satisfied users of their filter.

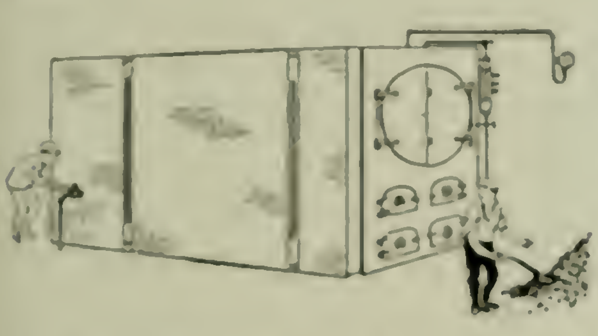


Fig. 1. Loose Scale Did Stunts in the Blowoff Pipe

One engineer writes in part as follows:

"No compound has been put in the boilers since water from the filter was turned on. The boilers were blown off twice a day as required and we could hear the scale rattling out the blowoff pipe."

It certainly looks as if the boiler had better be opened and cleaned, for if there is enough free scale in it to attract the engineer's attention as it passes through the blowoff pipe, it is about time the scale was removed by other methods.

Another engineer, since using the filtered water, states that "The boilers steam now in nine and a quarter against forty-five minutes before."

Getting up steam in forty-five minutes is going some, but generating steam in nine and a quarter minutes is a record and certainly speaks well for the filter.

> *Be careful how you read them. Don't jump at conclusions. The literal translation is frequently absurd.*

How about the boiler seams and tube heads?

Further on the same engineer says, "The purifier has accomplished everything claimed by them. It works automatically and requires no attention. We are now using water for drinking and washing purposes in our office and plant."

It is difficult to determine just what is meant by the above. Whether it is the purifier or the manufacturer that makes the claims, is not quite clear. The letter says it's the filter, but it must be a kind of filtered testimony.

The third sentence is enough to overcome the equilibrium of most readers,

Fig. 2. Used Real Water for Drinking and Washing Purposes

and cause them to wonder what liquid was used for drinking and washing purposes before the filter was installed. Most of us know that in breweries, Milwaukee and Cincinnati, water for drinking purposes is almost an unknown quantity, but it is not generally known that washing is performed with any other liquid than water. Oh, well, everyone to his own taste.

Still another engineer makes the following wonderful statement as to the results obtained from using filtered water:

"Never before had I seen the tubes of my boilers and shell as clean. Just nine and a quarter minutes after lighting the fire this boiler blew the safety valve off."

Nothing is said as to where the valve landed or how far it was blown. Truly these testimonials are most remarkable and convincing.

If there was anything under the sun which seemed to defy the old trite saying that there is a use for everything if you can only find it, it was the sudd of the Nile, that dense vegetable growth which is the continual bugbear of the Nile engineer and navigator. But now all that is to be changed; sudd is to become a commodity instead of a nuisance, and in time to come we may see its price rising in the market just as that of petroleum refuse rose when means of using it profitably as a fuel were found. What is to happen to the sudd is that it is to be conveyed to suitable machinery in which it will be dried, disintegrated and compressed into briquets suitable for consumption in steam boilers, in which it is expected to give an evaporation of about 4½ pounds of water per pound of briquet. When it is recalled that the present price of coal in Khartum is about $13 a ton, the possibilities of the new fuel are apparent. Experiments on a comparatively small scale have so far only been made, but there seems little doubt that in a short time sudd-briquet factories will be established on the banks of the Nile, and that the 20,000 square miles of sudd will become an Egyptian asset instead of an unmitigated nuisance.—Exchange.

Engine and Compressor Power Charts

By T. M. Chance

A graphic method of quickly determining the required dimensions for a given power, or vice versa, of a steam engine, gas engine or air compressor.

One of the most frequent calculations made by mechanical engineers is the horsepower of engines and compressors. When rough estimates of the power delivered by an engine of certain dimensions are hurriedly made, errors often occur from the improper use of the formulas or quantities under consideration. For example, it often happens that the number of revolutions is used as the value of the quantity N in the formula

$$\frac{PLAN}{33{,}000}$$

instead of the number of strokes per minute, and in a double-acting engine this gives a result only one-half as large as

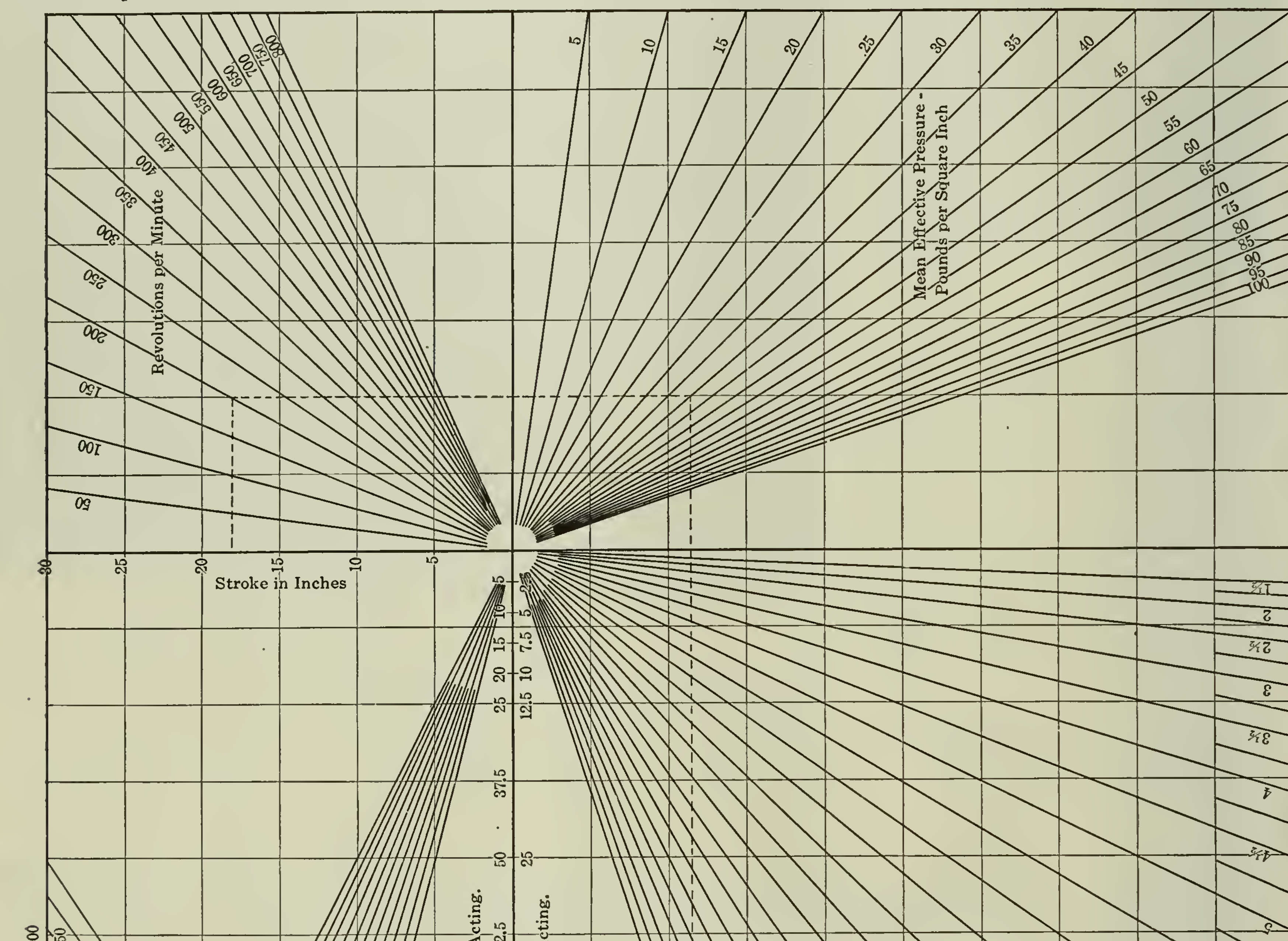


FIG. 1. HORSEPOWERS OF ENGINES UP TO 12½x30-INCH SIZES

that which should be obtained. Similar errors, as well as arithmetical inaccuracies not due to ignorance, are of common occurrence and may lead to large discrepancies in the subsequent result. It occurred to the writer that if a curve, or a series of curves, could be devised which would show at a glance the indicated brake and electrical output of an engine of any size, stroke, mean effective pressure and revolutions per minute, it would be exceedingly convenient and useful to engineers.

In the accompanying diagrams the horsepower rating is based upon the formula

$$\frac{PLAN}{33{,}000} = I.h.p.$$

Where,

P = Mean effective pressure in pounds per square inch;

L = Stroke in feet;

A = Area of the piston in square inches;

N = Number of strokes per minute (twice the number of revolutions).

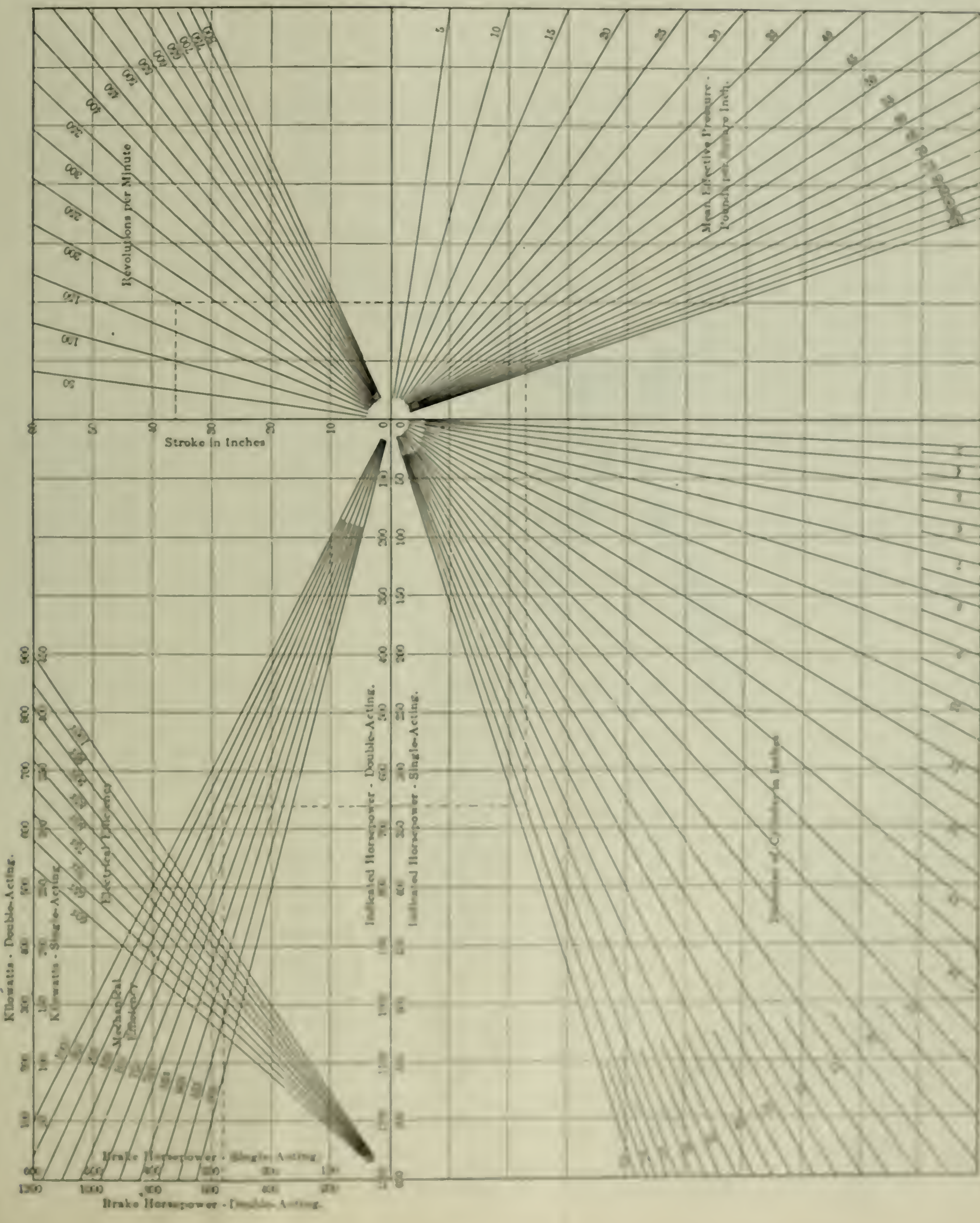


Fig. 2. Horsepower of Engines up to 25x60-inch Size

and,

I.h.p. $\times m =$ Brake horsepower;

B.h.p. $\times e =$ Kilowatt rating;

where,

$m =$ Mechanical efficiency of the engine,

$e =$ Total efficiency of the generator.

In the diagrams the stroke of the engine is laid off in inches instead of feet, and the diameter is similarly measured, the inch being the most convenient unit for this purpose. It should be noted that the horsepower varies directly with the area of the cylinder, that is, as the square of the diameter; hence, the diameters must be spaced proportionately to their squares, since they graphically represent the areas of the cylinders.

For the sake of accuracy in the smaller powers, the diagram has been prepared on three scales; Fig. 1 is to be used for engines up to 12½ inches cylinder diameter and 30-inch stroke; Fig. 2 includes engines up to 25 inches cylinder diameter and 60-inch stroke, and Fig. 3 deals with engines up to 50 inches cylinder diameter.

Referring to Fig. 1, suppose it is required to compute the horsepower of a 12x18-inch engine working under 40 pounds mean effective pressure and run-

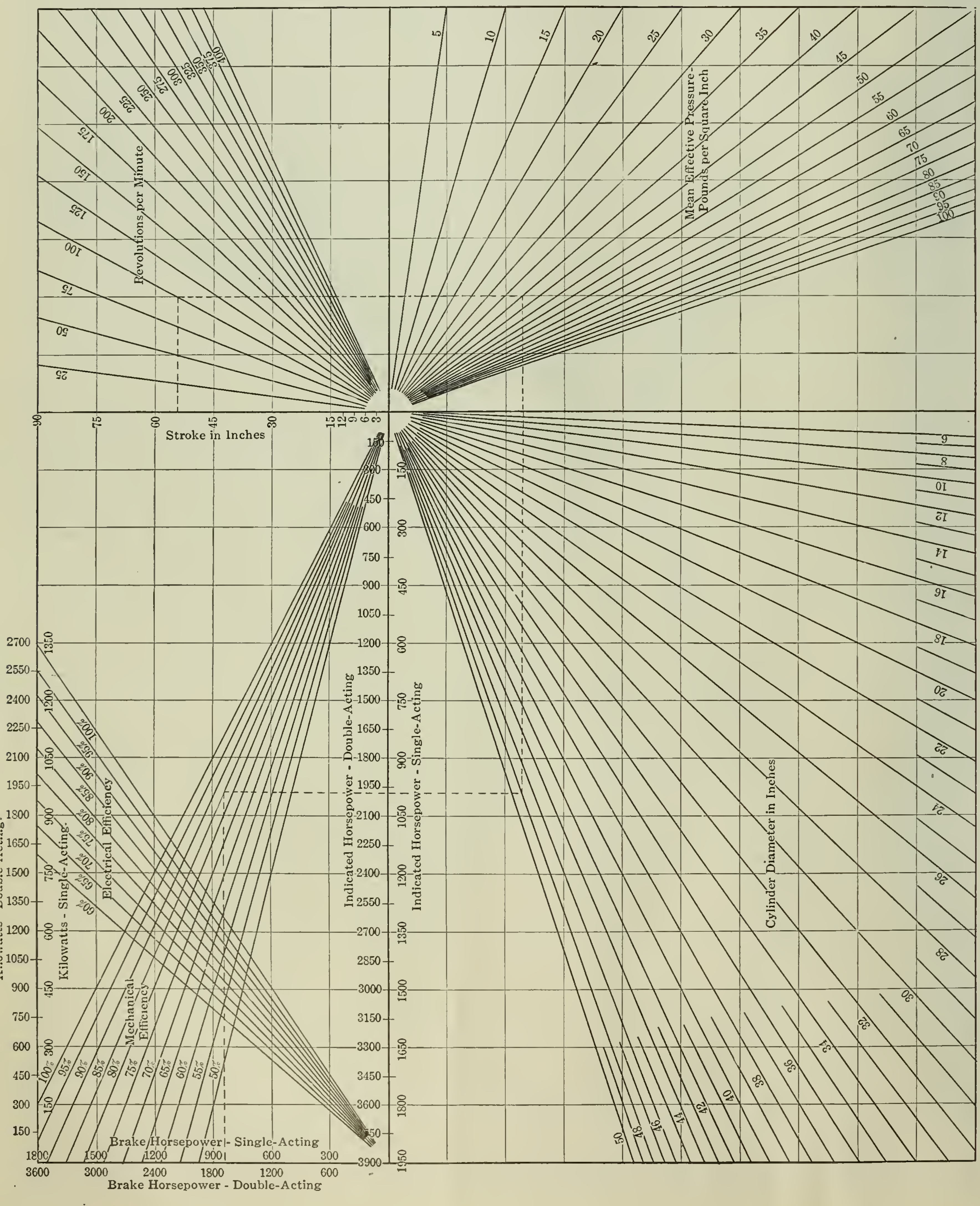


Fig. 3. Horsepowers of Engines up to 50-inch Cylinder Diameter

ning at 200 revolutions per minute, the dotted line indicates the steps taken in the solution of the problem. Reading up the scale of "Stroke in Inches" to 18 inches, follow horizontally across to the intersection of this line with the diagonal line marked 200 on the scale of "Revolutions per Minute"; from this intersection drop vertically downward until the diagonal line marked 40 on the scale of "Mean Effective Pressures" is crossed; follow horizontally across from this point to the line marked 12 inches on the "Diameter in Inches" scale and, running vertically upward from this intersection to the scale of "Indicated Horsepower, Double Acting," the result is found to be 82.5 indicated horsepower. If it is desired to find the horsepower of the engine running single acting, it will be found to read 41.25 indicated horsepower on the lower scale of "Indicated Horsepower, Single Acting."

If the brake horsepower and kilowatt capacity of the engine is desired, assuming 85 per cent. mechanical efficiency and 95 per cent. generator efficiency, read vertically upward along the 82.5 indicated horsepower line to its intersection with the diagonal line marked 85 per cent. on the scale of "Mechanical Efficiency"; the horizontal line passing through this point shows the brake horsepower to be 70 on the scale marked "Brake Horsepower, Double Acting." To determine the electrical output, follow vertically upward from the intersection of this horizontal line with the line passing through 95 per cent. on the scale of "Electrical Efficiency" and read 50 kilowatts on the scale marked "Kilowatts, Double Acting." The same use may be made of the single-acting scales for the brake horsepower and kilowatts output as was done in the case of the indicated horsepower.

Where refinement in the calculations is desired, the decrease in power due to the reduction in effective area of the piston on account of the piston rod and tail rod, if the latter is used, must be computed. This is easily done with these diagrams by considering the piston rod and tail rod as two single-acting engines having a cylinder diameter equal to that of the rods and working in opposition to the engine. When the piston rod and tail rod are of the same diameter they may be considered as one engine, running double acting. Therefore, if the decrease in power caused by the piston rod of a 100-brake horsepower engine amounted to 2 brake horsepower, the actual brake horsepower delivered by the engine would be 98.

The diagrams are also useful in calculating compressor dimensions. For example, a compressor is to be installed to develop 600 indicated horsepower; the stroke of the compressor is 30 inches, the mean effective pressure 40 pounds and the diameter of the cylinder 24 inches; find the number of revolutions. The dotted line in Fig. 2 indicates the steps taken in the solution of this problem. Starting with 600 on the scale of "Indicated Horsepower, Double Acting," drop vertically downward to the diagonal line marked 24 on the scale of "Cylinder Diameter in Inches." From this intersection follow horizontally across to the diagonal line marked 40 on the scale of "Mean Effective Pressures" and from this point run vertically upward to the intersection with the horizontal line passing through 30 inches on the scale of "Stroke in Inches." A diagonal line passing through this intersection and the common center of all the diagonal lines gives the number of revolutions, on the scale of "Revolutions per Minute," which in this case is 200.

The diagram may also be used to directly calculate the dimensions and power of gas or oil engines, if of the two-stroke type, as the horsepower of engines of this type is computed by the same formula as that used in steam-engine calculations; hence,

$$I.h.p. = \frac{PLAN}{33000}, \text{ for double-acting engines}$$

$$I.h.p. = \frac{PLAN}{33000 \times 2} \text{ for single-acting engines}$$

In the case of four-stroke engines the result obtained by the use of the diagram must be divided by two, as the four-stroke engine receives but half as many impulses as the two-stroke machine, during the same number of revolutions; that is,

$$I.h.p. = \frac{PLAN}{33000 \times 2} \text{ for double-acting engines}$$

$$I.h.p. = \frac{PLAN}{33000 \times 4} \text{ for single-acting engines}$$

When determining the dimensions of a four-stroke engine it should be remembered that the principal dimensions of a four-stroke engine and those of a two-stroke engine of twice the power are identical; hence, read twice the power of the machine under consideration on the horsepower or kilowatt scales and proceed as if the dimensions of a two-stroke engine of that power were being computed. The dotted line in Fig. 3 represent the procedure in the calculation of the dimensions or power of both a two-stroke engine of 1000 horsepower and a four-stroke engine of 500 horsepower.

Weighing Small Parts Accurately

By S. Kirlin

In machine shops, as well as in many other places, it is frequently desired to ascertain the exact weight of small pieces of castings, etc., and with the ordinary kind of platform scales generally used in those places it is impossible to weigh anything less than 5 or 10 pounds with any degree of accuracy. In machine shops especially, where the scales are used for weighing pig iron, heavy castings and subjected to the rough treatment usually given to them, it is practically impossible to weigh anything less than five pounds accurately.

Here is a method by which small parts weighing from a fraction of a pound up to several pounds may be weighed with extreme accuracy on almost any size of scales.

Slide the weight on the scale beam back to 0 and remove the weights from the beam in the same manner as when "balancing" them. Now, hang the small piece that is to be weighed on the end of the beam from which the weights were removed; next pile enough iron, or any other heavy material, on the platform until it just balances the small piece on the end of the beam. Now remove the small piece from the end of the beam and weigh the iron on the platform in the usual manner; divide this weight by the "ratio" of the scale and the product will be the exact weight of the small piece.

The "ratio" of the ordinary small platform scales is usually 100 to 1, that is, a weight of one pound on the end of the scale beam will just be balanced by a weight of 100 pounds on the platform. This ratio on larger scales may be 200 to 1 or greater.

Example: Suppose there is a small piece to be weighed; first remove the weights from the end of the scale beam, slide the weight on the beam scale back to 0 and see that the scales "balance." Now hang the small piece on the end of the beam from which the weights were removed and pile enough scrap iron on the platform to just balance the small piece. If the iron on the platform is found to weigh 175 pounds and the ratio of the scales is 100 to 1, then divide this 175 pounds by 100 and obtain 1.75 as the weight of the small piece. If the ratio of the scale was 200 to 1 it is obvious that it would have been necessary to place double the weight on the platform to balance the small piece. In this case there would have been a weight of 350 pounds, which divided by 200 gives 1.75 as the weight of the small part. This is extremely accurate even though the scales may be far from accurate in weighing anything less than 10 pounds in the ordinary manner.

I hear someone ask how you would go about it to find the ratio of the scales in case you did not know what it was.

This is easy. If you live east of the Missouri river, just lay your pound plug of "terbacker" on the end of the beam and see whether it required 100 or 200 pounds on the platform to balance it. Or if you are west of the above mentioned stream, where everybody carries a "Colt 45" (except when they go to church), you can use it for a test weight, as everyone knows that the regulation Colt "peacemaker" weighs exactly two pounds.

New Wave Motor of the Float Type

By A. R. Maujer
and Franklin Van Winkle

With this motor, by means of an ingeniously devised system of levers, power can be derived from every motion of the waves. Motor is governed by varying amount of submergence of floats, this being accomplished by compressed air which serves to force water out of a float to any extent desired.

The United States Wave Power Company is demonstrating on Young's "Million-dollar" pier, Atlantic City, N. J., the latest thing in wave motors. The ideas underlying this motor are most ingenious. By means of a system of levers and ratchet wheels advantage is taken of every motion of the water in sidewise and slantwise directions as well as in the vertical.

Fig. 1 is a general view of the upper part of the motor. Fig. 2 is a view under the pier, showing three of the floats which operate the machine. The motion and energy of the waves are imparted to the shaft *A*, Fig. 3, by means of mechanism which is the same for all floats; hence, a motor is divided into a given number of unit sections each composed of a float and the apparatus for converting the assorted motions of the waves into a rotary motion of the driving shaft.

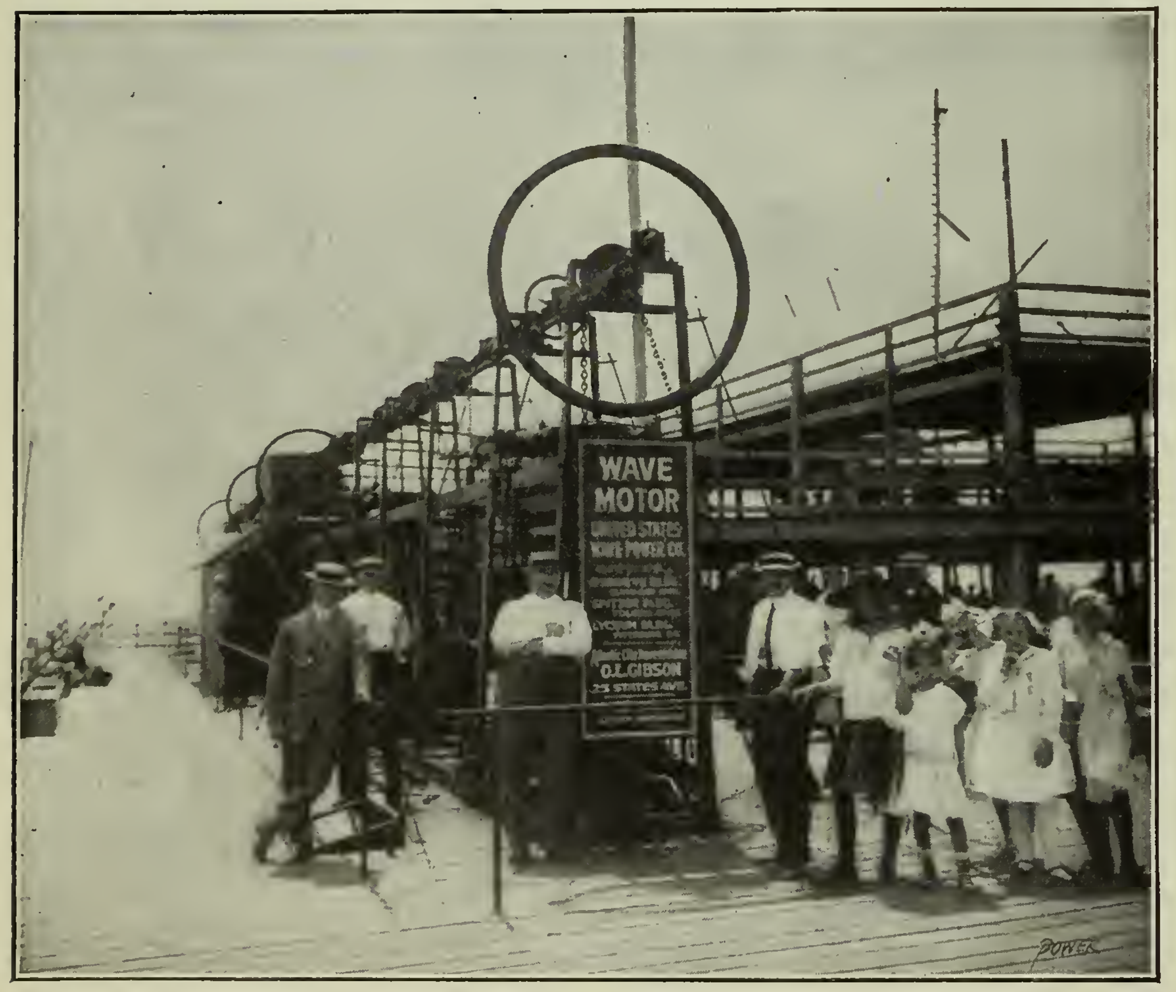


Fig. 1. View of the Entire Superstructure of the Wave Motor

The action of the machine may readily be understood by referring to Fig. 3. The float is free to slide up and down on the hollow rod *C* which has an open slot in one side. A lug at the top and one at the bottom of the float project through this slot into the core of the rod. To these lugs two chains are attached. The chain which is fastened to the upper lug passes up through the rod and over the ratchet wheel *D* and terminates with the weight *F*. When the float slides down on the rod, the chain causes the ratchet wheel to engage teeth on the shaft *B*, which is thereby caused to rotate with the wheel in a counterclockwise direction. When the float rises, the weight *F* makes the ratchet wheel rotate in the opposite direction; the ratchet then simply slides over the teeth.

The chain attached to the lower lug passes down through the shaft, over the pulley, then up again and over the ratchet wheel *E*, terminating with the weight *H*. When the float rises the chain causes the ratchet wheel *E* to turn the shaft counterclockwise, and when the float falls the wheel slides free. Thus, a vertical motion of the float either up or down tends to cause the rotation of the shaft *B*.

The upper end *I* of the rod *C* forms a ball and socket joint with the yoke *J*. The flanged disk piece *K* is integral with the ball *I* and the base ring *L* of the frame *M* rests on this disk. When a wave gives a sidewise motion to the float the disk *K* is thrown out of level and the frame *M* rides up on the high side of the disk. The lever *N*, which has its fulcrum at *O*, is fastened to the frame *M* at *P* by a compound hinge joint. As the end *P* of the lever is pushed upward the opposite end *Q* swings downward and the chain fastened thereto causes the ratchet wheel *R* to rotate the shaft *B*. Due to the large ratio between the lengths of the arms of the lever *N*, even a slight lateral movement of the float produces a considerable movement of the end *Q*. The counterweight *R* performs the same function as do weights *F* and *H*; namely, of keeping the chain taut on the ratchet wheel and causing the wheel to rotate in the reverse direction when the pull due to a wave is finished.

The power which the shaft *B* receives is transmitted through gear wheels of suitable ratio to the shaft *A*, which carries as many flywheels of proper size as are needed to steady the rotation; the number required depends, of course, on the size of the motor, that is to say, on the number of float units employed.

Method of Governing

The speed and the amount of power which the motor develops are regulated by means of compressed air. The floats, which are made of steel, are hollow and air tight except for four holes in the bottom, which are sealed by the water. Each float is connected by means of a flexible hose to a compressed-air tank which is located on the pier and in which a pressure of about 15 pounds is maintained. Thus, by admitting air the float can be entirely emptied or by releasing the air the float can be completely filled with water.

However little work there is upon the motor, it cannot run away, for, if the wheels upon which the pawls work were to run faster than the floats actuate the pawls they would receive no acceleration while such conditions existed. As there is always some resistance to the movement of the shaft its speed never gets beyond that at which a ratchet can exert a pull on its ratchet wheel fastened on the shaft. The energy taken up from the succeeding pulls of the ratchets is absorbed and distributed by flywheels on the main shaft which are of sufficient weight to do this efficiently.

Size and Capacity

The size and capacity of a motor are determined by the number and size of the floats. The demonstration motor at Atlantic City is composed of six floats and the necessary transforming mechanism. The floats are 4 feet in diameter, 4 feet long and have a displacement of about 50 cubic feet. It is said by the officers of the company that the machine is capable of developing between 100 and 125 horsepower, although no records of any authenticated test are available. A commercial plant would have not less than 32 floats.

Theoretical Estimate of Capacity

An estimate of the power derivable from the wave motions of a body of water by the employment of mechanism should be based upon a rational assumption of the forces and motions that are incident to water when agitated in the form of waves. When the crest of a wave is observed sweeping over the surface of an expanse of water, the eye naturally follows the moving crest and an impression is received that the same surface particles of the water remain on the crest of the wave, partaking of the same horizontal movement as the crest. As a matter of fact, visible wave motions consist, for the most part, of only a change of the form of the surface which rises up and down over the same place, much the same as a carpet on a floor would be disturbed by moving a rod sidewise over the floor under the carpet. The surface motions of waves are clearly comprehended when the effect of wave motion imparted to a body of water covered with irregular-sized floating bodies is observed, as a field of broken ice. The floating masses appear, from the action of the waves, to have the motion of rising and falling very nearly over the same spot, combined with an oscillation forward as they rise, and an oscillation backward as they fall, being left slightly advanced in the direction of the motion of the wave's crest. This lateral motion is illustrated in the swaying of a spile loosely held in the bottom when swept over by the waves. The net horizontal displacement of the water may be very small from the passage of a single wave over the surface of a placid body of water; but when the surface is disturbed by a succession of waves, each accompanied by greater energy in the direction of the wave movement over the whole surface, the effect is to drag along the whole body of water with accumulating velocity in the direction of the main surface-wave motion.

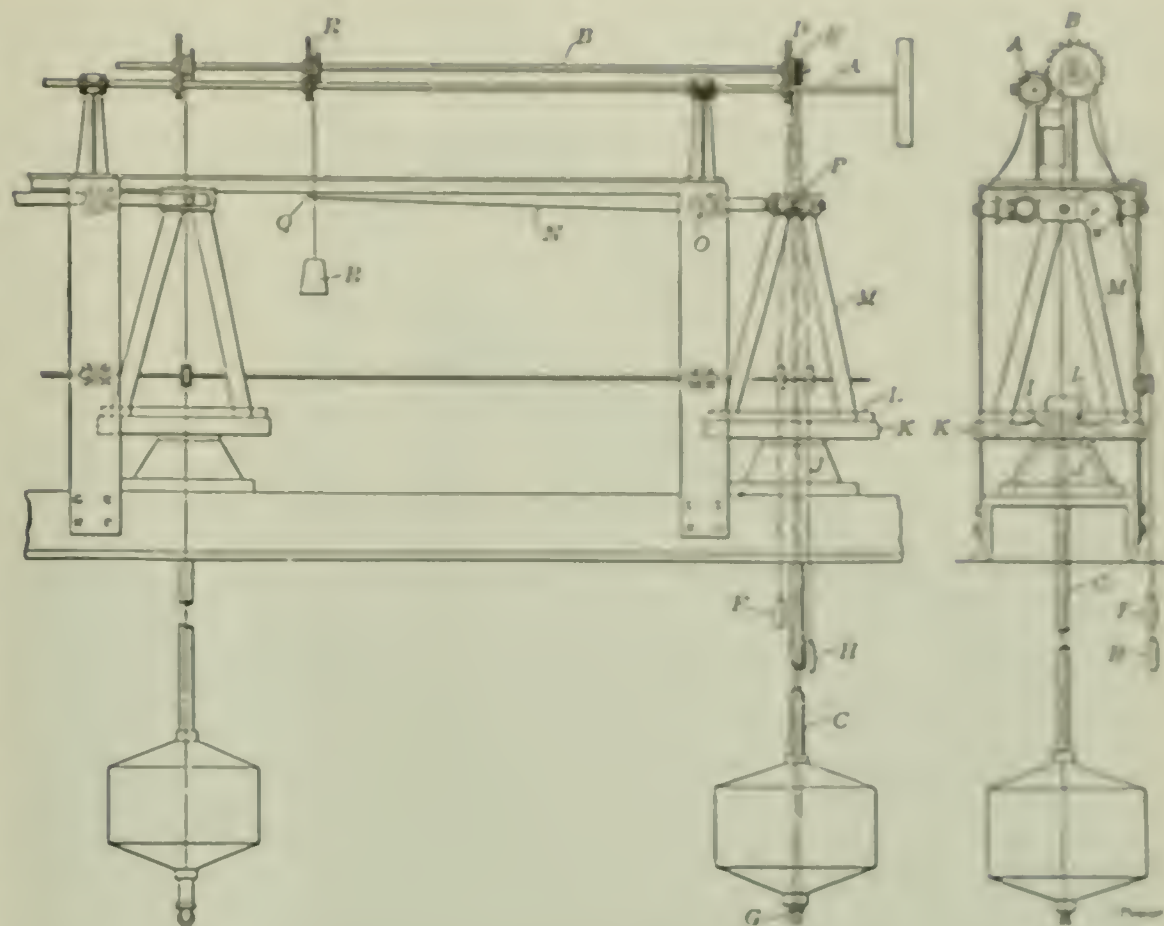


Fig. 3. Diagrammatic Arrangement of the Mechanism

Fig. 2. Three of the Floats Which Actuate the Motor

The wave motor herein described is intended to gather energy both from the horizontal and from the vertical motion of the particles of the water in which it may be immersed.

Wind, weather and other conditions which affect the height, speed and frequency of ocean waves are all so variable that any assumption of average combination of vertical and horizontal motions available for a power installation must be regarded as purely conjectural.

Computations based on data recorded by the promoters, and in which the motor is given the benefit of every doubt, result in convincing one that the power which the motor is capable of developing is decidedly less than 100 horsepower.

Each of the six floats, 4 feet in diameter and 4 feet high, has a displacement of about 50 cubic feet, and as a cubic foot of water weighs approximately 62.5 pounds, each float, therefore, weighs

$$50 \times 62.5 = 3125 \textit{ pounds}$$

less when in the water than when out. No matter what may be the form or material of a body, when it is submerged it is at all times buoyed up by a force equal to the weight of the water which it displaces. Assuming that a float of the wave motor is at the lowest point of its vertical travel, that it displaces 50 cubic feet of water and that the float itself has a total weight, out of water, of 3125 pounds, then the rise of a wave would lift the float, but the buoyancy of the water would lift nothing additional to the weight of the float. Under that condition, no work could be gotten out of the upward motion of the float. On the downward motion, work could be obtained to the full effect of the weight of the water which had been displaced during the upward motion, and through the distance raised, provided the mechanism for absorbing the work of the downward motion is of such a character that the wave in dropping falls so much more rapidly than the float as to exert no buoyancy to retard the gravity of the float. If the float is lightened or counterpoised in any manner exerting a lifting action during its upward travel, tending to decrease the weight of the float in the water, then an effect equal to such a lifting effect will act against the downward motion of the float. It is immaterial what proportion of ballast is carried or how the parts are counterpoised, the total effect for a rise and fall of a wave can be only the displacement (3125 pounds) raised the hight of the wave, minus the half hight of the float. Assuming the effective rise to be 2 feet and the frequency of the waves once in 5½ seconds, the total power exerted by the waves in raising six floats would be,

$$3125 \times 2 \times \frac{60}{5\frac{1}{2}} \times 6 = 409{,}090 \textit{ foot pounds per minute} = 12.4 \textit{ horsepower.}$$

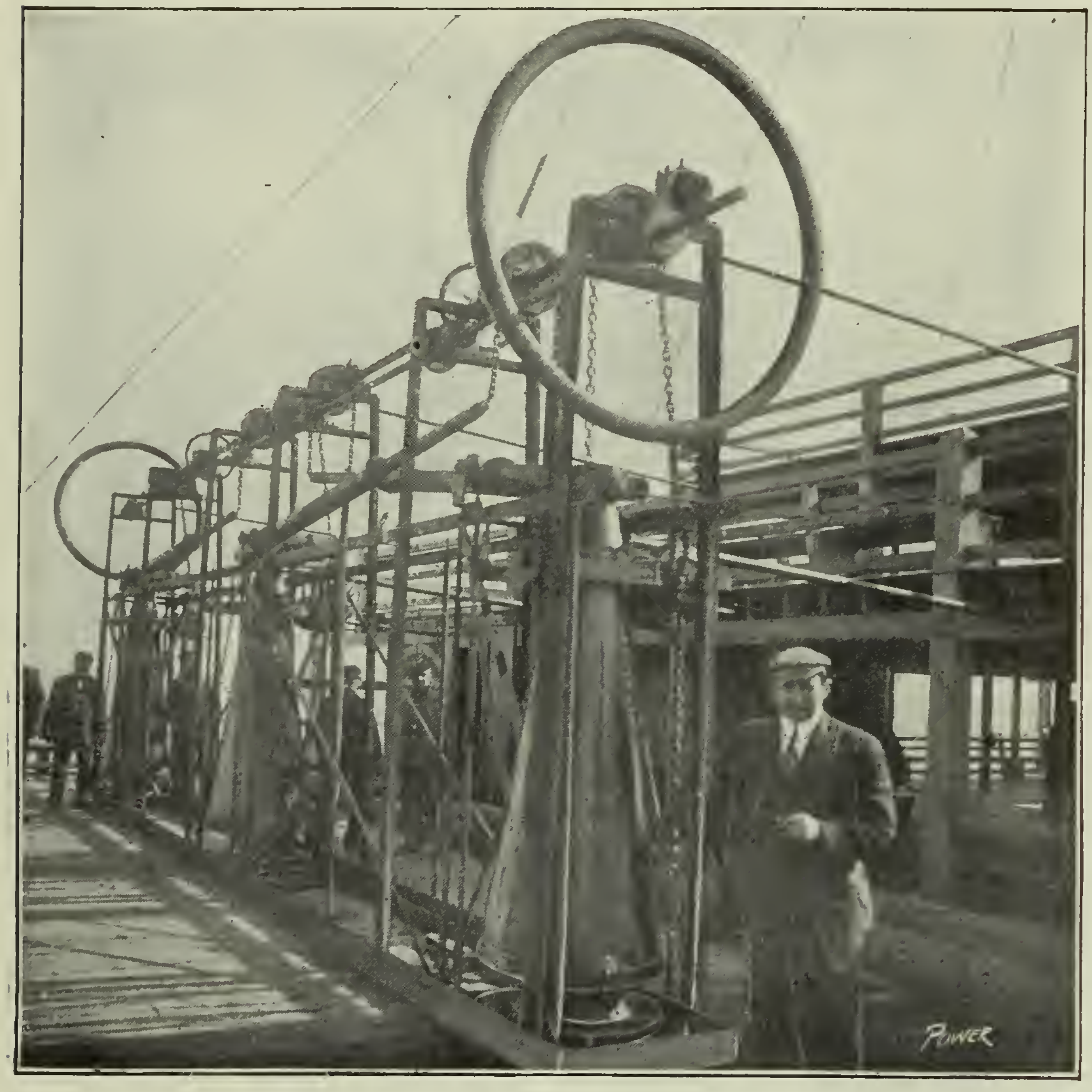


Fig. 4. View of One Section of the Superstructure

Conceding that the average lineal sweep of each float is six feet forward and six feet backward, occurring once every wave interval of 5½ seconds, then the total lateral motion per minute made by each float may be assumed to be

$$6 \times \frac{60}{5\frac{1}{2}} \times 2 = 130.9 \textit{ feet per minute}$$

According to the experiments of Poncelet, the highest efficiency in the conversion of the energy of the water is attained by a float in an unconfined channel, when the velocity of the float is one-half the velocity of the current. Therefore, to estimate on a basis of current velocity which would yield the highest efficiency for a float velocity of 130.9 feet per minute, calculation would have to be made on assumption of a current velocity of

$$130.9 \times 2 = 261.8 \textit{ feet per minute,}$$

assumed as an average velocity of water creating lateral pressure on the float. Each float being 4 feet in diameter and 4 feet high, a projected area of 16 square feet would be the greatest cross-sectional area of current acting on a float.

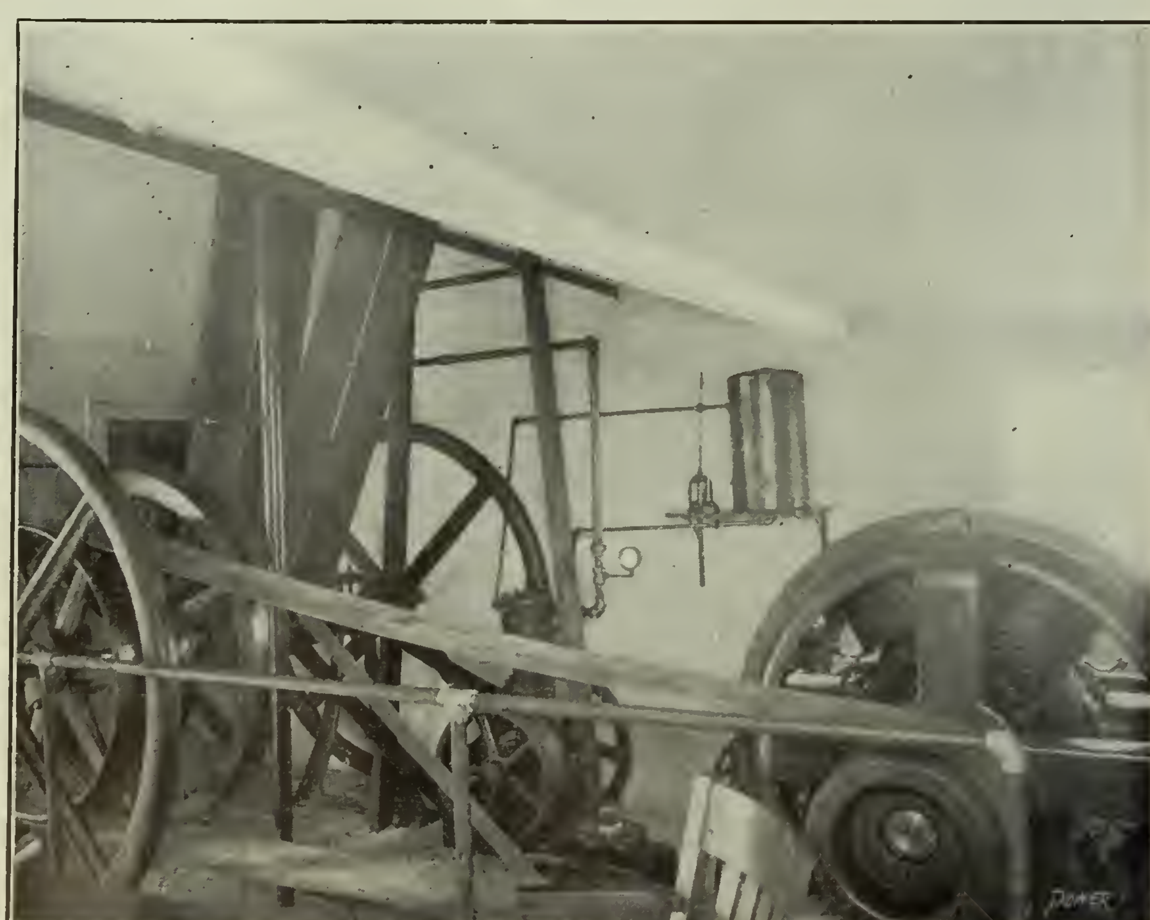


Fig. 5. The Countershaft, Generator and Air Compressor Driven by the Wave Motor

The assumed current velocity of 261.8 feet per minute is equivalent to a velocity of 4.36 feet per second. Each float would, consequently, have presented to it during a second of time

$16 \times 4.36 = 69.76$ *cubic feet of water,*

equal to

$$69.76 \times 62\tfrac{1}{2} = 4360 \textit{ pounds}$$

of water per second, at a velocity of 4.36 feet per second. Finding the kinetic energy of the water, in foot-pounds per second, by the usual formula,

$$K = \tfrac{1}{2} M v^2,$$

by substituting

$$M = \frac{4360}{g}$$

$v = 4.36$ feet per second and $g = 32.2$, we find:

$$K = \tfrac{1}{2} \times \frac{4360}{32.2} \times (4.36 \times 4.36) = 1287 \textit{ foot-pounds per second}$$

and presented to six floats would make,

$$1287 \times 6 = 7722 \textit{ foot-pounds per second.}$$

Poncelet determined that the highest percentage of energy obtainable from an unconfined current acting on flat float boards normal to the direction of the current was 40 per cent. of the kinetic energy of the obstructed current. In the case before us the surfaces acted upon by the current are convex-circular cylinders, a form well established as offering only one-half as much resistance to the motion of an unconfined fluid current as flat surfaces normal to the direction of the flow. Absorption of current energy by the cylindrical form of float could therefore not be in excess of 20 per cent. of the kinetic energy of the current. The maximum lateral or current energy absorbed by the six floats would therefore be but 20 per cent. of 7722 foot-pounds per second, or only 1544.4 foot-pounds per second, equal to 92,664 foot-pounds per minute, from which it becomes evident that the total power which the waves can impart to the six floats in lateral motion is

$$\frac{92{,}664}{33{,}000} = 2.8 \textit{ horsepower}$$

This, added to 12.4 horsepower, receivable from the up and down motions, gives 15.2 horsepower as the maximum power which the waves could impart by all motions to the six floats of the motor during continuance of the conditions which are conceded.

But, beyond this, the efficiency of the mechanism for the conversion of the energy applied to the floats into energy developed in the form of the rotation of the shaft and the losses of power consumed by the speed-governing mechanism have to be taken into account. From the character of the mechanism employed for these purposes it would appear that not more than 75 per cent. of the initial energy applied in the creation of the motions of the floats would be recoverable in useful work in the form of rotary power deliverable from the shaft of the motor. Thus, allowing 75 per cent. efficiency of the mechanism, the estimated actual or brake horsepower of the motor, operating under the conditions which are conceded, appears to net but 11.4 horsepower.

Commercial Value

The cost of operating a power plant is not made up of fuel and labor alone. The standing charges, made up of interest and depreciation, insurance, taxes, etc., form a considerable proportion. It is quite possible to put so much money into the development of a water power that the standing charges would pay those of a steam plant and the fuel and operating costs as well. This is the crux of the wave-motor situation. Can such a device be built for a cost that will permit its use in competition with established sources of power?

There is no authenticated test of the power which the motor under review will produce. On the day that the writer saw it, it was operating a small air compressor and furnishing air enough to blow a whistle occasionally. The generator could not be run because the belt was broken and something was the matter with the pump.

As has previously been mentioned, the promoters claim that they have gotten 100 to 125 horsepower out of the motor, and that its cost, including changes, revisions, substitutions of parts, etc., is in the neighborhood of $50 per horsepower. They also claim that they have estimates that show that a commercial plant can be built for $17.50 per horsepower, allowing $3 per horsepower for pier or crib work. The crib would be built of concrete and steel and the power transmitted to land by cable.

The plans of the company are to build a commercial plant at Boston or New York as soon as enough stock is sold to render this possible.

Intending purchasers of stock should satisfy themselves as to the correctness of the estimates of capacity and cost.

Flue Welding in Repairing Boilers

By H. S. Jeffery

If the condition of a boiler is such as to necessitate the removal of tubes in order to get at the inside of the shell, and the tubes are not pitted or otherwise rendered unfit for service, they may be used again by welding a small section on to the end which was cut during the process of removal.

It seems to be one of the first principles with many owners of boilers that the tubes shall not be removed until all efforts to keep them from leaking have been exhausted. However, when the efficiency of the boiler has been decreased to a marked extent due to the deposit of foreign matter, then it is often necessary to remove the tubes, whether they leak or not, and clean the boiler shell. The money expended for removing and replacing the tubes will be well spent, there being no necessity for throwing away the tubes which are removed from the boiler and replacing with new ones, unless they are badly pitted.

It is now the practice to again use the tubes which have been removed from a boiler. This is accomplished by welding on the end of the tube a section about six inches long, called a "safe-end." Frequently the safe-end is somewhat heavier than the tube, and the general rule is to install it so that this end of the tube is expanded to the flue sheet of the firebox or furnace. This is because the new end of the tube is firmer and stronger than the old tube, and consequently can be expanded into the fire-box tube sheet better than the old tube. Also, as a rule, the new section when expanded into the hole, produces a tighter joint than the older and thinner tube.

The chief difficulty with flue welding is the desire to weld a great many flues in a given time, and too often the quality of the work is sacrificed for quantity, the whole saving, however, is lost on account of the expense and time required to remove, reweld and replace those which get loosened or have defective welds when the boiler is tested. Although the flues may be sound when tested and after being installed in the boiler, a defective weld may not show until the boiler has been in service a short time.

The manner of scarfing the safe-end to the tube is very important, the attention to detail always being to scarf both the tube and the safe-end about ½ inch as shown in Fig. 1. This scarfing is open to the objections that the outer edge of the tube is liable to burn off, and unless the operator is experienced some parts of the flue when welded are liable to be welded thinner than the balance of the flue. Another method is to scarf the safe-end, opening up the flue to overlap the safe-end as shown in Fig. 2; while others reverse this process, scarfing and opening up the tube to overlap the safe-end. Many, however, have abandoned the practice of scarfing either the flue or the safe-end, depending upon the disk or cutter, used for cutting the flue and safe-end, to bevel the edges for the purpose of welding. Flues welded in this way are called "short lap-welded," the short bevel or scarf making a solid weld as it affords sufficient metal through the weld to be worked down to size. When welding the safe-end to the tube, the latter should be upset against a cross-bar at the back end of the welding furnace. It is also important to see that the welded portion is not oversize or undersize; a flue which is oversize at the weld will be hard to insert into the boiler, and if undersize the chances are that the walls at the weld are thinner than the balance of the flue. It is the practice in many shops to weld and swedge the flue in the same heat, but this requires that the whole safe-end be heated unless it is exceptionally long. This practice has in many instances injured the weld, the swedging operation being attempted when the safe-end was too cold. In other shops

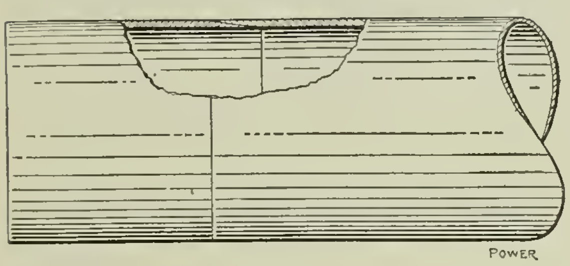


FIG. 1. BOTH TUBE AND SAFE-END SCARFED

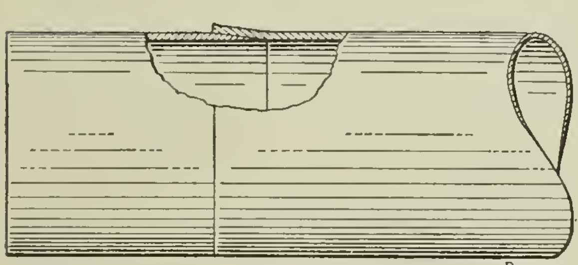


FIG. 2. ONLY SAFE-END SCARFED

the flues are welded, allowed to become cold and the weld tested, after which the ends of the flues are heated, swedged and annealed.

In some shops the welds of the flues are tested under pressure in a machine made especially for that purpose, although in the majority of cases a wooden plug is driven into one end of the tube; the tube is then filled with water under pressure, and the weld is hammered lightly with the peen of a chipping hammer. Still others test the welds after the flues have been installed in the boiler but this is poor practice. The flues when swedged should be turned several times, making the ends round and the swedged portion central with the balance of the flue. After the foregoing operations the flue ends while heated to a cherry red should be placed in a bath of lime, thus annealing the flue so that it can be expanded to the flue holes and beaded to the sheet without danger of splitting the flue.

Although a boiler may be opened and washed out periodically all the scale and mud will not be removed, and though the flues may not leak, it may be necessary to remove them so as to thoroughly clean the boiler. In such cases it is not usual to remove all the tubes, the practice with many being to remove the lower tubes as indicated in Fig. 3, which is called a V. This practice is more general with the locomotive type of boilers than with tubular boilers. The majority of the latter type of boilers are now being constructed with a manhole under the flues, which permits the scale and mud to be

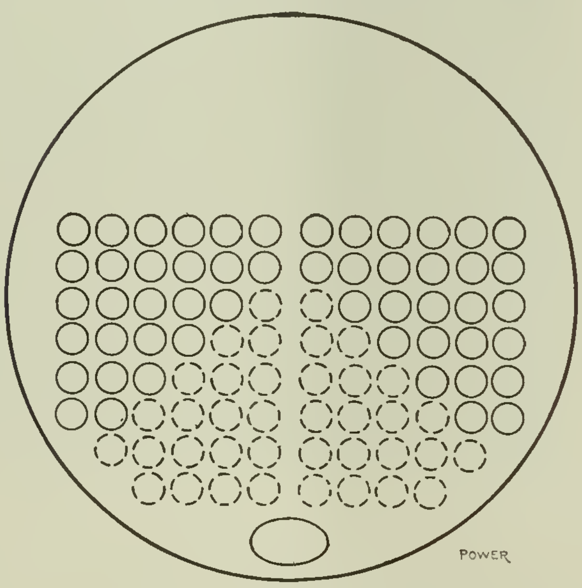


FIG. 3. DOTTED LINES REPRESENT TUBES REMOVED

removed from both the boiler shell and the flues without removing the flues.

It is important that the tubes be as straight as practicable. Those removed from the lower rows are liable to be bow-bent, especially if they are long and considerable scale has adhered to them. If installed in the boiler when bow-bent, some of the tubes may touch, or nearly touch, one another, creating unequal water spaces between the tubes and preventing proper circulation, also affording spots where sediment will lodge. The tubes which are cleaned in a revolving machine, called a "rattler," should be cleaned by rubbing against one another, the rattler revolving at a very slow rate of speed. Small pieces of iron and steel may be used in the rattler to aid in cleaning the tubes, but large pieces should not be used as they will cause dents in the tubes.

Frequently one or more flues will leak to the extent of practically putting out the fires. The leak may be the result of the joint between the flue and the hole becoming broken, or a hole being eaten in the flue or the weld in the tube parting. It is not always possible to cut the boiler out of service, in which case the flue is plugged by driving a cast-iron tapering plug into the flue.

Sometimes the joint between the flue and the hole will become broken and the bead of the tube partly broken off; in such cases, but only in an emergency, the flue may be repaired by cutting the bead off flush with the flue sheet and placing a section of tube inside of the tube as shown in Fig. 4. The old flue is first

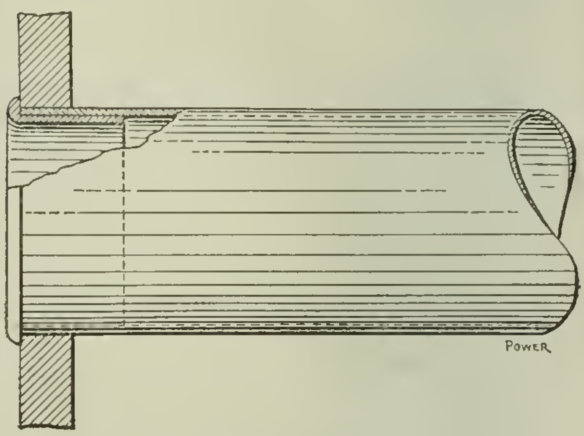


FIG. 4. TUBE HELD IN PLACE BY SMALL SECTION AT END

expanded hard against the sheet, after which the section is inserted within the old tube, expanded hard against it and beaded to the tube sheet in the same manner as the original tube. The section being only indirectly cooled by the water within the boiler is liable to become overheated, and especially if fine particles of coal, etc., are allowed to lodge around and within it. The only object in using the section in preference to plugging the flue is that the latter practically cuts out the flue and reduces the heating surface, while the former permits the flames and hot gases to pass through the tube as before, thus maintaining the heating surface.

The International Electrical Company, Limited, with offices in Nelson, B. C., and Portland, Ore., has filed plans for the development of a large electric power plant from the falls on the Pend d'Oreille river. The river runs from Canada to the United States, some 50 miles southwest of Creston, B. C., and for nine miles before reaching the boundary it is a series of rapids. At a point some six miles above, on the Canadian side, a site admirably adapted for the necessary development works has been staked, and it is expected that a city will be located in the vicinity, to be known as Falls City. W. E. Moore, hydraulic engineer, of Spokane, has made an investigation and report on the power sites of the river, in which it is stated that the upper site is capable of a total development of 65,000 horsepower and that the cost will be about $60 per horsepower. The Sheep creek and Ymir mining districts are only fifteen miles away, and the power sites are within 100 miles of Spokane.—*Electrical World.*

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Some Notes on the Operation of the Lackawanna Steel Works Engines*

By E. P. Coleman

The Körting engines used at the Lackawanna Steel Company's plant at Buffalo did not show satisfactory operation during the first three years of their existence, but the author believes that essentially all of the trouble can be traced to several major causes tending to produce premature combustion, and a number of minor details not well appreciated at that time.

The conditions tending to produce premature combustion and attendant failure of parts subject to the resulting high pressures and temperatures were imperfect piston rings, neither properly doweled nor provided with keepers; unsuitable oil used in the motor cylinders; and high hydrogen content in the gas. Minor causes of premature combustion were projecting portions of parts exposed to the fire, and accumulations of flue dirt which, in combination with the oil, baked on the surfaces of the parts; the projecting portions remaining incandescent and initiating premature combustion. Minor troubles were also due to various causes, such as wet gas which fouled the igniter points with its accompanying flue dirt; dirty gas which clogged the valves of the controlling devices, making the speed control more difficult; imperfect rod packing, which produced bad atmospheric conditions in the building; inadequacy of certain parts of the 1000-horsepower engines subject to high inertia stresses at 100 revolutions per minute.

Rectangular dowels are now applied to the piston grooves in such secure manner that the openings through the snap rings are confined to a location near the bottom of the cylinder, thus preventing leakage through the openings. The cylinder oil now used does not leave a carbonaceous residue of any considerable magnitude. The pressure of water supply to tuyeres, coolers and bosh plates is maintained slightly lower than the internal pressure of the furnace, hence cool water cannot enter the furnace to produce excessive hydrogen, following puncture of those parts.

As originally installed, the cylinders, pistons and muffling sprays were all supplied with water through individual connections, each wasting to a sewer. The system has since been modified so that the water passes through piston, cylinder heads, cylinder jackets and muffling sprays in the order named. A small portion of the water only is used by the muffling sprays.

Thermometers are set to indicate the temperatures of the water leaving the piston and cylinder jackets. The jacket water leaving each cylinder head discharges upward through a vertical pipe provided with a return-bend discharge nozzle. The water leaving the nozzle discharges downward into a funnel leading to the cylinder jacket, the stream thus being in full view of the operator.

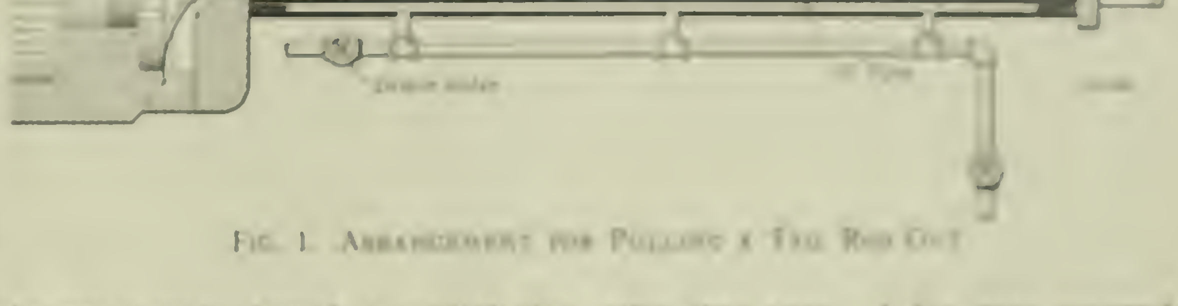


FIG. 1. ARRANGEMENT FOR PULLING A TAIL ROD OUT

Cylinders, Pistons, Rods, Etc.

The average life of a motor cylinder is about four or five years, during which time the wear as measured on a diameter is about 1/4 of an inch. The cylinder is then bored out and bushed. There are practically no cylinder failures from any cause other than wear.

Exhaust ports at power house No. 1* become clogged with flue dirt and require cleaning after about three months of operation. Exhaust ports at the blowing-engine houses do not foul at all. The difference is probably due to the cleaner gas at the blowing-engine houses, and possibly in some degree to the precipitation of moisture and dirt in the [illegible]-inch headers.

Cylinder relief valves require cleaning about once a month. Jackets of cylinders and heads are cleaned about once a year.

Cylinders and pistons are inspected only when conditions indicate. Their wear is measured and recorded at the same time. A test for tightness consists in placing the crank on the dead point and subjecting one end of the cylinder to air or exhaust pressure, the plugs being removed from the opposite head to indicate leakage, if any, through the piston.

The blowing-engine pistons have a life of from three to five years. There are but few piston failures due to any cause other than wear. A few have occurred which have been due to the water connections falling down inside the piston and wearing a hole through the bottom. When a piston has worn, say 1/16 inch at the bottom, it is turned over and used in a standard cylinder. There are at present two standard diameters, [illegible] inches for new cylinders and [illegible] inches for bushed cylinders.

In dismantling a piston the large piston nuts are heated, removed, cleaned up in the lathe and used again. About half of the small piston nuts have to be split off, the rest being utilized again. There is considerable corrosion around the studs and inner edge of the joint between rod and piston, forming what may be called a rust joint. The tail rods are removed from the piston either by means

*From a paper presented at the annual meeting of the American Society of Mechanical Engineers, December, 1910.

*[illegible]

of the special device shown in Fig. 1 or by means of screw jacks and rams. When using the former, the concentric pipes are first cooled with water and the nut at the end of the tail rod is set up; steam is then admitted between the pipes at atmospheric pressure to lengthen the pipes by heating them. This cycle is repeated until the rod is free from the piston. When it becomes necessary to remove the piston rod, the piston is broken away either with dynamite or under the drop hammer. The wear of piston rods occurs principally at the end of the stroke and amounts to about a quarter of an inch on the diameter in three years. It is then turned and will suffice for two or three years more.

The average life of the motor cylinder heads is not well established, but it may be set at three years or more. A few of the original heads at the blowing engines are still in service. Failures of these occur principally at the junction of the jacket wall and the main flange on each side of the inlet valve chamber, but this trouble has been substantially eliminated by employing proper fillets. Some heads have developed cracks through the inner wall; two or three have had the inner walls blown entirely away, but this was found due to faulty castings.

Gas-pump cylinders and heads require cleaning every six to eight months on account of dirt getting into the clearance near the bottom. By feeding a little kerosene through the pump valves cleaning is avoided.

Cylinder heads are packed principally with $\frac{1}{16}$-inch woven-wire insertion asbestos sheet. Piston joints are made up either with $\frac{1}{32}$-inch wetted asbestos paper, or with a paste of litharge and glycerin, or with another form of packing known under the trade name of "900." All give satisfactory results. The life of the $1\frac{7}{16}$-inch snap piston rings is about two years.

The piston rods are packed with four cast-iron rings of the Walker type in a casing exterior to the head. Packings are overhauled about every six months to renew broken springs and rings. Casings are trued up at the time of overhauling the piston once in two or three years.

The swinging connections for the piston water supply require to be packed about twice a year.

Valves, Cams, Shafts, Etc.

The inlet valves last about three years before turning and about the same time after they are turned down. They do not require grinding-in except when new. Stems are broken occasionally near the top yoke. Little cleaning of the inlet valve or the ports is necessary.

The inlet valves are operated through heavy push rods driven by cams and rollers. High inertia stresses are thus developed at the higher engine speeds. With present inlet-valve springs, which operate under a compression of 2500 to 3500 pounds at the blowing engines, the roller leaves contact with the cam at about 65 to 70 revolutions per minute. Many of the original push rods have been broken by the resulting inertia stresses and new and stronger rods have been made.

The life of the inlet cams is about six years. Wear of the steel gears of the layshaft occurs on four teeth at the end of four or five years; the gears are then shifted on the shaft so that unworn teeth are in action during the inlet-valve opening.

The shaft of the 2000-horsepower engine, which is of the built-up type, has caused no trouble whatever. There have been, however, several shaft breakages at the 1000-horsepower engines, which have shafts forged in one piece and operate at 100 revolutions per minute. The author has made no investigation relative to the stresses in these shafts, but believes that their life would have been longer had they been of the built-up type and of present diameters.

At the 1000-horsepower engines there has also been trouble with certain brackets and fastenings due to inertia stresses set up by the inlet gear. The governor being driven from the layshaft, considerable wear is imposed on the mechanism due to reversal of the torque at the layshaft as the point of each cam passes under the roller. Some trouble from premature ignitions by the 1000-horsepower engines was experienced, due to the indicator holes through the flanges of the cylinder heads, and water-cooled indicator connections were substituted.

Ignition

Ignition is effected by means of make-and-break igniters, of which there are two in each cylinder head. Until recently the ignition current was furnished by magnetos, one for each plug. The current is generated by this form of magneto in the following manner: The armature is first slowly rotated in opposition to the force of a spring through an angle of about 30 degrees from its initial position; it is then released and under the action of the spring executes a rapid return motion or oscillation. During this return motion the igniter terminals are mechanically separated and an arc formed, the motion of the armature being transmitted to the plugs through cranks and reach rods for this purpose. The magnetos are now being discarded in favor of a direct-current system of ignition of simple form.

The detailed construction of the igniter plugs is indicated in Fig. 2. The bronze bushing forming the spherical seat for the movable steel electrode is a driving fit in the cast-iron body of the plug. The cylindrical head of the stationary electrode seats on an asbestos gasket or washer carried by the porcelain insulating plug, which is formed as a conical frustum seated in a cavity in the cast-iron plug on a bedding of litharge and glycerin. Litharge also assists in maintaining tightness between the cast-iron plug and the bronze bushing. This construction is very satisfactory in every way.

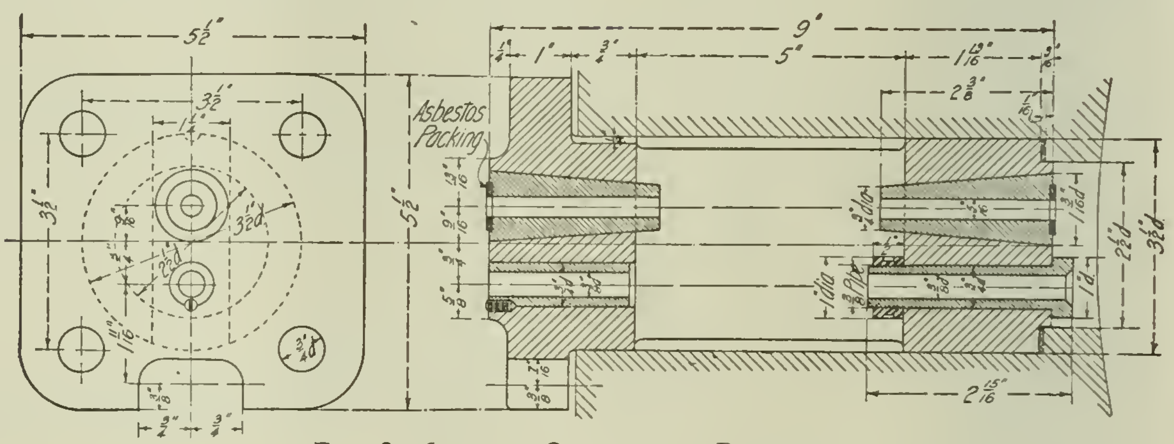


Fig. 2. Igniter Shell and Bushings

Using magneto or similar low-voltage current, there is little burning of the points, and the life of both electrodes is about one year. The bronze bushing lasts about six months, this material being the most satisfactory thus far used. The upkeep of the magnetos is relatively expensive, and a ten-volt direct-current system is being substituted.

Dirty plugs are caused by slipping furnaces and wet gas containing dirt which fouls and bakes at the terminals. The plugs require cleaning on an average of once or twice per month. The spherical seat requires regrinding once in two months, and the plug must be retubed once in six months.

With the type of ignition gear described there is an interval between the release of the magneto lever and the opening of the igniter terminals. There is also an appreciable time required to complete combustion. This time element being approximately constant, correct ignition requires that the timing of the release shall vary to some extent with the speed of rotation. The ignition gear may then be linked to the speed-adjusting device in such manner as automatically to maintain proper timing of the ignition at all speeds.

An Operator's View of the Diesel Engine

By G. H. Kimball

In an article in the May 31 issue, some very favorable statements were made in regard to the Diesel engine; these and others made in the catalogs convey the impression that the engine has no disadvantages whatever. If this were true, there is no reason why everybody should not install them.

It may be of interest to engineers and possibly to some owners of plants, to hear of some experiences in plants where these engines are in operation. As with all internal-combustion engines, there are many drawbacks which do not appear in a good steam plant, and where a steam engine will run under adverse conditions a Diesel will not operate at all.

Those of the three-cylinder and six-cylinder type, with 16x24-inch cylinders, seem to be the most successful. In one plant a six-cylinder unit was installed which gave excellent service for the first year, with no repairs other than a new governor gear. It was necessary, however, to spend about ten hours every week in inspecting and taking up connections and various other parts. One thing that made this type of engine successful in that plant was that there were both steam and water power besides, so that it was not necessary to hire any more help, as the firemen could be used when the steam was not required, and when there was plenty of water power available ample opportunity was given to thoroughly overhaul the oil engine and get it ready to give good service when needed. Moreover, when steam was depended on alone for auxiliary power it was necessary to keep a boiler in service for two or three months, in case of emergency, and this standby loss was saved by the Diesel engine. In this class of plant the Diesel engine can be used to marked advantage and with great economy.

In a plant where the whole load must be carried by the Diesel engine, however, we have a far different proposition. In one such plant where there were two units, one new and the other about three years old, it was necessary to spend all of Saturday afternoon, when part of the factory was shut down, and nearly all of Sunday in adjusting wristpin and crankpin boxes, inspecting parts and the condition of the crank-case oil. This was regular routine work, and in case of regrinding valves, renewing the oil or anything extra, just so much more time was required. The fuel valves gave trouble by breaking at the points and there was a great deal of wear due to the jar and shock of the six reciprocating systems working at such high pressures.

The governors gave a great deal of trouble in the way of unsteady running, so that it was necessary to replace them on both the old and the new units.

The first cylinder on the older engine after being overhauled gave great trouble by pounding at every second stroke, even when the clearance, as measured by compressing a lead wire, showed one-eighth of an inch, as required. Finally it was found that the piston head bulged upward by the heat to such an extent that when all the parts were hot it touched the cylinder head.

The cam-shaft gears of this unit were also badly worn, making new gears necessary. One cylinder of this and one of the newer engine were found to be worn from 0.015 to 0.005 of an inch large in places. The rings after a year's run became so badly carbonized as to require new ones to be substituted, and the wear of the wristpin boxes made either new boxes or shims on the wedges necessary in a short time.

Many of the published performances of Diesel engines have been those where the load factor is 25 to 35 per cent. The engines will run very steadily with such a load, because the heating and wear of the parts are not comparable to the heating and wear that occur with a load factor of 75 to 90 per cent. The load factor was the difficulty in the last mentioned plant; the management wished to carry full load all the time, and sometimes an overload, and it was disappointing to find that the cylinders must be made tight before such a heavy load could be carried. To this end the pistons were fitted with two more rings, which made a great improvement, but in a short time it will be necessary to rebore the cylinders.

In the article to which I have referred it was stated that after a four years' run the tool marks were not worn out of the cylinders. To anyone who has seen hard service by these engines this statement will seem rather far-fetched; in the plant which I mentioned last not only were there no traces of tool marks but there were deep grooves worn lengthwise of the cylinders, although there was plenty of cylinder oil in evidence.

When it is necessary to remove a cylinder head, about all the valve-gear and other parts related to the cylinder must come with it, which will consume no small amount of time, and everything must be replaced with the greatest care or the results will be very unsatisfactory.

The clearance must be maintained just right or the proper compression temperature to ignite the oil will not be attained.

Although the regulation is said to be equal to that of steam engines, it cannot equal that of a modern automatic cutoff or Corliss engine; regulation within 2 per cent. has not been shown in actual practice, 4 per cent. being considered good.

The crank-case oil is also a source of trouble and it is not surprising to find that the oil has disappeared after a hard week's run. Sometimes it is so thick that the bearings must be very warm before it will flow at all.

The air compressor is a very important part of the plant, and it must be capable of hard, continuous service, for any drop in pressure during a heavy load means a shutdown. Careless selection of a compressor will entail a great deal of trouble, for there are some designs that are very unreliable.

The fuel economy is very high and in plants where steam is not needed for other purposes than power there is a great saving in fuel. In the matter of labor, there is very little difference from a steam plant; it is customary to pay higher wages to Diesel engineers than to engineers in steam plants of like power, and while it is a simple matter to operate the engine, repairing requires plenty of help.

The first cost is excessive and unless a plant has a spare unit it cannot give the service that a steam plant would; and it is a question whether the engine would not have to be replaced after ten years of service.

In writing the foregoing it is not my intention to make any unfair statement; my experiences with the Diesel engine have been exactly as described in this article, and I have said nothing based on rumor or hearsay. Furthermore, I am convinced that this type of engine should, after some further experience and improvement, prove very successful and capable of continuous service at full loads.

[We do not question Mr. Kimball's sincerity, veracity or operating skill in the slightest degree, but we confess inability to understand why the cylinders of a Diesel or any other engine should be scored longitudinally when cylinder oil is plentifully applied, if the oil is of the proper kind and the air intake is carefully protected from dust and grit. We have known cases of extremely bad cylinder scoring caused by both unsuitable oil and unprotected air intakes.—Editor.]

The Navy Department is planning to experiment with electric lifting magnets for recovering torpedoes which are fired in practice and, through some fault of the controlling mechanism, go to the bottom after their energy is expended. These torpedoes are virtually small submarine vessels with self-contained power plant, steering mechanism, etc., and each one is worth a small private fortune. The points where they are lost will be marked by buoys and magnets then dropped down to grapple them and bring them to the surface. Owing to the lightness of the torpedoes magnets of relatively small lifting power may be used, but the magnets must be constructed to withstand the submersion and the temperature changes.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Catechism of Electricity

Single-phase Commutator Motors

1124. *Are commutators ever used on alternating-current motors?*

Yes; commutators are used on some single-phase motors. Fig. 363 illustrates one kind of commutator motor.

1125. *For what kind of work is this motor particularly intended?*

For driving machines which must run at variable speeds and those requiring considerable starting torque.

1126. *Explain the construction of the motor referred to.*

Fig. 364 shows the principal parts of the motor, and Fig. 365 is a diagram of its connections and windings. The field-magnet core *A* is fitted with a single-phase winding *N* of concentric coils, each coil being separately taped and insulated. For operation on 220-volt circuits these four nests of field coils are connected in series; for 110-volt circuits they are connected in parallel.

The armature is provided with a winding of the "twô-circuit" drum type, connected to an ordinary commutator upon which press two sets of brushes *E* and *C*, Fig. 365. The pair *E*, called the "energy" brushes, is permanently short-circuited and displaced at an angle to the lines of field or primary magnetization. The second set *C*, called the "compensating" brushes, is connected to a relatively small field winding which serves to induce in the armature an electromotive force which tends both to raise the power factor and to maintain approximately constant speed at all loads. By the use of a controller arranged to insert resistance or reactance in series with the energy and compensating circuits of the rotor, the speed can be reduced to any desired rate between full normal speed and half that speed. For example, if the normal speed is 600 revolutions per minute, any speed between that and 300 revolutions per minute can be obtained with the controller.

Fig. 364. Disassembled View of the Motor Shown in Fig. 363.

1127. *Will the speed be constant when reduced by the insertion of resistance?*

No. The motor behaves like a shunt-wound direct-current motor with resistance inserted in the armature circuit; when the load increases the speed decreases considerably, and *vice versa*.

Fig. 363. General Electric Single-phase Compensated Repulsion Motor

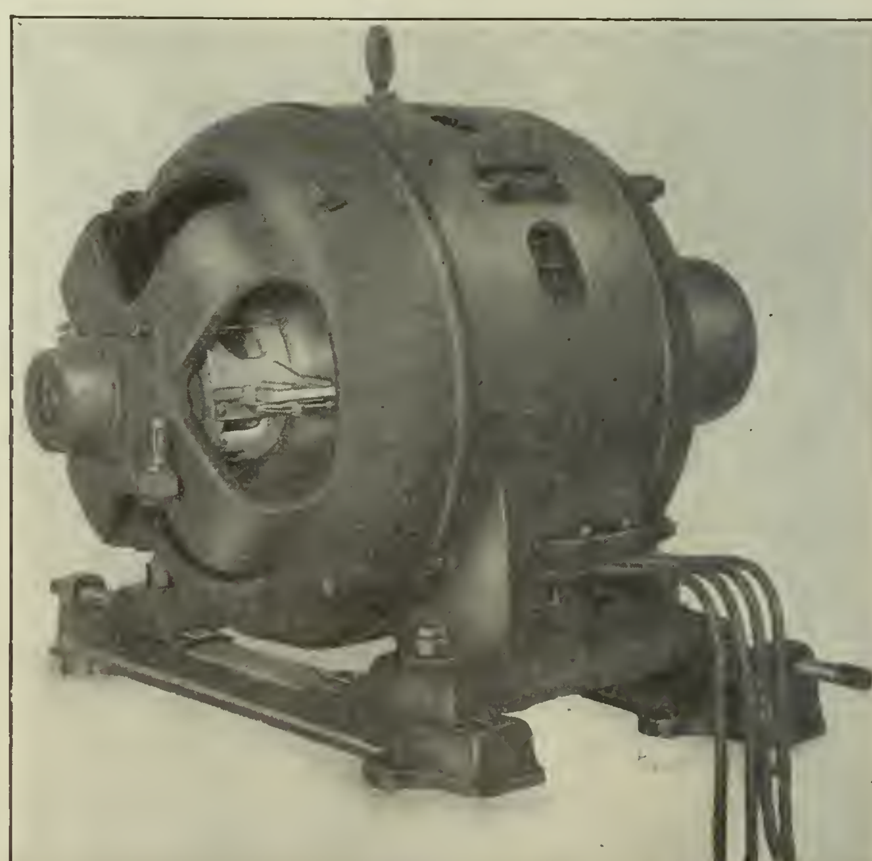


Fig. 366. Wagner Constant-speed Single-phase Motor

1128. *What kind of motor is the one just described?*

It is a compensated repulsion motor; this name is given to it because the motion of the rotor is due to magnetic repulsion between the current in the short-circuited part of the winding and the stator field, and the undesirable reactions

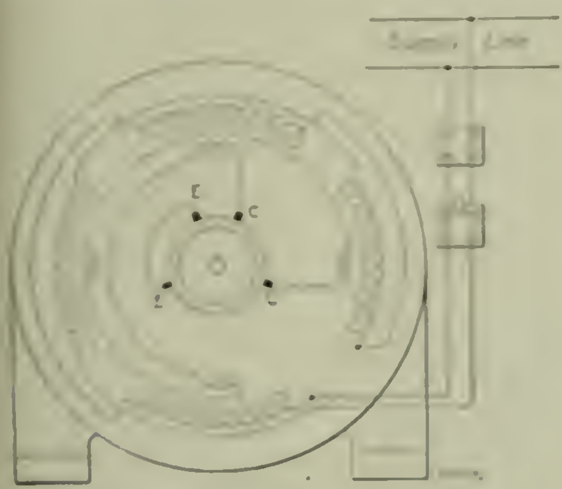


Fig. 365. Circuits of a Compensated Repulsion Motor

in the rotor winding are neutralized or compensated by the auxiliary field set up by the small stator winding connected to the compensating brushes.

1129. *Are there any other forms of single-phase commutator motor?*

Yes. There is a type of machine which acts as a repulsion motor while starting and is automatically changed to a simple induction motor when it reaches normal speed.

1130. *Illustrate and describe a motor of this type.*

Fig. 366 is a view of a 20-horsepower Wagner motor of this type, and Fig. 367 shows the commutator end of the Wagner armature. A disk-shaped commutator is used and the brushes press horizontally against it, as may be seen from close in-

Fig. 367. Rotor of Constant-speed Single-phase Motor Shown in Fig. 366. Commutator End

spection of Fig. 366, and these brushes are connected together electrically by the metal collar to which the brush holders are bolted. The brushes are therefore practically short-circuited, and they are so spaced with regard to the stator field poles as to produce a strong repulsion effect in the armature or rotor. This causes the motor to start and when it has nearly reached the regular speed, the brushes are lifted from the commutator and the commutator bars are all short-circuited; this changes the armature winding to what is practically the same (electrically) as a squirrel-cage rotor. Then the machine runs as an ordinary motor.

1131. *How are the brushes lifted and the commutator short-circuited?*

By a centrifugal governor which works against a spring. The governor weights are located within the rear end of the rotor spider, as shown in Fig. 368. By means of levers and links the governor weights slide the brushes away from the commutator and at the same time press a short-circuiting ring against the back face of the commutator, connecting all the bars together.

1132. *How does the governor mechanism move the brushes away from the commutator?*

A barrel slides along the shaft under the influence of the governor weights and the opposing spring; the governor weights move this barrel toward the commutator end of the shaft and the spring moves it in the opposite direction. The collar to which the brush holders are bolted is

Fig. 368. Pulley End of the Rotor Shown in Fig. 367.

cup-shaped, as shown in Fig. 369, and inside this collar a brass ring "floats" between the ends of the brush-holder fingers (which project into the cup through slots) and the end of the sliding barrel on the shaft. When the speed is high enough for the centrifugal force of the governor weights to overcome the opposing spring, the barrel is pushed against the ring in the brush-holder collar and the ring, pressing on the ends of the brush-holder fingers, pushes the brushes away from the commutator. The

Fig. 369. Brush Rigging of Century Motor

brush mechanism here shown is the one used on the Century motor, illustrated in Fig. 370.

1133. *How is the stator winding of this type of motor arranged?*

Exactly like that of an ordinary single-phase induction motor. Fig. 370 is a picture of the stator and rotor of the Century motor, from which it is evident that the stator core consists of slotted rings mounted in a circular frame or housing, and the winding is of the distributed type used in all induction motors of appreciable size. The machine here illustrated has four groups of coils which produce *four* magnetic poles on the inner face of the core.

Fig. 370. The Century Single-phase Motor

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Combination Piston Rod Packing

The following tells of a trouble I had with a badly scored piston rod on a locomotive.

Being a long way from the shop on a logging road, I had to pack the piston every night and then could not see for the steam that leaked out of the stuffing box. I had some graphite which I mixed into a stiff paste and then put in a round of ring packing in the stuffing box and filled the stuffing box full of graphite, put in another round of ring packing and screwed the gland up tight. The gland was then removed and more graphite put in, followed by another ring of packing. I had no more trouble for thirteen months and the packing was still in the box when I left the job.

J. A. McQueen.

Cheboygan, Mich.

Economic Boiler Feeding

An open heater is at its best when so designed and operated that all of the condensate from the heating system is returned to the boilers, and the amount of make-up water is reduced to the minimum. These conditions give the water the highest temperature possible with an open heater, unless live steam is used. And these conditions can best be obtained when a variable-speed pump is used with a variable delivery to feed the boilers, the speed or delivery of the pump to be controlled by a float in the heater connected to the pump governor or delivery-control valve, and not by connecting a float in the heater to the inlet or make-up water valve and regulating the speed of the pump by hand.

While the amount of condensate returned to the heater in an hour cannot equal the amount of water evaporated in the boilers in an hour, the maximum flow will raise the water level in the heater until it runs over the overflow and is lost if the speed of the pump is controlled by hand or by a feed-water regulator connected to a float in the boiler. While the periods of maximum flow are not long enough to raise the water level in the boilers perceptibly, owing to the larger area affected when the pump is controlled by a float in the heater, they are long enough to run a large quantity of water to waste via the overflow when the pump or water taken from the heater is not controlled by a float in the heater, owing to the comparatively small storage capacity of the ordinary open heater. Where the float in the heater is connected to the inlet valve, the make-up water is shut off altogether during maximum flow, and is admitted in so large a quantity during minimum flow that it has no time to be heated in the steam or trap space above the hot water but falls to the bottom, cooling the hot condensate in the heater. When the float valve in the heater is connected to the pump governor, the make-up water may be admitted continuously or nearly so. The fireman, having a mark on the inlet-valve wheel and only changing the amount, admitted slightly to keep the water level nearly constant in the boilers. In this way the make-up water has the longest possible time to remain in the trays and mingle with the steam in the upper part of the heater. The spasmodic flow of condensate from the heating system to the open heater is accounted for by the fact that nearly all heating systems contain pockets and water seals and in hotels, guests are opening and closing radiator valves at all times, traps are dumping and any slight change in pressure will change the flow from minimum to maximum. If the valve in the engine-exhaust pipe to the heater is nearly closed, as it often should remain, the condensation in the heater caused by admitting cold make-up water irregularly will cause a variation of pressure in the heater and at times quite a vacuum is formed, thus inducing an increased flow of condensate.

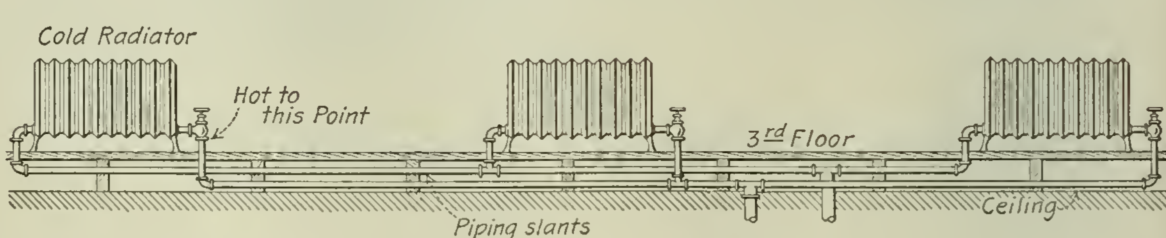
From the above it will be seen that a belt-driven plunger pump should never be used with an open heater, and if any constant-speed pump is used, we have a very undesirable and wasteful combination, unless the amount of water taken from the heater can be regulated by a float in the heater. There may be such an accessory on the market but I have not as yet seen one or an advertisement of one in any mechanical paper. A boiler-feed regulator might be attached directly to the heater and its motion reversed, so that as the water level in the heater rises, the main discharge from a centrifugal pump would open, and as the water level in the heater fell, the discharge from the pump would be throttled down. This would be a departure from any equipment I ever observed and, I think, from general practice.

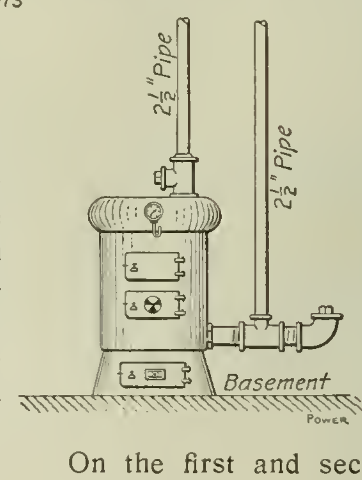
C. E. Bascom.

Worcester, Mass.

Radiator Failed to Heat

I would like to know what other engineers think of a radiator trouble in a heating system I recently installed.





Piping of Radiators

On the first and second floors, all of the radiators heat up nicely, but the three radiators on the third floor, which were put in later, did not heat satisfactorily.

When putting in the pipe to these radiators I tapped the feed pipe for a 2½-inch riser and also a 2½-inch pipe to the return pipe and carried them through to the third floor, and then branched off to each radiator with a 1¼-inch pipe, as a feeder, and a 1¼-inch pipe to each radiator for the return piping. On getting up steam two of the radiators heated up nicely but one failed to heat at all. The feed pipe to the radiator that did not heat was hot up to the valve, but the radiator remained cold.

I would appreciate the advice of engineers who have had experience along similar lines.

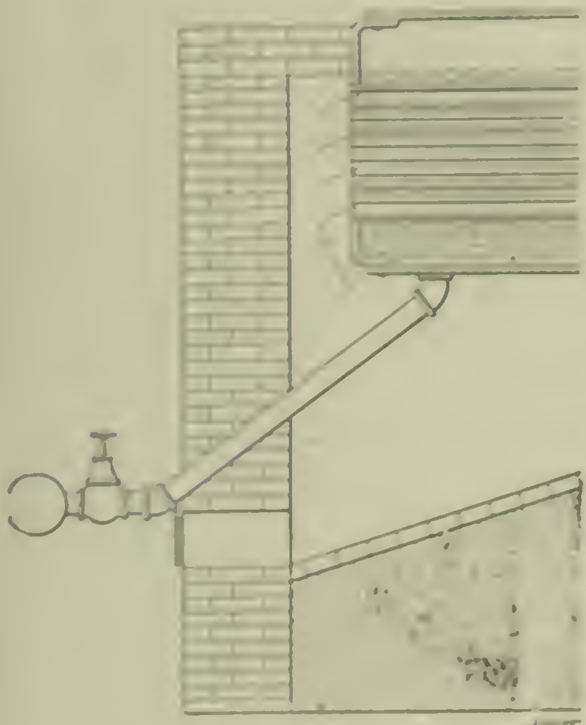
E. L. Morris.

Salem, Va.

Boiler Blowoff Pipe

The illustration shows the design of the blowoff pipe of my boiler, which I consider far ahead of anything I know of.

A close nipple is secured in the boiler



Blowoff Pipe

sheet and a 45-degree ell screwed onto it. A length of pipe reaches just through the rear wall and another 45-degree ell is screwed to the end of the pipe. The valve is connected as shown to the main blowoff pipe.

A. W. Fredrickson.

Willits, Cal.

Moisture Caused Trouble

A few years ago I took charge of a plant located at a coal mine. The boilers were each fitted with a dome and a 8-inch steam connection from the top of the dome to a 10-inch header, which extended across the engine room.

Steam was taken from this header through 6-inch outlets to each engine and a third outlet had been provided for a future installation in the engine room.

I was informed that the generators had been giving a great deal of trouble from sparking at the commutators, which proved to be correct, for I never saw such a display of fireworks as those machines were capable of exhibiting when carrying a load.

It was necessary to sandpaper the commutators two and three times a day and turn them down about every ten days.

I was also informed that there had been trouble with water in the engine cylinders and to overcome this they had connected a 6-inch pipe to the extra outlet in the header, and after turning downward this pipe extended below the floor level and ran out near the door, where it was reduced to 1 inch and fitted with a valve which was left slightly open to keep the pipe cleared of water.

This drip was located between the boilers and the first engine. Where it made connection to the header a very bad steam leak existed. As the weather was cold, and the engine room likewise, there was a great deal of moisture precipitated in the engine room from this leak. I wanted to take this pipe down at once, but the superintendent said No! very decidedly. Finally, one cold morning when the moisture was more in evidence than usual, I remarked to the fireman that the pipe was coming down that evening even though it cost me my job; and down it came. The outlet was blanked, thus stopping the steam leak.

In a short time I noticed that my generators were giving less trouble than formerly and they continued to improve until they finally got back to normal operating condition.

Then I took a tumble—the machines had been saturated with moisture and as they gradually dried out the trouble disappeared until finally all was once more in good shape, but the repairs to one armature which were necessitated by the work of that steam leak cost $600. Further, I never had any more trouble with water in the cylinders.

In this same plant they were using about twelve barrels of engine oil per year when I took charge of the job. After some persuasion I induced the superintendent to invest in an oil filter, and we used less than three barrels of oil that year.

A. Ramage.

Wheeling, W. Va.

Air Pump Cleaned the Boiler

There are four boilers in the plant where I am employed and it was desirable to inspect three of them one Sunday. Accordingly they were cut out of service Saturday night and cooled ready for the inspector. When he came he could not go into the boilers, they were so filled with hot vapor.

I cut out the boiler that was under steam from the others and opened the throttle valve to the engine room and freed the main of steam. Then I opened the steam valve on the head end of the cylinder and disconnected the exhaust valve on that end and did the same on the low-pressure cylinder. The independent air pump was started and the stop valve on the first boiler to be inspected was opened, and inside of five minutes the inspector was inside of it. When he got through with that boiler I opened the valve on the next two, as required. Naturally the stop valves were made tight before the next inspection.

Louis Kurtzmann.

Fall River, Mass.

Water Wrecked the Cylinder

One night the low-pressure cylinder of an 18- and 36- by 36-inch vertical cross-compound Corliss engine, running at a speed of 125 revolutions per minute, was wrecked. The engineer on watch at the time said that there was a very light load on the engine prior to the crash, and that the receiver pressure kept going up until it reached 30 pounds. He found upon investigating that the crank-end valve on the low-pressure cylinder had not been picking up, owing to worn catch blocks. When he made the blocks engage, the cylinder head was knocked off with the flange. The cylinder was also cracked in several places.

At first it was thought that water accumulated in the receiver, and was taken over to the low-pressure cylinder, but the receiver trap was found to be in good working order and there was no chance for an accumulation of water there. It was reasoned that, owing to the high receiver pressure on one side, and a 26-inch vacuum on the other, and the valve not hooking up, considerable condensation had accumulated at A in the sketch.

When the valve was made to hook up,

Where Water Accumulated

the high receiver pressure forced the pocket of water through the lower valve, under the piston which knocked it off the rod, and the next stroke brought the piston up against the head, which knocked it off.

Thomas [illegible].

[illegible]

Emergency Pump Packing

A short time ago the packing in the water end of our boiler-feed pump became so badly worn that it would no longer supply the boilers. As I had no packing of the proper size on hand, and the pump was the only means of supplying the boilers with feed water, I decided upon the following plan:

After carefully removing the old packing, I took some new tin and made a sleeve to fit nicely around the water piston.

After slightly softening the old packing, by putting it in hot water, I replaced it and found that the tin sleeve made it fit nicely. The pump was put into service and it ran two weeks until new packing arrived.

John C. Pitts.

Cherokee, Okla.

He Got an Increase in Pay

Several years ago I went to work for a wood-working company in northern Michigan. Before I took charge of the steam plant, which consisted of one 54-inch by 14-foot shell boiler and a 10x16-inch slide-valve engine, they had one man firing and another cleaning the shop, bring refuse into the fire room and acting as a helper. These two men were paid $1.25 per day, and another man was paid $2 a day to look after the engine, which was located about 50 feet from the boiler. This made $4.50 for wages and they were burning eight cords of 4-foot wood costing $1.50 per cord, or $12, a total daily expense of $16.50.

I did the work of three men, except cleaning the shop. I started in for $1.50 a day and a promise of a raise, and I never got such a roasting in my life as I got the first day, firing with 4-foot wood. I knew something was wrong with the engine, but I did not want to stop to investigate until night; but at 4 o'clock I was all in and stopped the engine, took off the steam-chest cover and found the lock nuts on the valve stem loose and the valve sliding ¾ of an inch on the stem.

I got the valve centered, but on turning the crank to the center, I found the valve had no lead until about one-third stroke. I got busy with the eccentric, and moved it around until I had 1/32-inch lead with the crank on the center. When the engine was started the men all ran out of the shop for, instead of 165 it was making 247 revolutions per minute. I soon got the governors set for 220, the speed wanted. I next began burning coal that the former engineer said could not be burned without shaking grates, and it required 2700 pounds for 10 hours. Coal cost $3 per ton, or $4.05 for the day, and my $1.50 made $5.55 against $16.50 they were paying before I came. Furthermore, I was giving all the power wanted for 10 hours a day, while before there was not enough power any of the time, and the engine had to be shut down several times a day to get up steam, which made a difference of at least $100 per day in the output of the factory.

After my ten days' trial, I got my increase in pay and my experience since has proved it to be a typical engineers' raise. I saved the company $10.95, increased the output $100 a day and I got a raise of 25 cents a day.

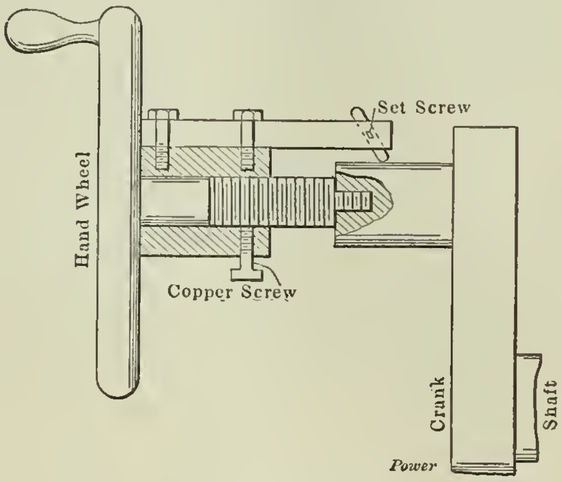
J. R. Morton.

Detroit, Mich.

Device for Turning a Crank Pin

The accompanying sketch illustrates a device that I made to true a crank pin. On taking charge of my present plant, I found the crank pin on the ammonia compressor in very bad shape. It had been allowed to get hot and was badly cut and scored, and it was almost impossible to keep the bearing cool.

On calipering the pin I found that it was not only badly cut, but that it was out of round 3/32 of an inch. The diameter of the pin was 4⅞ inches, with a bearing 5 inches long. I took a piece of $1\frac{15}{16}$-inch shaft, 9 inches long, and got



Turning Device

one end turned down and threaded to screw into the end of the crank pin, 1 inch, as shown in the accompanying sketch. A fine thread (24 to the inch) was cut on the remaining part of the 9-inch pin. A sleeve was made to fit over the shaft, and a copper set screw passed through the sleeve to tighten on the thread.

A piece of ¾-inch square steel was attached to the sleeve with two set screws, and a slot was provided near the end to hold the cutting tool that was secured by a small set screw. A small solid balance wheel fitted with a handle was bored out to fit on the sleeve, which completed my apparatus.

Having all my toggles together, all was ready to go to work on Sunday morning, and with one assistant I turned up the pin and made a splendid job of it in about three hours.

The only mistake that I made in constructing my machine was that the feeding thread was a little too coarse.

After removing the machine from the pin I took two pieces of hard wood of the proper width and about 18 inches long, bolted them together and then bored a hole through them. Then emery cloth was tacked in the bore, the device was put in place and the pin smoothed up.

The boxes were rebabbitted and scraped, which completed the job.

William G. Walters.

Stratford, Can.

Making Engineers

In almost every issue of Power one reads about engineers' hours, engineers' wages and engineers' associations, but I cannot recall seeing any article on making engineers.

When I took charge of my present plant, I had fourteen men under me and not one of them subscribed for an engineering magazine or devoted any time to studying engineering subjects. It took me but a short time to find out that they were ignorant of the most elementary parts of steam engineering.

I suggested to my assistant engineers and firemen that they subscribe for Power and other magazines, which they cheerfully did. I also suggested that they procure "Power Catechism," and showed them my own well worn copy and allowed each man to take it home for one evening's perusal, with the result that I placed five orders for the book. When any of my men asked me about any new appliance he saw advertised, I gave him stationery and the use of my desk at noon to write for a catalog and particulars.

At the end of one year eight men have procured engineer's licenses of various grades, two have left my employ and are running a plant of their own, three are studying hard for fireman's license and three are still in the same old rut, only wishing for 6 o'clock and the largest schooner of beer in the nearest saloon.

Where do I benefit and what recompense do I get for spending my evenings with my men? First, I have a thoroughly reliable crew of eleven men, and, with everyone trying his best to improve conditions in the plant it is kept up in better shape for less money, although the men have been given an increase of 25 cents per day. Second, I am a more uptodate engineer, as I continually have my memory refreshed, for when my men ask me a question I cannot answer I reply, I do not know but I will find out.

Now, some of you chief engineers get down off your "high horse," go down to the fire room and explain to your firemen that brains in the boiler room, as elsewhere, are worth more than muscles, and I will venture to predict that you can operate your plant for less money and with more satisfaction.

William T. A. Faulkner.

Seattle, Wash.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Pumping Problem

In the November 15 issue of POWER, Mr. Ellethorn contributes a pumping problem for which I offer the following solution:

Briefly, his problem is as follows: A 6x12-inch duplex pump, driven by a 12-horsepower engine, pumps 235 gallons of water per minute, through a 4-inch discharge line, which runs horizontally 200 feet from the pump, then vertically 200 feet and discharges into a tank. The water is drawn from four open wells, located 100, 110, 120 and 150 feet from the pump. The water level in these wells is 10, 12, 18 and 22 feet respectively below the ground. The main suction pipe is 5 inches in diameter, and the risers from the wells, all of which terminate in the main suction line, are of 2½-inch pipe. In the absence of any data to the contrary, I assume that the pump and suction line are at ground level.

The discharge, which is given as 235 gallons per minute, is equal to

$$\frac{235}{60 \times 7.48} = 0.523 \textit{ cubic feet per second}$$

The problem is to find how much of this comes from each well.

Numbering the wells 1, 2, 3 and 4, in the order in which they are mentioned above, it is first assumed that all of the water comes from well No. 1, in which the water level is 10 feet below the ground or datum. This water is lifted against, not only a static head of 10 feet, but a friction head, which is given by the following equation:

$$\textit{Friction head} = \frac{4fl}{d}\,\frac{v^2}{2g}$$

wherein

v = Velocity of water in pipe in feet per second;
g = Acceleration due to gravity = 32.2 feet per second;
d = Diameter of pipe in feet;
l = Length of pipe in feet;
f = An experimentally determined coefficient, depending not only upon the velocity of the water and diameter of the pipe, but also upon the condition of the pipe as regards corrosion, etc. A clean iron pipe is assumed in this case.

The area of the 2½-inch pipe equals

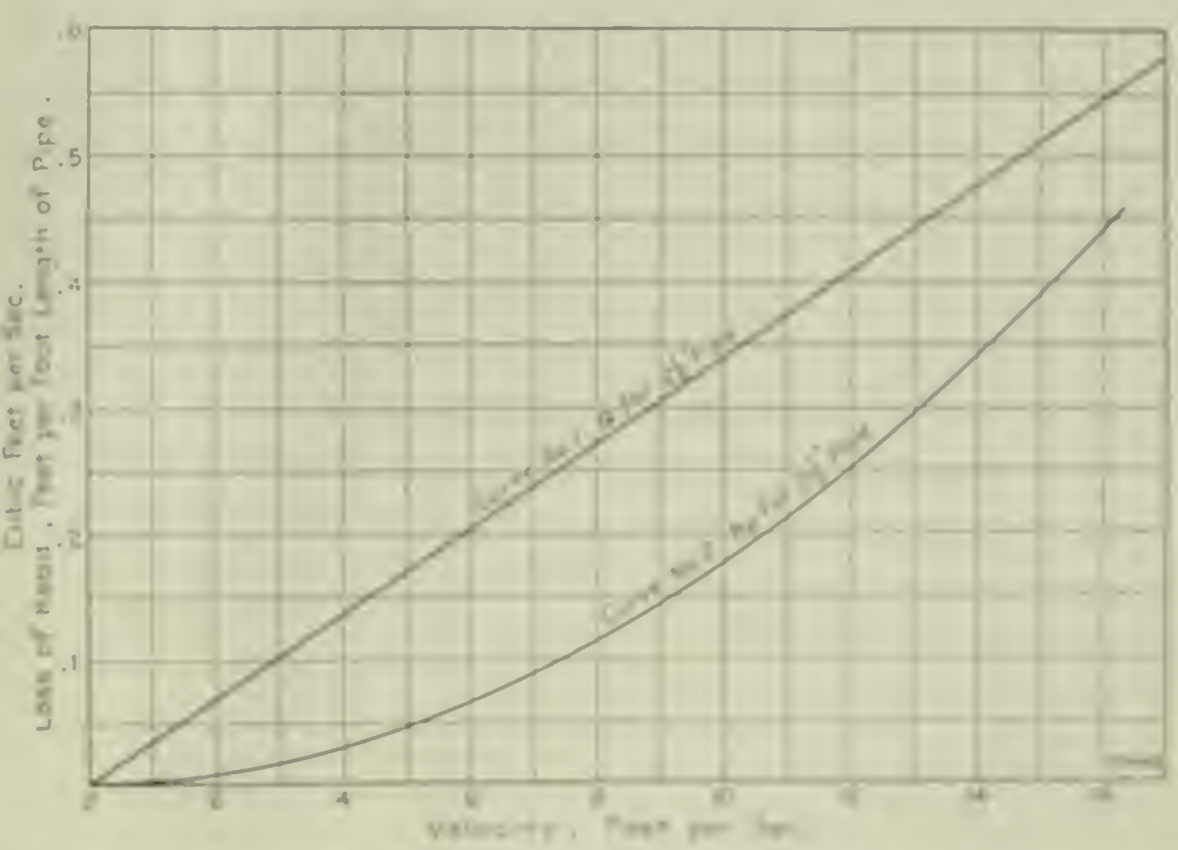
$$\frac{\pi}{4}(2\tfrac{1}{2})^2 = 4.91 \textit{ square inches} = 0.034 \textit{ square feet}$$

The velocity in the pipe equals

$$\frac{0.523}{0.034} = 15.38 \textit{ feet per second}$$

For a clean iron pipe, 2½ inches in diameter and a velocity of 15.38 feet per second, Fanning gives a value for f of 0.00580.

Substituting these values, the friction head is,



CURVES SHOWING VOLUME OF WATER DELIVERED AND LOSS OF HEAD

$$\frac{4 \times 0.00580 \times 10 \times (15.38)^2}{\frac{2.5}{12} \times 2 \times 32.2} = 4.12 \textit{ feet}$$

The total head (up to the 5-inch main suction pipe) is

$$10 + 4.12 = 14.12 \textit{ feet}$$

This being greater than the 12-foot static head of well No. 2, indicates that some water is drawn from that well; but no water will be taken from wells Nos. 3 and 4, because their static heads (18 and 22 feet respectively) are greater than this.

Let

Q = Total flow (0.523 cubic foot per second);
Q_1 = Flow in riser No. 1;
Q_2 = Flow in riser No. 2;
h_{f_1} = Loss of head due friction in riser No. 1, expressed as feet per foot of length;
h_{f_2} = Same for riser No. 2.

The problem now is to divide Q or 0.523 cubic foot per second between wells Nos. 1 and 2, so as to balance the following equation, which expresses the condition of equilibrium:

$10 + 10\,h_{f_1} = 12 + 12\,h_{f_2}$ = *friction head in 10 feet of 5-inch main suction pipe due to the flow of Q cubic feet per second.*

This problem necessitates using the "cut and try" method, that is, assuming a certain division of the 0.523 cubic foot per second and finding the resultant friction heads, until such values are found as will balance the above equation.

To save the work of solving the long formula for friction head for each assumption, curve No. 2 is plotted, with head lost in friction per foot of length of pipe as ordinates and with the velocities as abscissas. The variation of the coefficient f with velocity is taken into account in plotting this curve. Curve

No. 1 is that of cubic feet per second platted to velocity. All values are for 2½-inch pipe.

Assuming for the present that the friction loss in the 10 feet of 5-inch main suction pipe between wells Nos. 1 and 2 is negligible, the equation of equilibrium becomes,

$$10 + 10\, h_{F_1} = 12 + 12\, h_{F_2}$$

Assume that $Q_1 = 0.400$ and $Q_2 = 0.123$.

Referring to the diagram, pass horizontally across the line $Q = 0.400$ until it intersects the straight line, thus obtaining the velocity. Dropping vertically down this velocity line until it intersects curve 2, then horizontally to the scale at the left, we find,

$$h_{F_1} = 0.245 \text{ and } h_{F_2} = 0.025$$

Substituting in the equation of equilibrium,

$$10 + 10 \times 0.245 = 12 + 12 \times 0.025$$
$$12.45 = 12.30,$$

which indicates that the assumed value of Q_1 is too large.

Trying again with $Q_1 = 0.390$ and $Q_2 = 0.133$, from the diagram we find,

$$h_{F_1} = 0.233 \text{ and } h_{F_2} = 0.029$$

and our equation of equilibrium becomes,

$$10 + 10 \times 0.233 = 12 + 12 \times 0.029$$
$$12.33 = 12.35.$$

This being sufficiently close for our work, we will say that 0.390 cubic foot per second comes from well No. 1 and 0.133 cubic foot per second from well No. 2.

Now, knowing the value of Q_2, we must figure the friction loss in the 10 feet of 5-inch main suction pipe between wells Nos. 2 and 1 and see if our assumption that it is negligible, is sustained.

The area of the 5-inch pipe equals 0.136 square foot and the velocity in the 5-inch pipe is

$$\frac{0.133}{0.136} = 0.974 \textit{ foot per second}$$

For this velocity and a 5-inch pipe, Fanning gives $f = 0.007$. Substituting in the formula,

$$\textit{Friction head} = \frac{4 \times 0.007 \times 10 \times (0.974)^2}{\frac{5}{12} \times 2 \times 32.2}$$
$$= 0.00949 \textit{ foot}$$

which is negligible.

The pump or delivered horsepower is equal to the weight of water pumped per minute multiplied by the total head pumped against and divided by 33,000.

The total head is made up of four items, as follows:

(1) Discharge head = 200 feet.

(2) Friction head in 400 feet of 4-inch discharge pipe.

(3) Friction head in 100 feet of 5-inch main suction pipe.

(4) Static and friction heads (up to the main suction pipe) = 12.35 feet.

The manner of finding items (2) and (3) is exactly the same as that previously used, employing the formula,

$$\textit{Friction head} = \frac{4\, f\, l}{d}\,\frac{v^2}{2\, g}$$

using the proper values of f, as determined by the velocities and sizes of pipes. Item (2) comes out equal to 16.23 feet while item (3) proves to be equal to 1.41 feet.

Hence, the total head is,

$$200 + 16.23 + 1.41 + 12.35 = 230 \textit{ feet.}$$

The weight of the water pumped per minute is,

$$235 \times 8.34 = 1960 \textit{ pounds,}$$

8.34 pounds being the weight of one gallon.

The pump horsepower is,

$$\frac{1960 \times 230}{33{,}000} = 13.66 \textit{ horsepower}$$

T. B. Hyde.

Ithaca, N. Y.

Economic Engineering

With so many past records to uphold Power in its editorial in the September 27 issue, it seems superfluous to make additional comment on this subject. The argument offered by R. L. Rayburn in criticism, in the November 22 issue, however, makes further annotation necessary. Organization heads with manifold duties of office cannot take the part of the economic engineer; past performances have indicated this, and the particular type of the former which he depicts is considerably in the minority. The efficiency engineer called in on certain work possesses knowledge of many plants; the local superintendent has definite data on one—his own; the information that Mr. Rayburn mentions as being in the power of the superintendent becomes the property of the efficiency engineer; this is what he is placed in his position for—to investigate and learn actual existing conditions; he does not go blindfolded to his work. To afford efficient production his initial expenditures for new equipment may be large; he may change the system of the entire plant for future betterment—the results are manifested over a period of time, inclusive of interest on investment and depreciation; his arguments are based over a wide territory and, as Power states, he is not prejudiced. Is it not reasonable then to suppose that the economic engineer is in a far better position to offer suggestions for efficiency than the "man on the job"? The present Santa Fé Railroad system stands as a notable example of what an efficiency engineer can accomplish. The average superintendent, as found, is greatly in accord with keeping all expenses down—this is his province; in many instances (taken from actual experience) a superintendent has refused an installation which later the efficiency engineer has recommended.

I am under the impression that the superintendent is usually considered as an employer, and Mr. Rayburn contradicts his statements in noting, "I have found a great deal more unwillingness on the part of employers to furnish new equipment with which to improve the methods of operation, than unwillingness on the part of operators to break away from old established customs."

Efficiency work in its various branches is and has been for some time past a paramount issue with leading technical publications; the great results achieved, made known through this channel, leave no doubt in the mind that "the economic engineer is in a much better position to produce an effective solution of the problem" than any member of an organization, and that he is here to stay.

L. R. W. Allison.

Los Angeles, Cal.

Knocking Slide Valves

In the November 1 issue of Power W. H. Keller gives an account of trouble with a valve rattling or knocking.

I have had the same trouble with several engines. In one of these engines the pressure plate was held in place with two coil springs which rested over pins, and there appeared to be no cause for the trouble other than that the spring had become slightly weakened by the heat of the steam. Washers were put on and the rattle stopped.

In another case the trouble was with an engine which always ran well in warm weather, but when it was cold the valve rattled very badly. Owing to a very large heating system it was necessary to carry about 8 or 10 pounds back pressure on the heating system in order to heat the buildings. This high back pressure made the compression run up to about 10 or 15 pounds above boiler pressure. This trouble was also stopped by putting washers behind the spring.

Many automatic shaft-governed engines give trouble when running with a light load on account of the high compression, which occurs with a very early cutoff. This high compression not only makes the valve and pressure plate rattle, but often causes the engine to knock in the bearings. If the exhaust lap be trimmed off to remedy this, the compression will not be high enough when the engine is running under a heavy load. This difficulty may be overcome by running a pipe containing a check valve from the cylinder drain across to the steam-chest drain, or to any opening in the steam chest. The compression then cannot run above boiler pressure because the check valve will relieve it and let any excess steam return to the steam chest, but will prevent any steam being admitted except through the valve.

R. L. Rayburn.

Kansas City, Mo.

Leakage Past a Piston Valve

It is true that the leakage past a solid plug or piston valve is a hard matter to determine, but that there is leakage is well known. The amount depends on many things; probably the first is the quality of the material of which the engine was built, the second, possibly, the accuracy with which the engine was built and third, the care with which the engine is handled.

Many builders claim tight piston valves, yet they design these on the expansion principal, so that a valve can be expanded or adjusted to compensate for wear. With some rectangular plug-valve engines, such as use a much modified Sweet valve, an adjustable pressure plate is used; this must be for the purpose of taking up wear or preventing leakage past the valve. From operating experience as well as building, I know that when there is motion there will be wear, and unless we provide amply for such wear we are sure to find leakage. Many of the makers of engines having the Sweet valve could better their machines by carrying out the inventor's ideas—plenty of travel and plenty of surface means more life and a tighter valve.

Experience teaches that few engineers will take pains and care to keep rebuilding an engine so as to maintain a steam-tight valve, but instead, most of them allow the coal bill to run away with itself. The thing to do is to care for the machine properly, testing it at intervals for leaks and setting up the pressure plates so that leakage is reduced to the minimum; much coal can be saved in the engine room in this way. The steam-tight engine is a more difficult thing to find than many engineers think. Engineers should make more frequent tests so as to see that their engines are not leaking. This is just as important as locking the "cash drawer" and it is not for the want of knowledge upon the part of the operating engineer that tests are not made more often. Many engineers are past master machinists, know how to use the hand scraper and let down a pressure plate with as much skill as the engine-shop man. Thousands of dollars can be saved by following this suggestion.

While many piston-valve engine men say that these engines do not leak, they would be very shy of putting up their own money on a bet. If it is not a case of leaking or not leaking, examine your engine and see that the valves are tight; do this on behalf of the company you are working for.

In taking up the expansion-ring valve it is necessary to take it up slightly and allow it to run a while and then take it up again as in expanding the ring it changes the circle and has to find a new seat or bearing so as to become tight in the port. In testing these engines I have found many to leak, not only those of the horizontal type but also those of the vertical type in which the wear was less than in engines of the several marine types.

I have never been able to see but one advantage that the piston valve possesses, that is, the round piston valve. This advantage is that it runs light and is light on the governor.

To test an engine for leakage, place it on midcenter, disconnect the exhaust, if possible, remove both indicator plugs and turn on full steam pressure just as you would when starting. The fact that an engine runs well is no indication that the engine is not leaking. In some cases the engine that is leaking the most will be running the smoothest.

Only a few days since I had the opportunity of examining and measuring with standard gages a piston valve of the plug type and found that there was more than 0.033 of an inch play between the valve and the seat. The engine was of about 100 horsepower capacity, so one can imagine what the loss amounted to.

Frequent tests should be made. Engineers do not test and inspect enough; as a rule these matters are sadly neglected.

C. R. McGAHEY.

Baltimore, Md.

Underground Steam Piping

I note the answer given to a correspondent recently relative to underground steam piping. I have had a fair amount of experience along that line and rather doubt if the advice would apply to all conditions. With a gravelly ground which takes the water away the problem is fairly easy if your expectations are not too high. We have put the pipe in all the ways we could think of that promised success. Our ground is a water-tight clay which makes it a hard proposition. And, not only that, but in certain sections it is saturated with salt. The first pipe we put down was laid in a box and packed with cinders. As might be expected, this lasted only about six months; the sulphur in the cinders destroyed the pipe quickly.

Our next job was to put several hundred feet of return pipe from a steam-heating system in the ground. This was placed in a box of 2-inch plank and packed with mineral wool; the job was a rank failure. The ground held the water and the wool kept the moisture up to the pipe, causing a rapid corrosion. This job lasted one winter and was in bad condition when the steam was turned on the following fall. Mineral wool is not the best material for this line of work; it has a way of settling down in the box and leaving the top of the pipe exposed. We would not have had such poor results if the ground had been of a nature to let the water drain away. We realized that we had to get a better method and we tried two ways of protecting the pipe, both of which have been fairly successful.

A part of the pipe was placed in a box of 2-inch plank, as in the first case, except that it was not packed with anything and the pipe was supported in the center of the box by a cradle of iron rods that left it quite free to move lengthwise. This installation has been in nearly six years and has given no trouble at all. Of course, there is some loss by radiation but probably less than if any packing was in contact with the pipe. Several hundred feet of this same pipe was laid in a different way but with equally good results. In this case we wrapped the pipe quite loosely in two or three turns of tar roofing paper, wiring the ends. Around this we placed about 3 inches of mortar composed of cement and sand in the proportion of 1 to 3. This keeps the pipe in good shape and the roofing paper forms a core in the cement large enough to allow the pipe a free movement. I like this plan very well.

About three years ago we laid a 2½-inch pipe from the shop across the commons, 300 feet to the house. In this case we pitched the 2½-inch pipe down for a distance of 150 feet, then put in an expansion joint and a trap, raised the pipe size from 2½ to 3 inches and pitched it up to the cellar of the house. The extreme low point was over a sewer into which the trap discharged, all condensation from the radiators returning in the 3-inch to the trap. The system works well. The pipe is placed in a box of three thicknesses of [illegible]-inch plank with two [illegible]-inch air spaces and packed with pine shavings. Underneath the box is a 6-inch drain tile covered with gravel and over the whole is one thickness of tarred paper. This pipe has given no trouble whatever and we feel that it is fairly well insulated. The job was too small to pay for returning the condensation, especially as we had plenty of hot water for the boilers and a purifying system to remove the impurities.

Our last work was that of taking care of the returns from the heating system in a building 150x150 feet square and two stories high. Next to the side walls we made trenches 2½ feet wide and 3 feet deep to carry the main returns. The laterals are in cement ducts with boxes in the cement so that the pipe can be got at with the least damage to the floor. We use a plain gravity system with return pipes of a size that allows them being only partly filled with water, thereby balancing the pressure on the system and allowing the air in the wall coils and radiators to gravitate to the receiver, where it is expelled through simple means.

To my mind, there is no really successful way of burying a steam pipe in the ground so as to have it last well. The only way is to place it in a tunnel where it can be kept in repair and properly insulated.

I have seen 10-inch mains taken up in a district heating system that were practically destroyed after three or four years' use. If pipe has to be placed in the ground, make the covering as near moisture proof as possible. Even then there will probably come leaks in the joints that will keep the insulation wet and cause its destruction if the pressure is high.

J. O. Elder.

Anderson, Ind.

Handling Men

Much has been said in the columns of Power in regard to the treatment of men employed in the power house.

To know just how to treat each and every man in a power plant is no easy task, for if you try to act fair with all, there is bound to be some who will not appreciate kind treatment.

The men of a certain class do not seem to know when they are well off; they kick and complain about their surroundings, their hours of labor, etc., and they are always complaining about not getting a chance. Yet, when their conditions are bettered they abuse them, and whenever a chance for a better job turns up they are not prepared to accept it. The question is, what is the best thing to do with these men.

Men who are ambitious and ever ready to acquire a better working knowledge of their business as engineers, firemen or oilers, do not as a rule find much difficulty in commanding respect from the superintendent or chief engineer, especially if they can show that they are awake on their job. It is only the men who have to be told to do every little thing around the plant, or the men who try to see how much time they can kill without being discovered who find it hard to get along with the operating engineer. A majority of subordinates do not fully understand the position that the engineer in charge is placed in; they do not or will not reason the matter out to see that the owner or manager holds the engineer responsible for everything pertaining to the engine room, and yet when the engineer thinks up ways and means for saving fuel, oil or supplies and divulges his little schemes to his helpers, nine out of every ten of these men criticize him as soon as his back is turned, for catering too much to the boss.

To my mind the positon of engineer in charge of any plant is no sinecure, and I can positively state that you must treat the men that you are responsible for in a manner best suited to them, based on personal observation of them.

If, as Mr. Levy says in Power for December 20, a man finds fault simply because he wants it understood that he is it, he certainly shows his lack of sense and cannot expect the men who work for him to have any confidence in his judgment.

Referring to the article submitted by Mr. Carr in the same issue, in which he says that he treats his men as he would like to be treated himself, I must say that I agree with him in this respect, providing he is dealing with the class of men who have brains enough to know that they are being treated right. Mr. Carr further states that we all make mistakes, which is all too true, but here, as in all other things, a lot of judgment is needed to decide whether or not the mistake is pardonable.

Certain men when given an inch will take a foot; that, to my mind, is a very true saying and if this class of man is not kept in his place there is no telling what else he may take.

Regarding his statement as to a man who is frank enough to say he is not familiar with this, that or the other thing, I would like to say that as a rule this kind of a man usually makes the one on whom you can rely most, owing to the fact that what he has learned has to a large extent been gained from the knowledge which has been imparted by you; the right kind of man will show his appreciation of this fact by faithful service as long as he is in your employ.

H. H. Burley.

Brooklyn, N. Y.

Introducing Solvents into Boilers

Under the above heading, Charles H. Taylor had an article in the December 6 issue of Power in which he described his method of introducing solvents. I believe that it is better to feed the solvents in with the feed water, so that all the feed water will carry along with it into the boiler the required amount of compound necessary to precipitate the scale-forming matter contained in it.

One method of accomplishing the desired result is to have a small pipe connected into the suction pipe of the pump and extending up a little higher than the level of the water in the heater. The pipe should end in a funnel. Above should be mounted a tank large enough to hold at least a day's supply of the solvent used, dissolved in water. The outlet pipe from this tank should end in a petcock just above the funnel, so that the attendant can see and regulate the amount of the solution he is feeding. Of course, the above method will not apply where the feed water is supplied to the pump under city pressure, but as I never had that problem to solve I will leave suggestions along that line to those who have.

Where compounds are used that will act on the feed water below the boiling temperature and where an open heater is used, I introduce the compound into the inlet pipe to the heater, so that the compound can act on the water as it passes through the heater. The heater thus becomes a sort of a feed-water purifier. Under some conditions large quantities of scale-forming matter can be removed by the heater and if a heater is used that is easily cleaned there is a decided gain over the method of treating water after it leaves the heater.

On waters that soda ash has produced little or no effect outside of the boiler, trisodium phosphate has been found to act efficaciously even while the water is quite cold, so that by introducing this latter compound into the feed water before it enters the heater a large part of the scale-forming matter is precipitated and removed from the water before it enters the boilers.

G. E. Miles.

Salida, Colo.

Liquid Discharging Device

An article by Earl Pagett, on page 2196 of the December 13 issue of Power, interested me a good deal, as I have had some experience with a somewhat similar device for emptying barrels.

Several years ago I conceived the idea of making a similar arrangement, but to start with I applied the air at a separate opening. My arrangement worked beautifully on several barrels. One day I got hold of a barrel with a very short chime and when the air pressure came on, the head came out of the barrel. Forthwith I lost all interest in that means of emptying barrels.

A. G. Knight.

Omaha, Neb.

Lubricating Piston Packing

An article in the November 22 edition relating to a ring or sleeve between sundry rings of fibrous packing, with a hole in the said ring or sleeve through which oil is run by gravity onto the piston rod while it is in reciprocating motion, reminds the younger generation of engineers of their daddy's lectures that, say, a 40-horsepower stationary engine must have a cylinder diameter of, say, 14 inches and a stroke, say, 36 inches long—the longer the better and more effective—no cutoff and a speed of 50 revolutions per minute.

We wish to learn, and concede that we know very little, why it would not be well to utilize graphite instead, fed through a modern lubricator. Perhaps one reason has been the likelihood that graphite, mixed in oil for the purpose, would stop up or clog up the openings, which experience has proved to be so. Our idea is, however, to use graphite in connection with the lubricator in which the drops of oil pass over a bed of fine graphite, to the cylinder, lubricating the inside of the cylinder, the valves and, particularly, the *piston rod,* dispensing with the ring or sleeve for lubricating the rod and the packing.

C. C. Stilwell & Co.

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Contents

POWER

The Consumer Pays the Bill

Not many years ago the anthracite coal companies of Pennsylvania could market only their larger sizes of coal which was used largely for domestic purposes.

The smaller sizes now known as pea, buckwheat, rice and barley coal were dumped in great piles together with bone, slate and other refuse from the mines. These immense culm piles grew in number, and in some instances to almost mountainous proportions, but no attempt was made at that time to reclaim the fuel mixed with the noncombustible matter.

Just when the burning of the smaller sizes of anthracite coal was begun is not definitely known, but many large power plants are now using buckwheat coal extensively as a fuel.

Naturally, the growing demand for the smaller sizes of anthracite coal has not been from a desire on the part of the power-plant manager to reduce the culm pile or to add profit to the coal producer, but that the cost of operating the steam plant might be reduced by using a cheaper fuel. Accordingly he has devoted much attention to experimenting and the training of his fire-room force in handling the cheaper grades of coal.

It did not require much urging on the part of the consumer to awaken the coal producer to the fact that there were thousands of dollars to be had almost for the picking up, and as a result washeries were built, old breakers remodeled and the reclaiming of coal from the culm piles became a most prosperous enterprise.

The demand at first was for the larger size of the buckwheat coal, which was cheaper than the pea and chestnut sizes, but the price was put up as the producer saw the demand had become permanent. This forced the consumer to either purchase a cheaper grade of coal or increase the cost of the manufactured product, and the cheaper grade was bought.

As the purchase price increased on a certain grade of coal, still cheaper and finer sizes were tried until barley, the smallest of all except "[illegible]," became the cheapest grade of anthracite coal that could be used.

Barley coal, until recently, has been selling for $1.50 per gross ton of 2240 pounds, f.o.b. vessels at Hoboken, N. J.; rice, $2; buckwheat, $2.50; and chestnut, $[illegible]. Each of these coals has been advanced in price during the past month at the rate of 25 cents a ton.

To one known company using rice and barley coal this increase will make a difference of about $40,000 yearly in the cost of fuel. There is no cheaper grade of coal to fall back on and the additional cost must be met.

It is not at all probable that the manufacturer will stand the increases in the coal bill, and as there is not much chance of decreasing the amount of coal consumed per year, the logical conclusion is that the consumer will in the end pay for it.

It is not the cost of reclaiming this coal from the culm pile that warrants a selling price of $1.75 per ton, as a ton of buckwheat coal can be washed and loaded in a car for something like 10 cents per ton. The balance of the coal price is divided between profits and transportation rates.

And the consumer, who has created a demand for a byproduct of a mine at one time thrown away, must now pay an increase per ton just because the coal producer determines to make a greater profit on coal that costs practically nothing to market, and because there is no substitute in sufficient quantity to supply a B.t.u. at an equal cost.

Impossible Boiler Performances

There are being circulated printed records of tests conducted by John R. [illegible] at the plant of the American Printing Company, Fall River, Mass., upon horizontal return-tubular boilers, in which evaporations of over sixteen pounds of water from and at 212 degrees are claimed. Mr. [illegible] is the master mechanic of the above named corporation and evidently believes that he obtained those results.

To evaporate a pound of water from and at 212 degrees requires 970.4 units of heat. To evaporate [illegible] pounds, as Mr. [illegible] claims was done in one of his tests, would require [illegible] heat units.

Assuming that each pound of combustible makes twenty pounds of gas and that the gas leaves the boiler four hundred degrees above the room temperature, it would take some two thousand heat units to the chimney with it. Adding this to the heat put into the steam it is seen that such a performance would call for a coal of over eighteen thousand British thermal units per pound of combustible, even allowing nothing for radiation; and no such coal has ever been mined.

At the time that this impossible performance is claimed to have been effected the boilers were fitted with a device known as the Cornell fuel economizer. This consists of a number of metallic retorts behind the bridgewall, into which steam is admitted, and it is claimed that the steam in passing through them is decomposed into its constituent gases, oxygen and hydrogen, and that it is the combustion of the hydrogen which supplies the extra heat necessary to obtain the high evaporation reported.

This claim has been exploded over and over again in POWER. Even if the steam is so decomposed it takes as much heat to decompose it as the gases produced will generate in combustion. When hydrogen is burned, two atoms of hydrogen unite with one of oxygen to form H_2O or water vapor—steam. The decomposition of steam into hydrogen and oxygen is a reversal of the process, and takes just as much energy in the form of heat as was produced, or will be produced again, by the reunion of the gases in combustion.

If those in authoritative control of the Cornell Economizer Company do not know this, they had better inform themselves as to the elementary principles of combustion before entering the market as practitioners in this line.

Natural Sources of Power

Man has often been called a tool-using animal, this seeming to be the only characteristic difference between him and other animals. But more than a tool user he is a power user and as civilization advances the per capita demand for power increases in geometrical ratio.

Scarcely a century ago the modest demands of each community were met by the utilization of the energy of small, rapid streams by the means of crude waterwheels built in place by the local millwright. In some instances the ebb and flow of the tide furnished the power needed by small industries and, where both waterfall and ocean tide were lacking, great canvas-covered wind wheels turned the stones that ground the grain for man and beast.

With the parallel development of the steam engine, electric transmission and the factory methods of production came increased demands for power for manufacture and transportation.

Steam has been almost universally used as the medium of transmission. But the steady increase in the price of coal has turned the attention of men toward the natural forces of wind and wave and their utilization in power production. "The wind that bloweth where it listeth" and the sea which is never still could if intelligently harnessed be made to furnish power at a rate far beyond the dreams of the wildest enthusiast.

But at what price per unit?

Some of the oldest mills in the country were and perhaps are today driven by wave power. Built before the steam engine became the common prime mover and costing little for upkeep they have, where equal to the demand, been continued in operation. An investment once made, the interest cost of the capital goes on forever, and it will doubtless be found on investigation that the interest on the investment in any of the old-time water or wind powers at prevailing rates would operate a steam plant of equal capacity and leave a margin of profit.

With the ever-increasing demand for power for every conceivable purpose it is not to be wondered at that every move tending toward the development of unused forces of nature should attract attention, but it "passeth understanding" that palpably inefficient and expensive methods of utilizing the rise and fall of the tides, the heat of the sun and the current of rivers beyond the reach of a possible market should find such ready support from even a guillible public.

No investor would buy land without having the title examined by competent authority on such matters. But the first successes of a Keely or a Carroll show that the professional promoter of any kind of a scheme to beat the law which affirms that action and reaction are equal and opposite, finds ready buyers for his wares.

No one should consider the investment of money in any enterprise to control and direct natural forces until he has paid a competent engineer to make an exhaustive examination of the proposed program.

A Pioneer

For his work in advancing condensing and compound-engine practice in this country, William Coutie, who died recently at Troy, N. Y., deserves attention from the engineering fraternity. Mr. Coutie was in his ninety-second year. He came to the United States from Scotland before he was thirty, and in 1849 he was working as a machinist at the Starbuck shops in Troy, then located close by the river. Near the shop was a coffee and spice mill doing a large business for those days and driven by an ordinary high-pressure noncondensing engine. He arranged to take the exhaust from this engine, placing a valve in the pipe which guaranteed that there should be no back pressure, and with this steam he drove a condensing engine which supplied him with power for a machine shop which he started in 1850. This was his sole source of power for ten years or more and it was an incontrovertible example of the economy of condensing.

He made a specialty of simple and compound steam engines, always condensing, and built quite a number for Troy and the immediate vicinity. The engines never proved to be what would be considered high-class machines, but they saved fuel and cost little for repairs. He was one of the first builders of "Troy laundry machinery" and did a general and repair trade, but never anything big, and discontinued business in 1899.

Mr. Coutie was spoken of as a scientist and had affiliations with some of the societies. He wrote a number of papers of a pseudo-scientific character which could scarcely be considered seriously. They all had the somewhat unusual merit of being short. His hobby for fifty years was the commutation of metals, and he is said to have died in the belief that this he had actually accomplished.

In utilizing exhaust steam that had previously been wasted, Mr. Coutie allowed his Scotch thrift to come to the front. In effect his engine was merely a low-pressure cylinder added to the engine in the spice mill, but for so early a period in steam-engine history, his work was ingenious to say the least, and he should be given due credit.

The following is a squib which appeared in one of the Pittsfield, Mass., papers on the day following the disastrous boiler explosion, described in the January 10 issue of POWER:

"When asked by the reporters for a statement concerning the exact cause of the explosion, Inspector McNeil spoke in full as follows:

"...............................
....
....
..............................."

If an engineer takes a lively interest in all matters pertaining to his vocation he will be a successful engineer.

Some idea of the importance of apparently small things may be had when it is realized that in a 30,000-kilowatt plant one inch in vacuum represents a total of $14,000 in the operating expenses for one year.

With the water-power developments and the adaptation of the internal-combustion motor to all classes of power service, how long will it be before steam engines will be unfashionable?

San Francisco started the new year with an earthquake. That's nothing. Pennsylvania and Massachusetts had three boiler explosions just before New Years, and killed twenty men.

Low Pressure Steam Turbine

Osborn Monnett

At the works of a rubber-manufacturing company live steam at 40 pounds pressure, after being used in the vulcanizers, is utilized in a low pressure turbine.

No installation better demonstrates the possibilities of the low-pressure steam turbine than does that of the Diamond Rubber Company at Akron, O. The power plant originally contained a 1500-horsepower, cross-compound, Corliss engine, direct connected to a 1000-kilowatt generator, the set running condensing. In addition there was a 250-kilowatt, tandem-compound noncondensing engine and numerous auxiliaries exhausting into the low-pressure system, which supplied the heating coils of the indirect heating system.

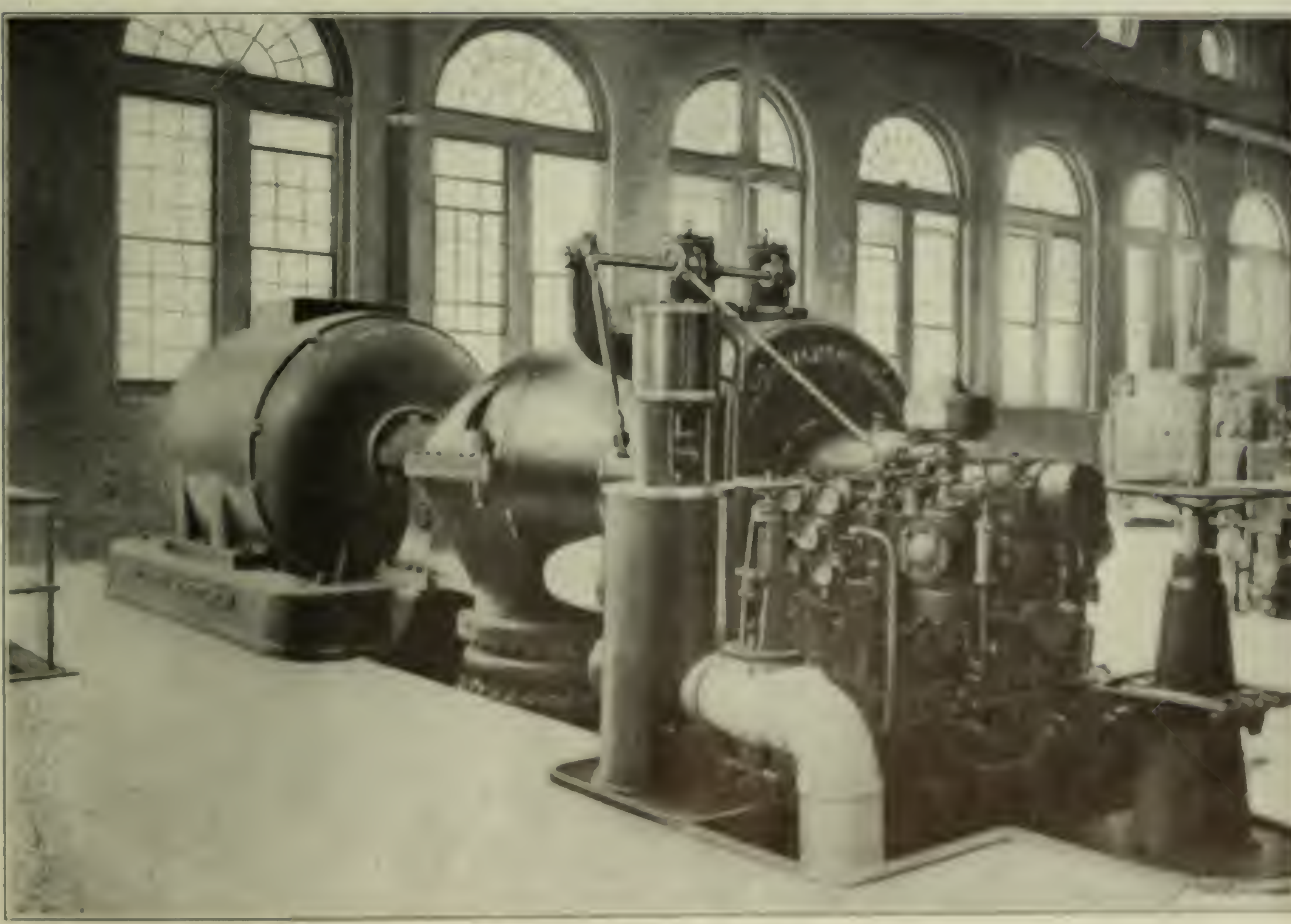
In the process of manufacturing rubber goods a large amount of heat is necessary, and at these works this is furnished by live steam at about 40 pounds pressure. Formerly this steam was considerably in excess of that used in the power plant itself; only a comparatively small amount of the exhaust steam available from the engines and the vulcanizers was utilized, while the rest was exhausted into the atmosphere. Realizing this loss and looking for a means to stop it, the idea was conceived of collecting all the exhaust steam in a large receiver which would serve as a source of supply to a low-pressure turbo-generator. Accordingly, this plan was finally worked out and a 1000-kilowatt, 25-cycle, two-phase, 240-volt Allis-Chalmers turbo-generator was installed to operate in parallel with the main generator.

The success that has attended this arrangement is apparent from the fact that even under extremely adverse conditions the turbine has been able to carry the entire electrical load, thus allowing the Corliss engine unit to be shut down.

One difficult feature of the installation was the selection of the proper condensing apparatus to meet the conditions existing. Due to the use made of the steam before it enters the receiver it carries a large amount of air. Also, owing to the source from which the condensing water is secured, it is impossible to obtain this at as low a temperature as would be desired. An Allis-Chalmers jet condenser with a special dry-air pump was finally installed. The circulating water and condensed steam are removed from the condenser by a centrifugal pump driven by a small impulse turbine, the exhaust steam from this small turbine discharges into the main receiver on the inlet side of the low-pressure turbine and consequently does work through the complete range of pressure.

To handle the large amount of air that passes to the condenser, a 12 and 30 by 24-inch dry-air pump was installed; this is of the rotative crank and flywheel type, and has about twice the capacity that would normally be required for a turbine of this size.

Condensing water is obtained from the lock of an old canal just behind the power house, which also serves as a supply for other manufacturing plants. This lock also receives the discharge from all the condensers and, as it is comparatively small, the water soon becomes warm. During the summer months the temperature of the water frequently rises above 100 degrees Fahrenheit, yet the turbine carries its load successfully.



1000-Kilowatt Low-pressure Turbine

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Compound Engine Balance

When a compound engine is said to be balanced, does it mean that the load is balanced between the cylinders or that the cranks are balanced so that the engine will run quietly?

C. E. B.

In a compound engine the load is balanced when it is equally divided between the cylinders. The engine itself is balanced when the inertia effect of the reciprocating parts is neutralized by weights on the cranks.

Number of Expansions

What is the rule for finding the number of expansions in any size of cylinder?

N. O. E.

The diameter of the cylinder has nothing whatever to do with the number of expansions. This is determined by the point of cutoff. The number of expansions is the reciprocal of the cutoff; that is, 1 divided by the fraction of the stroke completed at cutoff. If the cutoff is at 1/4 stroke, the number of expansions will be 4, because 1 divided by 1/4 equals 4. If the cutoff is at 1/3 of the stroke, there will be 3 expansions, and so on.

Size of Steam Chest

What is a simple rule for proportioning the size of the steam chest of a slide-valve engine?

S. S. C.

Make it no larger than is necessary to accommodate the valve and give room for the passage of what steam will be used.

Double Acting Pump

What is a double-acting reciprocating pump?

H. A. T.

One in which the piston acts in both directions, alternately for suction and discharge, drawing in the water at one end of the cylinder while discharging at the other.

Direct Acting Pump

What is a direct-acting pump?

P. D. A.

One in which there is no rotary or walking-beam motion. The piston movement is reversed by an impulse controlled by itself. The steam and water cylinders are in a direct line and the movement of the water piston is identical with that of the steam piston.

Steam Furnished by Compression

If an indicator diagram shows 85 pounds initial pressure and the compression runs up to 42 pounds, what proportion of the steam which fills the clearance space to initial pressure is furnished by compression?

S. F. C.

One cubic foot of steam at 85 pounds gage pressure weighs 0.2296 pound. The same volume at 42 pounds pressure weighs 0.1355 pound. Then

$$\frac{0.1355}{0.2296} = 59 \textit{ per cent.}$$

of the steam in the clearance space furnished by compression.

Compound-Engine Valve Setting

How should the valves of a compound-condensing engine be set?

C. E. S.

The valves of condensing engines having the same duties to perform as those of noncondensing engines should be set the same. A slight improvement may be made in some cases by giving the low-pressure exhaust valves more lead than is common for a noncondensing engine.

Pressure in Condensing Engine

If the steam pressure in the boiler is 75 pounds and a condenser is attached to the engine, how much will it increase the pressure in the engine cylinder?

P. C. E.

The pressure in the cylinder will be the same as before the condenser was attached, but the difference of pressure on the opposite sides of the piston will be increased, because the condenser removes a part of the atmospheric pressure from the advancing side of the piston. This is equivalent to increasing the pressure on the other side and amounts in average practice to 10 or 12 pounds per square inch of piston area.

Racing in Compound Engine

When the load is thrown off of my compound-condensing engine it races. What is the cause?

R. C. E.

Incorrect valve setting or maladjustment of the governor. The connections between the governor and the valves should be so adjusted that when the governor is in its highest position the admission valves on neither cylinder will be opened.

Change of Cutoff

How can I change the point of cutoff on a Brown engine?

C. O. C.

By changing the load or the steam pressure. The point of cutoff is controlled by the governor and takes place at that point which will keep the engine at the right speed.

Condensing above Sea Level

At a hight of a mile, is the vacuum in an engine cylinder as effective as at the sea level?

C. S. L.

It is.

Legal Ownership of Patent

If, while working for another, I invent, make and patent a machine or tool, using his time, tools and materials, does the patent belong to him or to me?

L. O. P.

If a man working at a machine conceived a better way of producing the piece that he was making and got up an attachment to the machine for doing so on his own initiative it would be unreasonable for his employer to claim the rights to the patent because it was developed while the man was in his pay and perhaps used a pound or two of brass and steel.

If, on the other hand, an employer wanting a machine or process worked out, hires a man to develop it, he pays for brains and ingenuity and is entitled to whatever is evolved in that connection. Between the two cases there are many gradations, the equities of which are often difficult to settle.

The legal ownership of a patent is vested in the one to whom it is issued.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

New Method of Flanging Pipe

This method of flanging pipe by the cold hydraulic process was devised for the purpose of cutting down expense and eliminating the necessity for skilled labor, the latter being so essential to many of the methods now in use. A rectangular groove is first cut around the inside of the flange, which is then placed in position

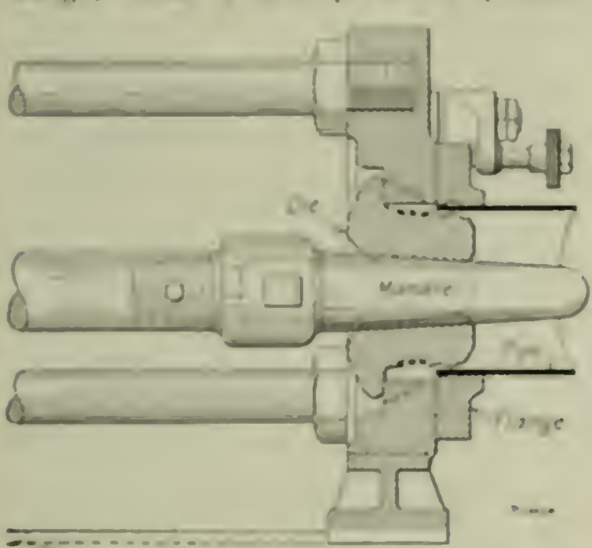


Fig. 1. Portion of Flanging Machine, Showing Flange and Pipe in Place

over the pipe as shown in Fig. 1. The die, consisting of a number of segments having projections corresponding to the groove in the flange, is then expanded by the hydraulically-driven tapered mandrel. Thus the flanging is accomplished, practically, in a single operation. A hydraulic chuck, which is shown in Fig. 2, and consists of six radial hydraulic pistons, is placed over the flange and takes up any radial strains produced by the mandrel. Each machine is fitted with an adjustable pipe rack and an attachment for bringing the flange face exactly parallel, thus doing away with the necessity of refacing and at the same time permitting extreme precision in measurements. Another significant fact is that it is not essential for the pipe to fit closely the bore of the flange; and, when so desired, the flange may be put on at an angle with the axis of the pipe. By fitting a collar over the flange a flexible joint may be had the same as with a welded or rolled flange.

Recently one of these joints was subjected to a severe test by being placed in service under superheat at a tempera-

Fig. 3. Flange Showing Finished Joint

ture of 750 degrees for six consecutive days, and twice each day a stream of cold water was directed against it. An examination of the joint at the end of the test revealed no signs of weakness.

At present machines are built to handle pipes from 2 to 20 inches in diameter and it is claimed that one man and a helper can flange forty 4-inch or twenty-five 8-inch ends in an hour. The process is applicable to either cast-iron, wrought-iron or steel flanges and is allowed in the marine service by authority of the United States Steamboat Inspection Bureau.

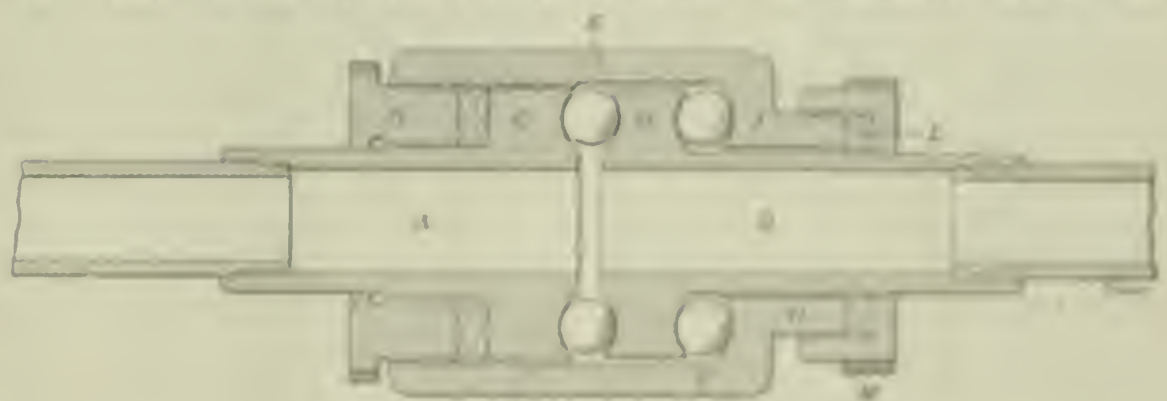
The machines are built by the Patterson-Allen Engineering Company, of Jersey City and 2 Rector street, New York City.

Walder Rotary Joint

This joint is a connection for steam or other pipes containing fluid under pressure and is designed to form a liquid-tight connection between ends of two pipes and at the same time to permit such pipes to have free turning movements.

In the accompanying illustration is shown a longitudinal section of two pipes connected by this type of joint. The spaced ends of the pipes are threaded to the outer ends of the tubular members A and B, respectively. These members each have at their inner end annular shoulders or enlargements, as shown at C and D, the end faces of which are divided with annular concave seats or runways E for the interposed balls. A sleeve F is threaded to the enlargement C, as shown at G, and its opposite end is reduced as shown at H.

Between the shoulder I, which is formed by reducing the end of the sleeve F, and the shoulder D, are placed a set of balls, the shoulders having their



Walder Rotary Joint

faces concaved to provide suitable runways for the balls. Leakage is prevented between the members B and the reduced end H by a suitable packing ring L, which is pressed closely to the member B and to the reduced end of the sleeve by a gland M.

N designates a nut which is screwed into the large end of the sleeve and onto the member A and serves to lock the sleeve F in an adjusted position relative to the member A. To overcome any leak-

Fig. 2. Pipe Supported by Rack and Hydraulic Flange Chuck in Place

age, which might otherwise occur between the sleeves and the shoulder on *A*, a suitable packing is used.

It is evident that with this construction the member *B* and its attached pipe are permitted to have free turning movement relative to the member *A*, as shown, the sleeve *F* and the packing parts, and that the opposite thrusts of the shoulders against the sets of balls may be adjusted to a nicety to prevent longitudinal play between such parts.

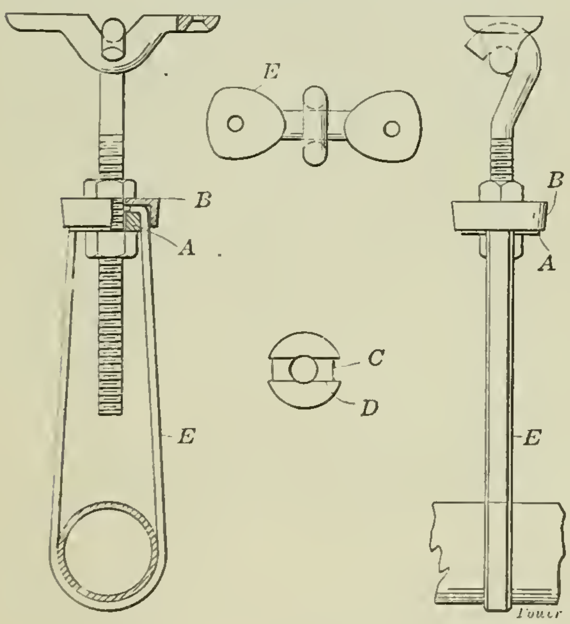
This joint is the invention of August Walder, Archibald, O.

Improved Pipe Hanger

This hanger, illustrated herewith, is constructed so as to be put up either before or after the piping is hung. It is adjustable, so as to maintain the alinement of the pipe and also to allow for expansion and contraction.

The drawings show an elevation of the hanger, partly broken away to illustrate the construction, and also a side view. The hanger consists of a threaded shank that passes through a sliding block *A* and sliding cap *B*, both of which are provided with a central opening for the shank piece to pass through. The block is provided with side recesses, as shown in *C*, being opposite to each other, and a top recess *D* is also provided.

The pipe is supported by a spring loop, the upper turned-in ends of which lie in the side recesses in the block *A*.



Two Views of Pipe Hanger

When the two nuts are screwed down tight, the ends of the spring loop is held in place between the block and cap. The whole swings on the. head of a shank piece, which is suspended by the holder shown at *E*. This allows for expansion; the adjustible nuts permit of raising or lowering the pipe. The device is the invention of Elmer A. Roberts, Norwalk, Conn.

If the wood handle has been broken from a monkey wrench, a serviceable substitute can be made by slipping a piece of hose over the wrench, then filling the hose with babbitt.

Minneapolis in Darkness

On January 6, the power plant of the General Electric Company, furnishing current to the city, was visited by fire. Crossed wires in the engine room started the trouble. Electrical machinery of 6000 kilowatts capacity was reported to be totally destroyed. The city was dark on Friday night, but on Saturday normal conditions were restored with the load on the St. Croix station. Full particulars will be given in an early issue.

OBITUARY

At the age of 54, Patrick Mullen died on Tuesday, January 3, at the New York home for the aged, where he had held the position of chief engineer for the past twenty-eight years. Mr. Mullen was an earnest and active member of the Eccentric Association of Engineers No. 1, of New York City, and was always an energetic worker for the betterment of the condition of the engineer. His ambition was to see the engineers of Greater New York united in one body. Mr. Mullen had a host of friends and his loss will be keenly felt.

The Germantown council, American Order of Steam Engineers, announce the demise of Past Chief William M. Leitch. Mr. Leitch took an active interest in the affairs of the American Order, both subordinate and supreme. The American Order of Steam Engineers Exchange, of which he was chairman, was a direct result of his activities in securing employment for engineers. Practically, during the time he was a member of Germantown council, he took special interest in this important work, and during the time prior to organization of the exchange, he had through his own efforts secured more than 150 positions. His reputation in this respect became circulated throughout the engineering fraternity of Philadelphia.

At the Baltimore convention, 1908, Mr. Leitch was nominated for supreme chief engineer, and, although unsuccessful at that time, he did not allow this defeat to affect his attitude or efforts toward the welfare of the members of the American Order. He was conscientious in everything that he did, and was considered one of the most capable engineers in Philadelphia. For a number of years he had been employed by the William H. Hoskins Company, Philadelphia, as chief engineer, and was still connected with that company at the time of his death.

PERSONAL

C. O. E. Sanders has associated himself with the Thermoid Rubber Company, of Trenton, N. J., which will put upon the market a line of mechanical rubber goods, including packings, in which field Mr. Sanders has already made a reputation.

On January 4, W. H. Whiteside resigned the presidency of the Allis-Chalmers Company, which position he has held for about six years. Mr. Whiteside's first industrial connection was with the Hercules Powder Company in 1881. Four years later he went over to the Cleveland Electric Manufacturing Company, where he remained 12 years. He then became manager of engine sales for the Gates Iron Works, of Chicago. Two years later he was placed in charge of the Wilmington office of the Westinghouse Electric and Manufacturing Company. D. W. Call, formerly assistant to the president of the American Steel Foundry Company, has been chosen as successor to Mr. Whiteside.

BOOKS RECEIVED

Physical Significance of Entropy. By J. F. Klein. D. Van Nostrand Company, New York. Cloth; 98 pages, 6x9 inches. Price, $1.50.

Qualitative Chemical Analysis. By J. I. D. Hinds. The Chemical Publishing Company, Easton, Penn. Cloth; 264 pages, 5½x9 inches; indexed. Price, $2.

International Municipal Congress

Hon. John MacVicar has been selected for the position of commissioner-general of the International Municipal Congress and Exposition, to be held in Chicago, September 18 to 30, 1911. John MacVicar is a well known authority in this country on all that pertains to municipal government and the administrative affairs of cities. He has been in active service in municipal work for more than twenty years. He was named to the office of president of the League of American Municipalities upon its organization, fifteen years ago, and has ever since been actively connected with that organization, for the past ten years as secretary. Mr. MacVicar is at present a member of the commission, and superintendent of streets and public improvements, at Des Moines, Ia., which city has recently attracted some attention because of its advanced form of government.

This congress and exposition will cover in a practical as well as theoretical manner matters of interest to all branches of municipal service. Upon each day of the congress, papers will be read and discussed by prominent municipal officials, and prominent municipalities of this country and foreign countries will have attractive exhibits of municipal undertakings in which they excel.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

HYDRAULIC MOTOR. William C. Kelly, [illegible], Mich. 979,511.

INTERNAL COMBUSTION POWER GENERATOR. Alfred [illegible], Chicago, Ill. 979,554.

TURBINE. Thomas James [illegible], [illegible], Wash. 979,619.

ROTARY ENGINE. George E. [illegible], [illegible], R. I. 979,628.

TURBINE. Alonzo W. [illegible], [illegible], Conn. 979,765.

INTERNAL COMBUSTION ENGINE. Adolph [illegible], New York, N. Y. 979,791.

TWO-CYCLE INTERNAL COMBUSTION MOTOR. Frederick [illegible], London, Eng. 979,971.

ROTARY ENGINE. Horace [illegible], [illegible], Conn. 980,075.

TWO-CYCLE INTERNAL COMBUSTION ENGINE. Charles L. [illegible], [illegible], Cal. 980,110.

EXPLOSIVE ENGINE. Frank W. [illegible], Minneapolis, Minn. 980,174.

WINDMILL. William P. [illegible], [illegible], Ill. 980,172.

BOILERS, FURNACES AND GAS PRODUCERS

BRICK FOR FLAME WALLS OF WATER-TUBE BOILERS. [illegible], New York, N. Y., assignor to [illegible] Wall and Boiler Company, a Corporation of New York. 979,[illegible].

FURNACE GRATE. George [illegible], Chicago, Ill. [illegible] 979,787.

FURNACE TILE. George [illegible], Camden, N. J. [illegible] 979,627.

FURNACE. John E. [illegible], [illegible] 979,[illegible].

AUTOMATIC STOKER. William L. [illegible], Cincinnati, Ohio, [illegible] Mechanical Construction Company, Cincinnati, Ohio, a Corporation of Ohio. 979,850.

GAS-PRODUCING FURNACE. [illegible], Lansing, Mich. 979,[illegible].

POWER PLANT AUXILIARIES AND APPLIANCES

HOSE COUPLING. [illegible] 979,481.

LUBRICATOR SYSTEM. William S. [illegible], Milwaukee, Wis. 979,484.

FLEXIBLE PIPE JOINT. [illegible] 979,[illegible].

VALVE. Frank A. Merrill, [illegible] 979,[illegible].

FEED-WATER HEATER AND [illegible]. [illegible] 979,612.

VALVE. [illegible] 979,[illegible].

GREASE CUP. [illegible] 979,[illegible].

VALVE. [illegible] 979,[illegible].

GOVERNOR FOR INTERNAL COMBUSTION ENGINES. [illegible] 979,[illegible].

VALVE-OPERATING MECHANISM FOR USE IN INTERNAL COMBUSTION ENGINES. [illegible] 979,[illegible].

LINER FOR STEAM PUMPS. [illegible] 979,[illegible].

VALVE DISK CUTTING MACHINE. Frank L. Smith, Chicago, Ill., and [illegible] Williams, Orange, Mass., [illegible] Machine Company, Orange, Mass., a Corporation of Massachusetts. [illegible].

FEED-WATER REGULATOR. [illegible], Lawrence, Mass. [illegible].

LOCKING DEVICE FOR LUBRICATING CUPS. [illegible] 980,[illegible].

VALVE ARRANGEMENT FOR CONTROLLING FLUID [illegible]. [illegible].

PIPE COUPLING. [illegible] 980,116.

ELECTRICAL INVENTIONS AND APPLICATIONS

ELECTRIC STREET LIGHTING. [illegible], St. Louis, Mo. [illegible].

ELECTRIC MOTOR. [illegible], New York, N. Y. [illegible].

ELECTRICAL HEATER. [illegible] 979,542.

ELECTRIC CABLE CONNECTION. [illegible] 979,[illegible].

ELECTRIC SWITCH. [illegible] 979,[illegible].

ELECTRIC SOLDERING IRON. [illegible], Chicago, Ill. 979,904.

ELECTROLYTIC CELL. [illegible], New York, N. Y. [illegible].

ELECTRIC IGNITION APPARATUS FOR INTERNAL COMBUSTION ENGINES. [illegible], Birmingham, England. 979,917.

METHOD OF ELECTRIC WELDING. [illegible], New York, N. Y. [illegible] Electric Welding Company, a Corporation of New York. 979,[illegible].

ROTOR FOR HIGH-SPEED ELECTRICAL MACHINES. [illegible], Chicago, Ill. 980,[illegible].

MAGNETO ELECTRIC GENERATOR. [illegible], Buffalo, N. Y. [illegible].

COMBINED ELECTRIC CONNECTION PLUG AND SOCKET AND SWITCH. [illegible], London, England. 978,841.

CIRCUIT CLOSER. [illegible] 978,840.

CIRCUIT BREAKER. [illegible], Pa., assignor to Westinghouse Electric and Manufacturing Company, a Corporation of Pennsylvania. 978,882.

ELECTRIC CIRCUIT-CHANGING MECHANISM. [illegible], W. Va. 978,875.

AUTOMATIC ELECTRIC PUMP CONTROL. [illegible], Fort Wayne, Ind. [illegible] Fort Wayne, Ind., a Corporation of Indiana. 978,[illegible].

LIGHTNING ARRESTER. [illegible] New York, N. Y., a Corporation of New York. [illegible].

POWER PLANT TOOLS

JACK SCREW. [illegible].

BELT STRETCHER. [illegible].

TUBE REAMER. [illegible].

WRENCH. [illegible].

RATCHET MECHANISM FOR SCREW DRIVERS AND THE LIKE. [illegible], New York, N. Y. [illegible].

SOLDERING TOOL. [illegible].

ADJUSTABLE TOPE FOR RATCHET DRILLS. [illegible].

WRENCH. [illegible].

WRENCH. [illegible].

WRENCH. [illegible].

WRENCH. [illegible].

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., [illegible]; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., [illegible]; sec., Ralph W. Pope, 33 W. 39th St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. [illegible]; sec., T. C. Martin, 31 West 39th St., New York.

AMERICAN SOCIETY OF NAVAL ENGINEERS

[illegible] Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

[illegible]

WESTERN SOCIETY OF ENGINEERS

[illegible], Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

[illegible], Pittsburg, Penn. [illegible].

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

[illegible], New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

[illegible]

AMERICAN ORDER OF STEAM ENGINEERS

[illegible], Philadelphia, Pa. [illegible].

NATIONAL MARINE ENGINEERS' BENEFICIAL ASSOCIATION

[illegible], New York, N. Y. [illegible].

INTERNATIONAL [illegible] ENGINEERS ASSOCIATION

[illegible]

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

[illegible]

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

[illegible], Ohio [illegible] 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

[illegible], New York [illegible] 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

[illegible] 1911.

NATIONAL [illegible]

[illegible]

BUSINESS ITEMS

The Robb Engineering Company, Ltd., has purchased the Robb-Mumford Boiler Works, at South Framingham, Mass. The management and manufacturing organization will be continued as at present.

Franklin Williams, manufacturer of engineering specialties, 39 Cortlandt street, New York, is issuing a rather unusual calendar, which is so compact as to include the whole year within very small compass. It might be called a thumb-nail calendar, and should prove useful to busy people.

The Nelson Valve Company, Philadelphia, Penn., is sending to engineers on application a set of danger signs to hang on valve wheels, etc., to show that the wheel is to be left alone until the sign has been removed by the proper authority. Send and get a set, they are handy and useful.

The Murphy Iron Works, manufacturer of the Murphy automatic furnace, has arranged for an office in Atlanta, the same to be in charge of Roland B. Hall, Jr., who will handle its business in connection with that of the Harrisburg Foundry and Machine Works, whom he has represented in the southern territory for some time. Mr. Hall's offices are located in the Empire building, and he will be very glad to furnish any information regarding the Murphy automatic smokeless furnace that may be desired.

Bulletin No. 130 has been issued by the Bristol Company, Waterbury, Conn. It is a 56-page illustrated catalog of the Wm. H. Bristol electric pyrometers and includes description and lists of both indicating and recording forms of these pyrometers with explanation of the special patented features, as for instance basic patents on means of compensating readings of thermo-electric pyrometers for changes in cold-end temperature. On pages 48 to 55 of this catalog partial list of more than 700 users of the Bristol pyrometers is given.

The Royersford Foundry and Machine Company, of Royersford, Penn., manufacturer of the Sells roller bearings, found, it so difficult to obtain a satisfactory lubricant for its roller bearings that it has brought out a lubricant of its own, which is especially adapted to meet the requirement of bearing lubrication. "Rollerine" is the name it has adopted for this special bearing lubricant. Anyone writing to the Royersford Foundry and Machine Company, at its Philadelphia office, 52 North Fifth street, can obtain full information on both Rollerine and Sells roller bearings.

NEW EQUIPMENT

Gleichen, Alberta, will install a new waterworks system.

New Carlisle, Ohio, will construct waterworks system.

The citizens of Rush, Tex., voted to issue bonds for waterworks.

Chilliwack, B. C., will spend $40,000 extending waterworks system.

C. F. Melinde, Hudson, N. H., is building an addition to his engine room.

Whittemore, Iowa, has voted to issue $7000 bonds for municipal waterworks.

Swift & Co., of Chicago, will erect a cold-storage plant at Muskogee, Okla.

Falls City, Ore., will issue $30,000 bonds for the construction of waterworks.

Leavenworth, Wash., will construct a water-supply system to cost $40,000.

Hopkins, Mo., is considering the construction of a municipal waterworks system.

The Lynn (Mass.) Storage Company will erect a warehouse and cold-storage plant.

The city of Alturas, Cal., has voted $33,000 bonds for improvements to its waterworks.

The Farmers Union, Chico, Cal., will erect a warehouse and install refrigerating plant.

The Calexico (Cal.) Creamery Association will build a creamery and cold-storage plant.

The Canadian General Electric Company will erect a $100,000 power house at Auburn, Ont.

S. S. & T. B. Davis, Rock Island, Ill., will erect and equip a large power house on Rock river.

The town of Woodbury, N. Y., is considering the construction of a municipal water plant.

The city of Fairburn, Ga., will vote on issuance of $10,000 bonds for electric-light plant.

The citizens of Lyndhurst, N. J., voted to issue $25,000 bonds for extending its waterworks.

The Standard Furniture Company, Portland, Me., is in the market for an air compressor.

Smithfield, Va., will vote on issuance of $55,000 bonds for electric-light and sewerage systems.

Martinsville, Va., voted to issue $35,000 for improving its electric-light plant and waterworks.

The Libby (Mont.) Water Works, Electric Light and Power Company will install a lighting system.

Strathcona, Alberta, will considerably increase electrical equipment in the municipal power plant.

The Truckee River General Electric Company, Reno, Nev., will build a power plant on the Truckee river.

Improvements will be made to the power and light plant at the Boys Industrial School, Lancaster, Ohio.

It is reported the Jacksonville (Fla.) Electric Company will erect a power house on Riverside avenue.

The citizens of Sierre Madre, Cal., voted to issue $40,000 bonds for waterworks. P. C. Carter, city clerk.

The Duquesne Light Company, Pittsburg, Penn., will erect a new power house on Shakespeare street.

The citizens of Boone, Iowa, voted to issue $180,000 bonds for extending waterworks. Otto Hile, city clerk.

The Siloam Springs (Ark.) Ice and Cold Storage Company's plant was destroyed by fire. Loss, $150,000.

E. B. Hillman, of Peoria, Ill., has been granted franchise to erect an electric-light plant at Hamburg, Iowa.

The Olympia Railroad and Power Company, Elma, Wash., is planning for extensive power-plant enlargement.

The Pacific Mill, Lawrence, Mass., will install a steam turbine and electric generator of 3250 kilowatts capacity.

The Wilkes Barre (Penn.) Railway will erect a three-story addition to its power house on South Main street.

A five-story packing plant will be erected for the Hammond-Standish Company, 20 Cadillac square, Detroit, Mich.

The Morrison Electrical Company, Boston, Mass., is in the market for a 15-kilowatt direct-connected generating set.

The Eastern Oregon Light and Power Company, Canyon City, Ore., will build a hydro-electric plant at Lagoon lake.

The Steelton (Penn.) Light, Heat and Power Company is reported to be planning the erection of an electric plant.

The city of Polytechnic, Tex., is considering the construction of a municipal waterworks plant to cost about $32,000.

The Oklahoma City (Okla.) Railway Company will spend $125,000 in making additions to its power station at Belle Isle.

The People's Power Company, Rock Island, Ill., is planning extension and improvements at its gas and electric-light plant.

The Atlantic Ice and Coal Corporation, Albany, Ga., has awarded contract for the erection of a new engine and power house.

The Norfolk & Western Railway will enlarge its power house at Bluefield, W. Va. Two additional boilers will be installed.

The city of Georgetown, Tex., will spend about $30,000 improving its waterworks and electric-light plant. R. E. Ward, mayor.

Vancouver, B. C., will buy one 1500-kilowatt steam turbine generating unit and one 500-kilowatt, direct-current generating unit.

J. A. Haberer, town clerk, Rippey, Iowa, will receive bids until February 6, for furnishing material and constructing waterworks.

The Northwestern Development Company, Spokane, Wash., will build a 30,000-horsepower hydroelectric plant to cost about $1,800,000.

The town of Roberta, Ga., will receive bids through W. J. Marshall, Lizell, Ga., for the construction of an electric power and pumping plant.

The board of water and light commissions, of Bayfield, Wis., has completed plans for a new boiler house for the municipal water and light plant.

The Eastern Michigan Edison Company, of Pontiac, Mich., is said to be planning the erection of a 5000-horsepower steam-electric plant, near Amy.

The Woodlawn (Ala.) Ice Company has been incorporated with $40,000 capital to manufacture ice. W. J. Worthington, president and treasurer.

The Union Power Company, Hagerstown, Md., has had plans completed for a new power house. O. G. Keilholtz, Continental building, Baltimore, is engineer.

The Twin City Light and Traction Company will erect a new generating plant at Chehalis, Wash. Headquarters are in the Trenton building, Portland, Ore.

The Leader Publishing Company, owners of the *Cleveland Leader*, is planning to erect a 14-story building with an estimated cost of $1,000,000 to $1,500,000. An electric power plant for operating the presses will be installed.

Bids will be received until January 19 by R. G. Arthur, secretary, board of water commissioners, Douglas, Ariz., for furnishing material and making improvements to waterworks, including pumping plant, pump house, etc. About $85,000 will be expended.

E. M. Statler, of Buffalo, N. Y., will erect a hotel building in Cleveland, at the corner of Euclid avenue and East Twelfth street, and has commissioned George B. Post & Sons, architects, Cleveland, to prepare the plans for the structure. The estimated cost of this work is $2,500,000.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

POWER

NEW YORK, JANUARY 24, 1911

WHY all this squealing, hissing, pounding, knocking and groaning? Why all these young clouds of steam, showers of oil and hot breezes bearing suggestions of scorched metal and burnt insulation? Why all the apparent confusion—is this a blast furnace?

No, this is not a blast furnace, this is an engine room.

You see, the engineer here is *getting results*. He has no time to put on "frills"—he is a *practical* man, he says, and glad of it. None of your nonsense about appearances for him.

He is too busy keeping the wheels turning to monkey with such details.

What if a joint or two is sprung or needs a new gasket! "Ain't" he delivering the goods?

What if the valves complain a bit and the engine booms every time it passes a center? "Ain't" he keeping the mill agoin'?

What if the stuffing boxes wheeze and squeak just a little? "Ain't" he furnishing all the power needed?

Two years ago he came here to get results—so he said. And, by the looks and sound of things, he *has* got them.

If a thing doesn't fit, he fits it—with a sledge. If a nut doesn't turn home as easily as it ought, he persuades it with a bigger wrench. He gets his results by the most direct methods.

This engineer is a "world beater"—you don't have to prove it, he admits it. He *knows* that he is always right. Was he not engaged to keep the machinery running? And has he not kept it running?

Economy? Nonsense!

A machine can do so much work. In order to do a certain amount of work the machine must have so much steam. It doesn't matter if a stuffing box leaks a bit or if a bearing or two is a little warm—set up on the box a little harder and run some water into the bearings. The amount of steam used is about the same in any case—he says so, and isn't he always right? Besides, the boilers are big enough anyhow. So, "let her rip."

He argues that to correct *little* defects such as those just mentioned would cost more than they are worth, not to mention the fact that it would cause him lots of bother and trouble, and take up too much of his time which is fully taken up as it is, getting results—and telling about it.

* * *

The foregoing concerns what may be termed a horrible example. Such an engineer does not realize that it is his duty not only to furnish power, but to furnish it as economically as he possibly can.

Genius has been described as the ability to take infinite pains, to be thorough, in other words.

In a given plant, that engineer is the best who can seek out and stop the greatest number of leaks and losses, no matter how small some of them may be. It is just as true in the power plant as it is anywhere else that if you take care of the cents the dollars will take care of themselves.

Wherever you are, whatever your duties, you are not making the best of your opportunities if you do not get results with the best economy that the equipment under your charge can be made to show.

Hydroelectric Power at Wausau, Wis.

By D. B. Hanson

A brief description of three small plants drawing their power from the waters of the Wisconsin river and the possibilities of further development.

Slightly north of the geographical center of the State of Wisconsin, is situated, on the banks of the Wisconsin river, the town of Wausau, the county seat of Marathon county. The town has been built up largely on the lumber industry, and is still noted for the sawmills, tanneries and paper mills in its vicinity, which depend upon the forest products for a large share of their raw materials.

A portion of the power developed for these various industries is obtained from hydraulic plants situated on the Wisconsin river which, here, is capable of producing a head of about 25 feet, and is absorbed within the city limits by three installations.

The first of these, as shown on the map in Fig. 1, is McEachron's flour mill, situated on the west or main chan-

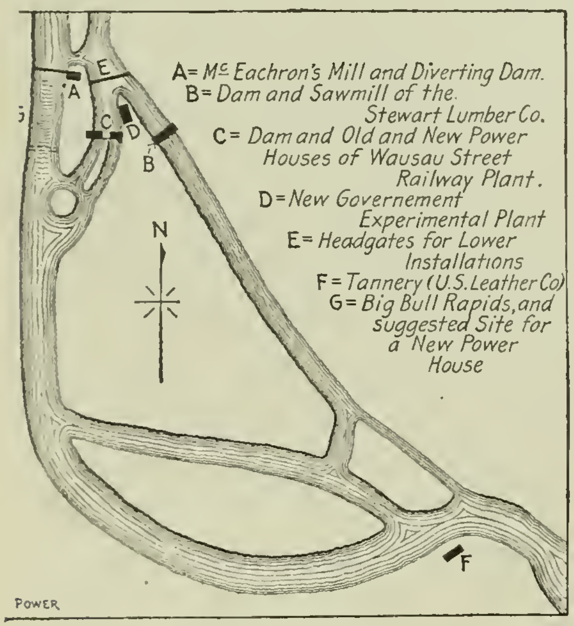


FIG. 1. WISCONSIN RIVER NEAR WAUSAU

nel of the river. The mill is driven by single vertical turbines aggregating some 250 horsepower when operating under a 7-foot head, which is the maximum obtainable under the conditions prevailing at that point. The dam here is of the rock-filled timber-crib type and, while serving to maintain the head for this installation, also serves as a diverting dam for the other two, which are situated on the east fork of the river. At this point the river flows through several channels among a number of islands. The dam also serves for a spillway for the entire river in times of flood, there being no space provided at the dams of either of the other two developments for this purpose; to control the head in the eastern channels, a second dam has been built across their upper ends, thus converting these portions of the river into mere head and tail races, whose supply is determined by the regulation of the head gates in the second dam shown at the reference *E* in Fig. 1; the western channel is thereby made the main course of the river, only enough water being admitted to the east branches to supply the demands of the lower power houses which are situated about 1000 feet below the two dams above mentioned.

Plant No. 2, that of the Stewart Lumber Company, is the smaller of the lower installations and is equipped with three horizontal shaft turbines of 275 to 300 horsepower aggregate capacity when operating on a 14-foot head. It drives a portion of the lumber mill of this company, its head race being used also to float down the logs to the conveyers of the main mill. It is decidedly a surprise to the ordinary man, who, though well informed, is not familiar with the large scale upon which the sawmills of this district were wont to operate in their earlier days, to see the immense storage yards and thousands of feet of elevated platforms carrying the extensive system of tramways used by this company in transporting its finished products from its sawmill and planing mill, which, for many years, averaged a cut of 30 million feet per season.

The third installation, that of the Wausau Street Railway Company, equipped with two independent turbine units and an auxiliary steam plant, is the largest of the three and operates under the highest head. It consists of two sections known as the old plant and the new. The old plant is a fair example of what one might expect to find in a plant which started in a very small way and was gradually enlarged to meet the increased demand for the electrical service which the plant supplies. This plant consists of a quadruplex horizontal tur-

FIG. 4. OLD AND NEW WAUSAU PLANTS

bine of Leffel make, which is direct connected to a line shaft driving two main generators, each of 350 kilowatts capacity, one generating current at 2200 volts, the other, being installed later, generating at 2300 volts. Both machines were originally two-phase, 60-cycle units operating at 150 revolutions per minute, but were later rewound to generate three-phase current. This new arrangement naturally resulted in a decreased output and a high overload upon the exciters, of which there are two 30-kilowatt machines, each belted to the main shaft of a generator.

The two generators are operated in parallel, and considerable trouble has been experienced. These units will shortly

FIG. 2. McEACHRON'S MILL DAM

FIG. 3. HEADRACE OF STEWART LUMBER COMPANY

Fig. 5. Old Wausau Plant

Fig. 6. Switchboard Corner of Old Plant

be changed back to generate two-phase current, and their output will be transformed to three-phase before being sent out on the transmission lines. The electrical load of this station consists of factory motors, incandescent and arc-lighting and street-railway load, the latter being very severe in its fluctuations.

Fig. 7. Main Generator in New Wausau Plant

Fig. 8. Oil-pressure Governor of Main Unit

On account of the small number of cars operating, it is comparatively easy to have nearly the whole system at rest or starting all at the same time, thus making the change from no load to the heaviest accelerating load occur in a very short space of time, often not more than ten seconds. This street-car load was originally handled by means of two 100-kilowatt direct-current Westinghouse generators, belt driven from a line shaft. Later, as these machines became inadequate, a 300-kilowatt motor-generator set was installed, the motor taking three-phase current at 2300 volts from the main generators. A number of 50-horsepower pump motors, installed in a paper mill some five miles away, still further complicate the fluctuations of load, as they have no starting boxes, and their starting current when they are cut in directly across the line, is naturally heavy.

The usual switchboard apparatus, which serves both plants, completes the hydroelectric installation in the old plant, and a twin simple noncondensing slide-valve 18x30-inch engine with its battery of boilers comprises a means of driving the main line shaft through a friction clutch, in cases of low water or other emergencies which would cripple the hydraulic plant. This old plant with its machinery poorly chosen for its ultimate use became overloaded by the constantly growing demand in the town for electrical energy, and a new plant to supersede it became necessary. The new power house contains up-to-date machinery of sufficient capacity to meet the

Fig. 9. Big Bull Rapids at Time of Average Flow

Fig. 10. Tail Race of Two Wausau Plants

present load, with a generous margin. It is built of cement block and is approximately 35x40 feet. The machinery installed consists of a quadruplex horizontal-shaft turbine, with 45-inch runners arranged in pairs and discharging into a common concrete draft tube. This unit is rated at 1700 horsepower at 150 revolutions per minute when operating under a 20-foot head. It is direct connected to a 900-kilowatt alternator, generating three-phase 60-cycle current at 2300 volts. A twin-turbine-driven exciter unit furnishes current for excitation. Both units are controlled by oil-pressure governors which are so connected to the wicket gates of the turbines as to eliminate the possibility of any lost motion occurring, the resultant regulation obtained being exceptionally good.

The present plan is to operate the new station at all times, holding the old plant in reserve for emergencies, and the steam plant for times of low water when the head races are fouled by large amounts of sawmill refuse and driftwood. Due to the close proximity of the several mills, this is very troublesome, as no means of ridding the forebays of this trash, except unwatering them and cleaning them by ordinary hand labor, are provided.

Taken collectively, the installations at Wausau show a chance for considerable improvement in the engineering details; the dam at McEachron's mill leaks badly, thus wasting power which in a dry season cannot be well spared. Further, its low head of 7 feet allows but a small amount of the natural power easily obtainable to be absorbed. At the sawmill of the Stewart Lumber Company, the head is still much too low, as a proper location of the installation could easily double the head used, while at the Wausau Street Railway Company's plant the normal head of 22 feet still falls at least 25 per cent. short of the possibilities of the situation.

Referring to the map, Big Bull Rapids, indicated at *G*, is an ideal location for a hydroelectric plant. The river here flows between banks at least 50 feet high and 600 feet apart over a solid rock bottom composed of a tough, brown granite, and at normal flow for nine months in the year at least 1000 kilowatts yet remains to be developed. This location would give ample room for proper forebays, and would also provide a chance for spillways that would readily take care of the large quantities of driftwood that now form such a disturbing and annoying factor in the operation of the present plants. It would provide the finest of foundations for a dam, and, last but not least, would increase the head from 30 to 400 per cent. of that used by the existing plants. It would also permit of the whole flow of the river being utilized, while now but a small part can be used in times of high water. In fact, the advantages are so many and so obvious that one can scarcely discern a reason for the neglect of the opportunity, and with the growth of the demand for power at this point it would seem that a plant must eventually be erected on this site.

In view of the agitation now prevailing over the question of conservation of our forest and other natural products, and the growing scarcity of pulp woods which are largely utilized by a large number of paper mills in this section of Wisconsin, it would seem but fitting to mention in this connection the experiment station now being erected by the United States Government at *D* in Fig. 1. This plant is being installed with the idea of conducting an exhaustive series of tests to discover methods which will permit of new varieties of timber being used in pulp making and will thereby, it is hoped, open up new fields of raw material to supplement those now being rapidly exhausted by present operations. This plant will absorb in its motors some 500 horsepower, which will be largely furnished by the street-railway company, and will load the plant to its fullest capacity.

Keeping Power Plant Records

By Warren O. Rogers

A most complete system of daily and monthly reports which show at a glance the cost of fuel, wages and any charge that should be credited to the cost of operation.

The one way of knowing what a power plant is doing is to keep a suitable set of records, so that it can be known at any time just what the cost of operation is or has been, not only as to the cost of fuel, upkeep and wages, but of other

RECORD FOR.................................... ...19...

Kind of Coal.........................

Quality...............................

COAL—Day run .... lbs. .... Fireman.

Night run ....lbs. ....

Total .... lbs.

ASHES—Day run ..... lbs.

Night run ..... lbs. } % Ash...............

Total .... lbs.

Water evaporated 24 hours ....

Pounds water to one pound coal ....

Current generated .... K. W.

REMARKS:

FIG. 1.

charges that should be credited to the cost of plant operation. It is not a simple matter to get up a set of report sheets that will exactly fit individual conditions, the tendency being to border on the incomplete, rather than overdoing matters in recording power-plant data.

Keeping records does require considerable time on the part of the engineer and, for this reason, many fail to take a right view of the matter, contending that it is the business of the office to keep track of the power-plant costs.

There are engineers, however, who believe that it is their business to keep the records of the plant, not only so that a monthly report can be submitted to the manager, but for their own satisfaction and protection. Among the latter is Asa P. Hyde, chief engineer in the building of the Security Mutual Life Insurance Company, Binghamton, N. Y. A set of report sheets, gotten up and kept by Mr. Hyde, consist of daily, weekly and monthly reports.

The daily reports are used as a check on everything that occurs in the plant, and have much to do with the results obtained. A second factor is good help, all working together for the one purpose of seeing how much and how cheaply the work can be done.

The coal man takes quite an interest in the daily-record sheet shown in Fig. 1. This report and the chart from the re-

Ash Ticket. ______________ 190

CANS FILLED	FIREMAN.	CANS TAKEN.	CARTMAN.

FIG. 2.

cording steam gage are filed daily in a glass case in the boiler room for the inspection of the men. As the plant operates day and night, the report of both the day and night firemen are put on the same card. Each fireman, one for each watch, records the number of pounds of coal burned during the time he is on duty, also the weight of ashes made during his run. The percentage of ash obtained is what interests the coal dealer, and the knowledge that an ash record is kept, as well as a record of the amount of water evaporated per pound of coal, tends to keep the quality of coal up to the standard. No. 1 buckwheat coal is burned and must not contain more than 16 per cent. of ash. Other fuels and sizes have been carefully

FIG. 3.

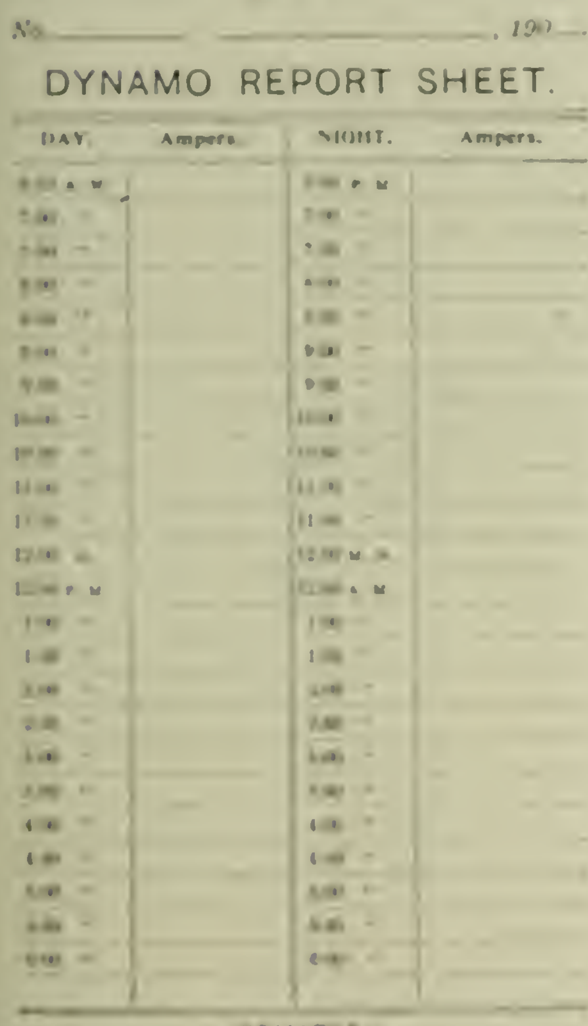


FIG. 7.

tested, but it has been found that more current can be produced at less expense with No. 1 buckwheat coal than

FIG. 4.

from any other, if it is carefully handled, as is done in this plant.

The ash ticket, Fig. 2, looks simple, hardly worth bothering about, but it prevents the cost of cartage of refuse from the building being charged up to the cost of power-plant operation. For instance, if the firemen get four cans of ashes per day and the cartmen remove six cans of ashes and refuse the cost of removing

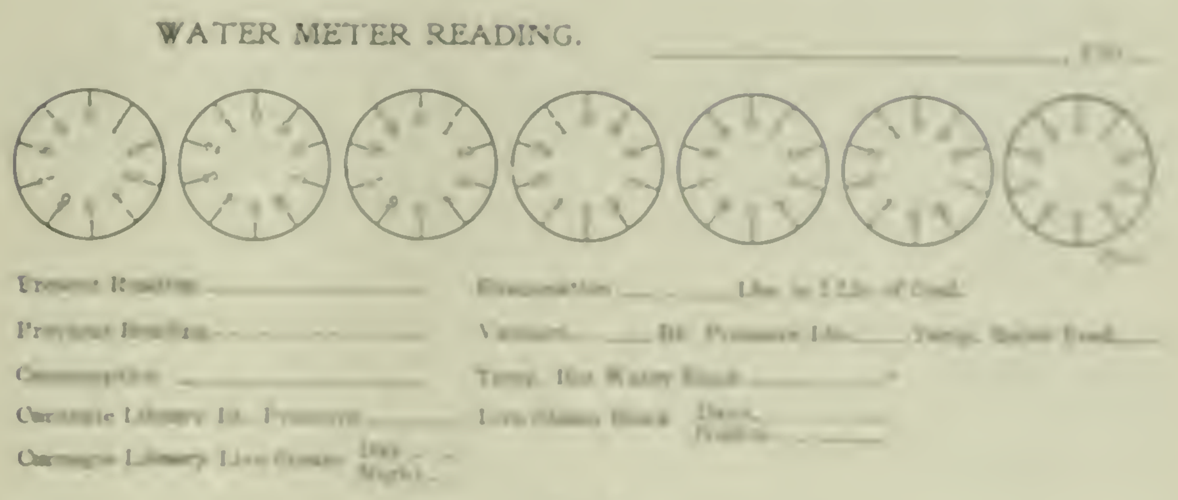


FIG. 5.

six cans would ordinarily be charged up against the plant, when the cost of removing two cans of refuse should have been charged against the building. The ash ticket prevents this and the charges for cartage are correctly made.

Figs. 3 and 4 show both sides of the daily coal ticket which is filed with the chief engineer. One side shows the kind and amount of coal burned and ashes obtained by each fireman from 6 a.m. to 6 p.m. and 6 p.m. to 6 a.m., also the amount of water used in gallons and pounds and the amount of water evaporated per pound of coal with boiler-water tests.

The reverse side of the ticket contains the fireman's reports of the quality of the coal used, how it burns, whether the fires have been worked during a shift and other items that might shed light on the performance of the plant.

Water-meter readings are recorded on a card similar to that shown in Fig. 5. Fig. 6 is used for recording the total output of electrical energy to the various tenants.

FIG. 6.

The daily dynamo-report sheet is shown in Fig. 7, the number of amperes carried being recorded each half hour, this being done to check the peaks and for charts if wanted later.

All renewals, repairs and new work about the building are performed by the engine-room force, but their time is credited to the plant. For instance, if a tenant of an office desires changes made in the arrangement of lights, or anything else, the man put to work making the alterations files the report shown in Fig. 8. It includes by whom the work was ordered, also the labor and material used, the cost of each being recorded. From this report sheet the work slip, Fig. 9, is filled out and the signature of the tenant is affixed thereto, as all material and supplies remain the property of the Security Mutual building. In case the tenant moves he must leave all fixtures, charged up to him over his signature.

Fig. 10 shows the engine and pump report which indicates when the various units were started, how long they were in operation and when shut down, also all work done on them and the materials used. This is all of the daily-report cards and from them the weekly report is compiled.

For instance, Fig. 11 shows the weekly report of the amount of coal burned, ashes made, water used, kilowatts generated and the total number of elevator trips made during the week.

Expenses for the month for the plant, block and elevators are tabulated on the sheet shown in Fig. 12. The data found on the expense sheet for the month of October were taken from the workman's daily-report sheet shown in Fig. 8. The monthly expense report shows at a glance when the work was done and what material was used and to what department of the building it has been charged.

A more complete power-plant expense sheet is shown in Fig. 13. It designates the expenses for the month and what they were for; it is made up of five departments, as shown in the margin. The items having a check mark are charged to the operating expenses of the plant, but they should not be as they are of foreign character and are carried by the plant as a matter of convenience.

Data relating to the machinery of the plant are kept on a report sheet ruled as shown in Fig. 14. Here the daily record is tabulated and the items not filled in with daily readings are entered monthly.

A fuel-evaporation report sheet for October, November and December, 1910, is shown in Fig. 15, the month of October only being tabulated. These reports also

Workman ______ Ordered by ______ No. ______

To ______ *Date* ______ *19*

LABOR.				MATERIAL.			
	Hours.	Rate.	Amount.	ITEMS.	Quantity	Rate.	Amount.
	TOTAL..					TOTAL..	

Labor	
Materials	
Total	

REMARKS:

FIG. 8.

WORK SLIP No. ......

Security Mutual Building.

.... 19

Office No ...... Mr ......

To ...... Desk Lamp No ...... $......

" ...... " " " ......

Changing—Adding—Renewals— $......

WORK: ......hours @ ...... per hour ......

MATERIALS USED: ...... $......

$......

$......

The above work has been performed at the request of the undersigned, and the material and articles above described are the property of Security Mutual Life Insurance Co., and will be returned to said Company in good condition at the termination of lease or removal from said office. Any materials or articles not returned to be charged to and paid by the undersigned.

______ Tenant

FIG. 9.

Total for Week Ending ______, *190*__.

AMPERES:— Low ______ High ______

COAL—Day.		COAL—Night.	
Sun	Total and averages for day of 24 Hours	Sun	Total and Evaporation figured here
Mon		Mon	
Tues		Tues	
Wed		Wed	
Thur		Thur	
Fri		Fri	
Sat		Sat	

ASHES.		WATER.
Sun	Total and % figured here	Last Reading ......
Mon		Previous Reading ......
Tues		**Total K. W.**
Wed		Last Reading ......
Thur		Previous Reading ......
Fri		**Power K. W.**
Sat		Last Reading ......
		Previous Reading ......

ELEVATOR TRIPS.

	No. 1	No. 2
Sun		
Mon		
Tues		
Wed		
Thur		
Fri		
Sat		
TOTAL		

FIG. 11.

No. ______ ______, *190*__

ENGINE AND PUMP REPORT.

DAY	Engine 1.	Engine 2.	Engine 3.	Comp. P.	Elect. 1.	Elect. 2.	Jack.	S. House.	Elect. " 1.	Elect. " 2.	Vac. 1.	" 2	B F 1.	B F. 2.	Air C.	Sump. 1.	" 2.	Trips 1.	Trips 2
8:30 A.M.																			
7:00 "																			
7:30 "																			
8:00 "																			
8:30 "																			
9:00 "																			
9:30 "																			
10:00 "																			
10:30 "																			
11:00 "																			
11:30 "																			
12:00 M.																			
12:30 P.M.																			
1:00 "																			
1:30 "																			
2:00 "																			
2:30 "																			
3:00 "																			
3:30 "																			
4:00 "																			
4:30 "																			
5:00 "																			
5:30 "																			
6:00 "																			

REMARKS:

NIGHT.	Engine 1	Engine 2	Engine 3	Comp. P.	Elect. 1.	Elect. 2.	Jack.	S. House.	Elect. " 1	Elect. " 2	Vac. 1.	" 2	B. F. 1.	B. F. 2.	Air C.	Sump. 1.	" 2.	Trips 1.	Trips 2
6:30 P.M.																			
7:00 "																			
7:30 "																			
8:00 "																			
8:30 "																			
9:00 "																			
9:30 "																			
10:00 "																			
10:30 "																			
11:00 "																			
11:30 "																			
12:00 M. N																			
12:30 A.M.																			
1:00 "																			
1:30 "																			
2:00 "																			
2:30 "																			
3:00 "																			
3:30 "																			
4:00 "																			
4:30 "																			
5:00 "																			
5:30 "																			
6:00 "																			

REMARKS:

FIG. 10.

contain the monthly switchboard reading. The readings of all items are the totals of the weekly reports.

A comparison of the corresponding three months for three years is recorded on the card shown in table form. The totals are given for each month for coal, loads in kilowatt-hours and elevator trips. In the margin is recorded the increase in coal used one year over another, and per cent. the increase in output.

At the bottom of this sheet remarks are entered which may have any bearing on any increase or decrease in coal consumption during the year.

Referring to the bottom of the record sheet, Fig. 13, it is shown that $640.53 has been charged up against the plant for operating expenses and an income of $1345.20 from the electrical output, making a profit of $704.67 per month, a large profit for a $15,000 investment, the cost of the plant. During the six years that this plant has been in operation it has never been run at a loss.

Details relating to the plant and the method of operating it will be published in another article. It is through the courtesy of the chief engineer, Asa P. Hyde, that the data and accompanying report blanks have been obtained.

THREE MONTHS DATA OF 1907, 1908 AND 1909

Date.	Coal	Load Kilowatt-Hours	Elevator Trips	
1907				
October	221,260	23,840	21,942	Coal 25,248 pounds more coal 1909 than in 1908 and generated 15,360 kilowatt-hours more output.
November	223,471	21,610	21,127	
December	225,680	25,080	21,341	
Totals	670,409	70,430	64,210	
1908				
October	210,189	29,150	22,912	Increase in fuel used in 1908 over 1909 2½ per cent. Increase in kilowatt output 14 per cent.
November	214,731	30,600	19,971	
December	222,880	32,600	21,190	
Totals	647,800	92,240	64,262	
1909				
October	212,018	33,010	21,384	Increase in fuel used 1909 over 1907, .6 of 1 per cent. Increase in kilowatt output 52 per cent.
November	222,094	31,610	21,107	
December	240,032	36,770	22,611	
Totals	674,145	101,390	65,108	

Took on additional load from "Phelps Building," September 18, 1908.
Carnegie Library taken on October 26, 1909, consisting of lighting, heating and hot water service.

Power from the Sun and Wind

Next to discovering perpetual motion, probably one of the most alluring fields for experiment on the part of scientists in search of great reward is that of utilizing the radiant-heat energy of the sun and the kinetic and potential energy of the wind and waves. The problem of converting the energy from these sources into a form which is suitable for commercial use is extremely complicated and, so far, has baffled complete solution. Of course, windmills have been successfully used for centuries in the performance of certain kinds of work, principally that of pumping water. However, the power derivable from a windmill, depending as it does on the variable weather conditions, would not be suitable for driving an electric generator connected directly to the mill because the apparatus would be dead still in a calm and working very much "overtime" whenever a gale happened to be blowing. Hence, no dependence could be placed on any forecast of the quantity of power to be obtained at a given time.

It has often been proposed to have the windmill work a pump to raise water from one reservoir to another, say, 100 feet above the first, at whatever rate the winds will drive the mill; then, to allow the water to flow back into the first reservoir at a given steady rate of flow, and, in so doing, operate a waterwheel-driven dynamo. For such a scheme to be suc-

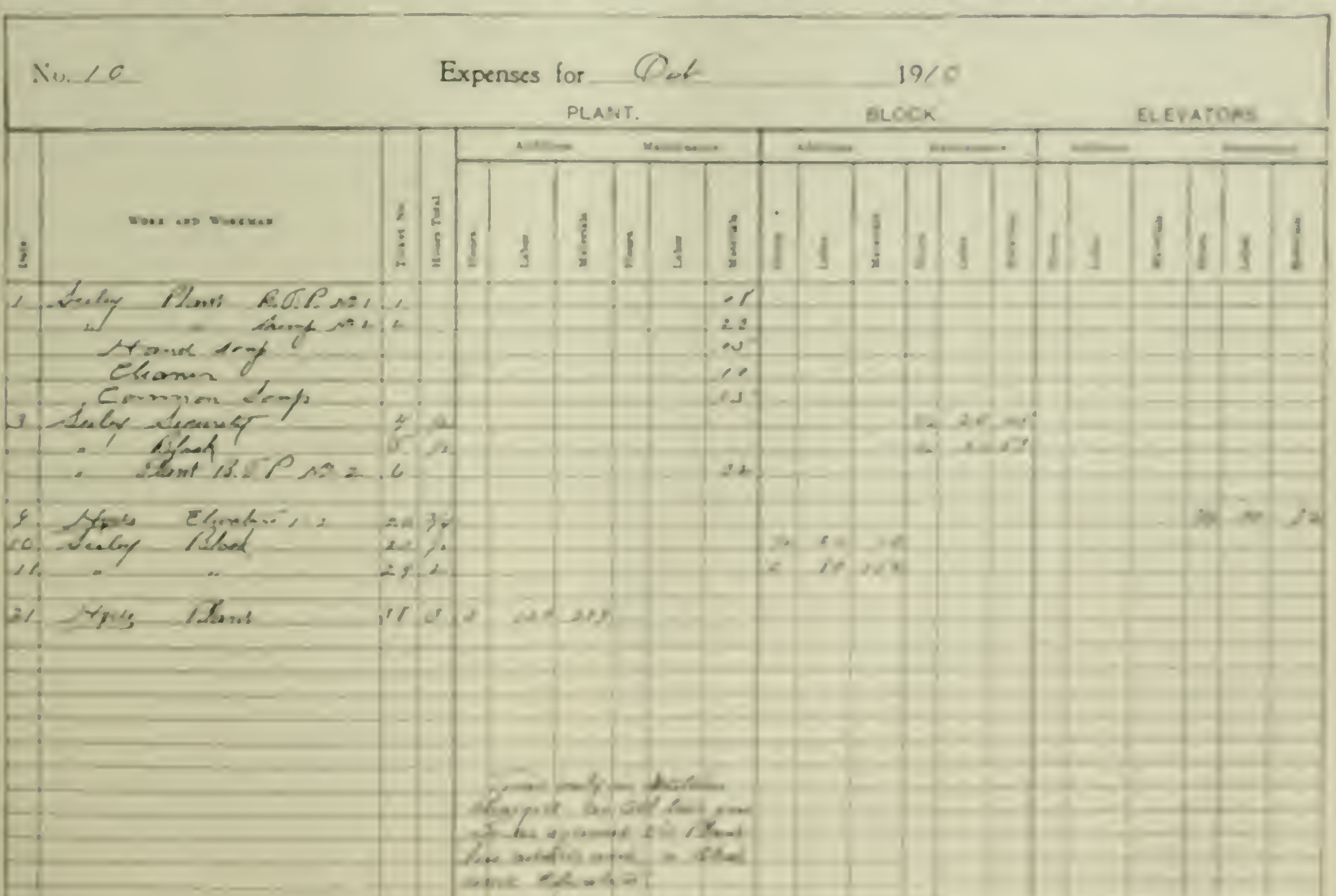

No. 10 Expenses for Oct 1910
PLANT. BLOCK ELEVATORS
Work and Workman

Fig. 13.

No. *10* POWER PLANT EXPENSE SHEET *Oct.* 19*10*

Section	Items	Amount	Total
BOILERS H. P. STEAM AND EXHAUST LINES.	Coal *206365* Lbs. $ *2.85* per Ton.		*25490*
	Carting Ashes *19* Loads *.35* per Load. *"Emins"*	*665*	
	Boiler Compound *111* Lbs. *.12 Frt. add* per Lb. Kind *Dearborn very heavy*	*1332*	
	City Water "Plant only."	*10*	
	Hose, *none* Gaskets, *none* Tools, *none*		
	Repairs Boilers, *none* Arches, *none* Lines, *none*		
	Water Glasses, *none* Gaskets, *none*		
	Feed Water Heater, *none*		
	Boiler Feed Pumps, *Packing .48*	*48*	
	Extras, *Set up Dearborn boiler compound Pump. time 1.20*	*120*	
	" Pipe and Materials 2.99	*299*	
	" Forgings. Bracket and Shelf "Shapley" 2.00	*200*	*3664*
ENGINES AND GENERATORS.	Repairs Engines, *none* Repairs Generators, *none*		
	Packing used, *none* Lamps Plant, *1.44*	*144*	
	Oils and Greases, *7.61* Switch Board, *none*	*761*	
	Cotton Waste, *1.00* Extras, *none*	*100*	
	Repair Traps, *none*		
	Extras, *Sleeve and jack to draw No. 3 governor bushing "Shapley"*	*184*	
			1189
HOUSE PUMPS AND LINES.	Labor *4* Men $ *275.00* Less *8¾* Hours Elevators $ *3.30* Plant.		*27170*
	Packing Steam, *Sump .23* Water, *No. 2 Elev. .10*	*33*	
	Valves, *none*		*33*
	Repairs Pumps, *none*		
	" Motors, *none*		
	Tanks and Lines, *none*		
	Extras, *none*		
ELEVATORS AND ALL APPARATUS.	Motors and Belts, *none* Cars, *none*		
	Controlls and Lines, *none* " Fibres, *none*		
	Extras, *none* " Cables, *none*		
	Waste, Oils, Grease, Etc., *2.08*	*208*	
	Triplex Pumps, *none* Plunger Packings, *No. 1 1.80*	*180*	
	" " Packings, *No. 2 .90* Leather Valves, *1.94*	*267*	
	" " Valves, *none* Tank Compound, *15# @ .16*	*240*	
	" " Extras, *none* Extras, *Window top of shaft ✓.20*	*20*	
	Signals 1-2 .50	*50*	
	Compound Pump, *none*		
	" " Packings, *none* Air Compressor, *none*		
	" " Valves, *none*		
	" " Extras, *Repair sight feed. new glass & gaskets .25*	*25*	*987*
GENERAL ACCOUNTS.	Work Total, *8¾* Hours *.40* per Hour *3.30*		*330*
	Soaps Hand, *.25* Soap Common, *.30*	*55*	
	Tile Cleaner, *.35* Laundry, *.30*	*65*	
	Mops, *.25* Polishes, Etc., *.75*	*100*	
	Paints and Brushes, *none* Printing, *none*		
	General Supplies, *Exp. Lamps. samples .45* ✓	*45*	
	Shop Tools, *Oil Stone .65*	*65*	
	Motors Plant, "all" *none*		
	Fans " " *none*		
	Extras, *Pack hot water bibb sink, .05*	*05*	
	Windows rear Boilers broken by Balls rear yard. 2.75 ✓	*275*	
	One piece Toweling 40 yds. .09 360 Made up 17 Towels. cut 5½ each	*360*	
	One picture frame "Auster Pump" 1.70 Liniment .50	*220*	*1180*
			640.53

Outside Work *63* Hours *.40* per Hour – – – $ *25.20* Maintenance

Work *8¾* Hours on Elevators *.40* per Hour – *3.30*

28.50

Elevator Supplies – *9.87*

38.37

All Other Charges Foreign to Plant (*✓ Window .20, ✓ Rear 2.75, ✓ Exp. lamps .25 = 3.20*) – – *✓ Cr. not taken*

Foreign Charges – $ *38.37*

Current Generated *33630* K. W. *Hrs* for *Month* Cost *1.90/100¢* per K. W. *Hour* and Maintain Entire Apparatus at *$640.53*

" " Less Foreign Charges (*38.37*) *1.79/100¢* per K. W. *Hour*

" " " " and $ *100.00 / 41.66 / 141.66* Cr. for heating Block, Bath, Hot water, Barber, Steam Pumps, *Carnegie Library* Etc. *1.36/100¢* per K. W. *Hour*

" " @ .04 per K. W. Selling Price $ *1,345.20* Total Expenses $ *640.53* PROFIT/LOSS $ *704.67*

Elevators Made *26654* Trips and Cost *36/100¢* per Trip for Current.

Library lighting charge only. @ $5.00 for Month. No heat. — Checks ✓ should be credits. or $3.20

Hyde.

FIG. 13.

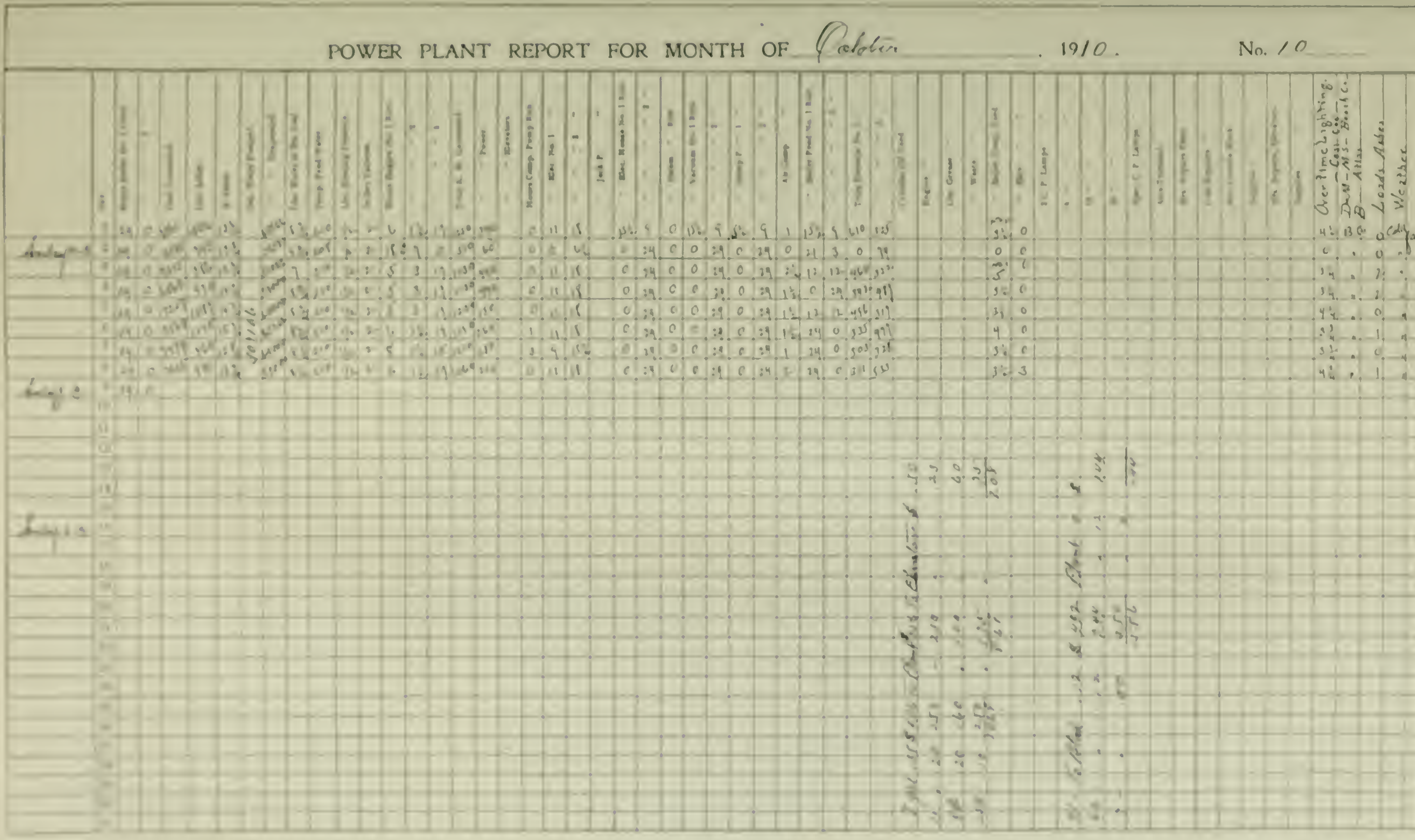


Fig. 14.

around the reservoir must be large enough to hold the excess water while the windmill pumps during high winds so that this excess water will be available to keep the waterwheel running when there is a calm and the windmill is "dead." This arrangement would be commercially successful if the cost of the windmill, pumping apparatus, reservoirs, piping, waterwheel and dynamo were not so great that the interest on the money spent, together with the operating cost and the upkeep charge, would exceed the interest on the investment in another system, such as steam or gas power, plus the cost of operation, upkeep, fuel and water.

To build a tower 1000 feet high sufficiently large and strong to support the quantity of water needed by a system of commercial size would involve such an expenditure that a plant for commercial use could not be built.

Another popular proposed system of obtaining power without using fuel as a source, is that of converting the heat energy radiated by the sun into electrical energy. In one system for doing this a

No 10 Fuel and Evaporation Oct- Nov- Dec 1910 Switch Board Load.

Date.	Firemen.	Day.	Night.	Coal Each Man.	Total Both Men.	Average 12 Hours.	Average 24 Hours.	Average Month.	Total for Month.	Ashes Lbs.	Ash %	Water Evaporated Lbs.	Lbs. Water to Lbs. Coal.	Low Amperes.	High Amperes.	K. W. Weekly.	K. W. Monthly.	Cost Current Monthly.	K. W. Power Weekly.	K. W. Power Monthly.	Cost of Power Monthly.	K. W. Elevator Power Monthly.	Power for P't'g Dep't, House Pumps, Fans, Etc.	Trips No. 1 Elevator.	Trips No. 2 Elevator.
Oct 1	Garrick	✓		3725		3725																			
	Johnson		✓	3636	7361	3636	7361			1006	13 6/10	63666	8 7/10	55	875	1210			310					610	325
" 9	Johnson	✓		27495		3785																			
	Garrick		✓	20167	49662	2881	6666			6850	14 7/10	410833	8 5/10	45	700	8710			2120					2487	2538
" 16	Johnson	✓		26055		3722																			
	Garrick		✓	19672	45727	2810	6532			5587	13	385333	8 3/10	45	750	7160			1550					2292	2392
" 23	Garrick	✓		27723		3960																			
	Johnson		✓	19743	47466	2820	6780			6780	14 2/10	394250	8 3/10	45	800	7530			1850					2668	2601
" 29	Garrick	✓		27301		3900																			
	Johnson		✓	20149	47450	2735	6635			7481	15 7/10	395250	8 3/10	45	1000	7620			1800					2777	2477
" 31	Hyde	✓		6184		3037																			
	Garrick		✓	4515	6699	2257	5254			1629	21 3/10	54749	9 3/10	45	275	1400			190					510 / 15934	387 / 10720 / 15934 / 26654
								6544	206355	25773	18 2/10	1745915	8 7/10	46	743	33630			7900						
																	33630 K.W.H.	1 36/100 ¢ Care for all, 79/100 ¢		7900 K.W.H. @ 1 36/100 ¢ = $107.44	$107.44	7200 K.W. @ 1 36/100 ¢ $96.48	Printer 300 @ 1 36/100 ¢ = 4.08; Plant 400 " = 5.44; 5.52; 7900 − 500 = 7200 Elevator		

Fig. 15.

multitude of thermoelectric couples is used. The hot junctions of the couples are exposed to the heat of the sun and an electric current is generated. The current so made is used to change a storage battery. The number of couples used must be large enough not only to furnish current for the day load, but also to change the battery so that current can be drawn from it at night and on cloudy days when the couples are not generating, due to the fact that there is no heat from the sun available. As in the previous case, the cost of constructing a system of this kind more than offsets the gain due to the fact that there is no fuel or water expense involved.

Another means devised to utilize the sun's radiant energy consists of an air-tight glass chamber or boiler, in which water is heated by the sun rays and steam at atmospheric pressure is generated, and a low-pressure turbine outfit to utilize the steam so generated. The turbine may operate either an electric generator or, preferably, a pump for raising water to an elevated reservoir from which the water flows as needed to run a water-wheel and generator.

Recently, Prof. R. A. Fessenden, of Washington, D. C., in a paper presented to the engineering section of the British Association for the Advancement of Science, outlined a plan whereby power on a commercial scale may be obtained from the sun and wind. He proposed to combine wind- and sun-power apparatus in order that a plant might be capable of furnishing a fairly constant output with only moderate storage capacity. His paper aroused considerable interest, especially as he intimated that he has a 3000-horsepower plant under construction at a worked-out copper mine. By locating the plant at the mine it will not be necessary to provide any tower for the upper water-storage reservoir, for it will be built at the mouth of the shaft while the lower reservoir will be placed in one of the bottom chambers of the mine, 1000 feet below.

The two features of novelty in Professor Fessenden's scheme seem to be the combination of windmills with sun-radiation power apparatus and the subterranean reservoir. In his "sun-heat boiler" the water is to be directly exposed to the sun's rays under the double glass roof of a building which forms really the shell of the boiler. The steam or vapor is to be generated at, or near, atmospheric pressure and led off to a low-pressure steam turbine discharging into a condenser. Details of the design have not been given out, but it is stated that the water to be used will contain a small amount of potassium bichromate and flow in thin streams over the floor of the absorption room, the thickness of the streams being regulated to the amount of sun radiation being absorbed at any moment. The glass of the roof will be tinged green by a slight amount of iron sulphate so as to reflect back into the interior any radiation from the water itself, while still being fairly transparent to the sun's rays.

It is assumed that the low-pressure turbine will either pump water when the wind and commercial load are slight, or will furnish power direct when the wind and load are heavy.

One large windmill, or series of smaller windmills mounted upon a turn table, is proposed for utilizing the energy of the wind, particularly when the sun is not shining. These windmills are to be connected in some way by rope drives to a common shaft drive which will pass down the shaft of the mine and operate the pumps located at the lower reservoir to elevate the water to the surface reservoir, thereby storing the energy secured from the wind.

Without going into the details of the estimates submitted as to the cost of constructing the proposed plant, suffice it to say that, based on reasonable impartial figures, the cost of the plant will so much outweigh the cost of a steam plant of equal capacity that the scheme is shown to be wholly impracticable. The results obtained, however, will be interesting.

Automatic Stokers Which Throw Coal

By F. R. Low

This type of stoker is used extensively in Europe upon internally fired boilers. It spreads the fuel evenly over the fuel bed and will handle a variety of coals.

In many European plants I found in use mechanical stokers which threw the coal more or less continuously over the surface of the fire. These were especially used upon furnace-tube and other internally fired boilers with constricted furnaces to which they are more adaptable than the traveling grate or the underfeed. They are used successfully with all kinds of hard and brown coals, and to some extent with small brown-coal briquets. Lignite is used by mixing with other combustibles of larger lump. They are exceptionally well adapted to the use of gassy coals on account of the thin fires which they carry and the rather free admission of air. In order to prevent too great an ingress of air through the hopper, it is recommended when stoking with briquets to mix them with a smaller coal to fill the interstices.

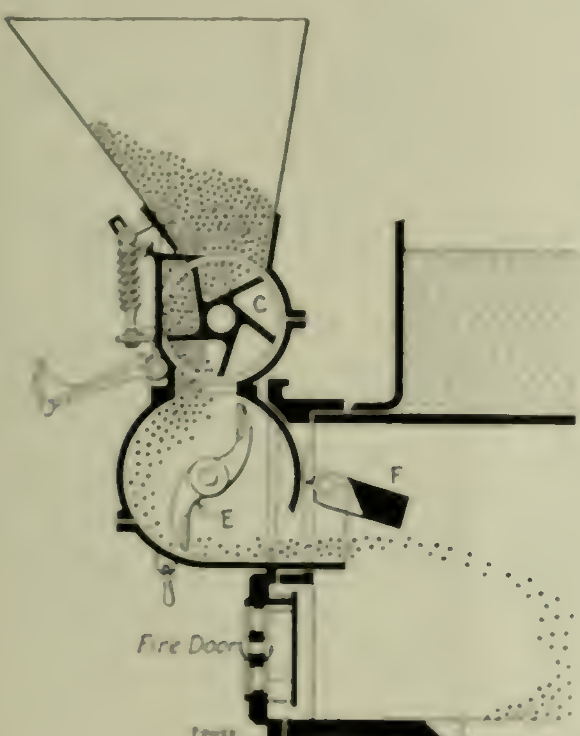


Fig. 1. Leach Stoker as Made by Saxon Machine Works

The wide range of variation in rate of feeding and the uniform distribution of the coal upon the grate, whatever the rate at which it is provided, adapt the stoker to varying demands, and several engineers whom I asked said that they had very little trouble with burning out the exposed parts. If the shovel and deflecting plates are eroded by impact with the coal they are easily and cheaply renewed. I did not meet with any case where what we would call large rates of combustion were being used with this type of stoker.

One important advantage of the type is that it may be used with any kind of a flat grate, and hence with a bar adapted to the fuel used, whatever that may be. The ordinary fire door is left intact and accessible so that the fire may be worked with the ordinary tools and in the ordinary way, or may be hand-stoked through the door in case of interruption to the operation of the stoker. For the long, narrow grates of internal-furnace boilers they are particularly adapted. They are used singly for such narrow furnaces or in batteries for the wider furnaces of externally fired boilers.

These stokers, although I found them largely in use on the Continent, are based upon English inventions, and naturally divide themselves into two types, one in which the fuel is brushed or projected into the furnace continuously, as in the type invented by Leach, and the other where the action is somewhat intermittent as in that of Proctor. From a paper presented at a meeting of the International Association of Steam Boiler Inspection Societies at Lille, by Herr Ober-Inspektor Pröbsel, of Chemnitz, I am able to present several sections of the principal examples.

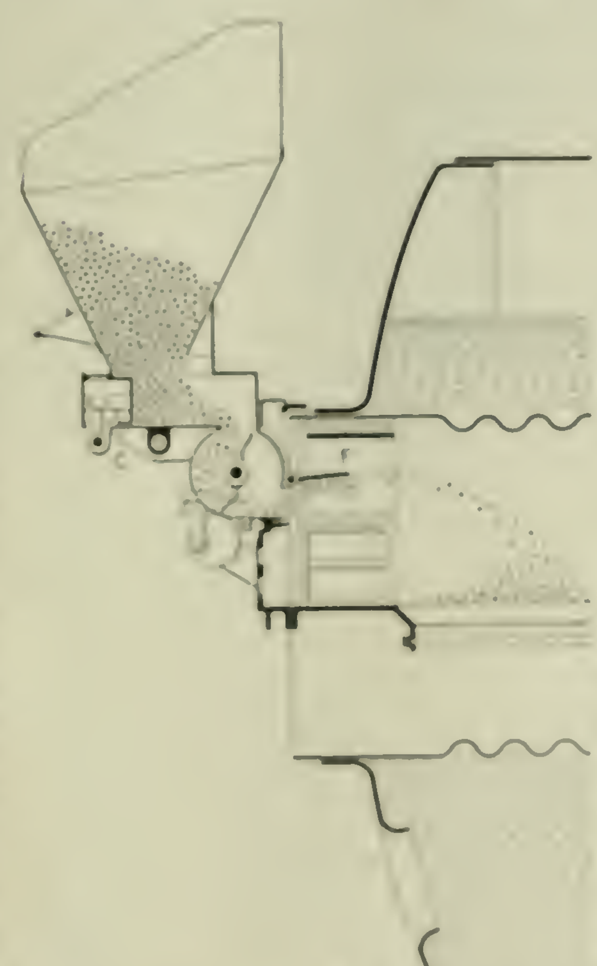


Fig. 2. Leach Stoker as Made at Meerane, Germany

Fig. 1 shows the Leach stoker as it has been made by the Saxon Machine Works at Chemnitz for twenty years. At the outlet of the hopper is a feed roll C operated by a ratchet movement which delivers the coal to a housing in which is a blade wheel E turning at a speed of 300 revolutions or higher, which throws the coal into the furnace. Between the wheel and the furnace is a hinged baffle plate F against which the coal strikes and which is automatically and continuously moved up and down, distributing the coal over the entire fire bed. The ratchet wheel which drives the feed roll has a sliding cover adjustable by hand over a greater or less number of its teeth so as to control the rate of feed with about ten gradations independent of those afforded by cone pulleys on the drive. This stoker is best adapted to sized coal, in particular, nut coals of from one-quarter to three-quarters of an inch in size. The use of briquets, except in the smallest sizes, is precluded, but the Leach apparatus, although thus restricted, and the more so because the price of so suitable fuel is relatively high, is much used, about 350 of them being under the care of the Saxon Steam Boiler Association.

Fig. 3. The Proctor Stoker

In the Whittaker design, also an English invention, the feed roll C of Fig. 1 is replaced by a pair of crushing rolls which, being driven at a greater or less speed, control the rate of delivery of the fuel as well as reduce it to the proper size. The baffle plate F is adjusted by hand. This furnace is quite popular in Austria.

Fig. 2 shows another modification of the Leach. It is made by F. L. Oschatz, of Merane, Germany, who replaces the rotary feed roll *C*, Fig. 1, with the re-

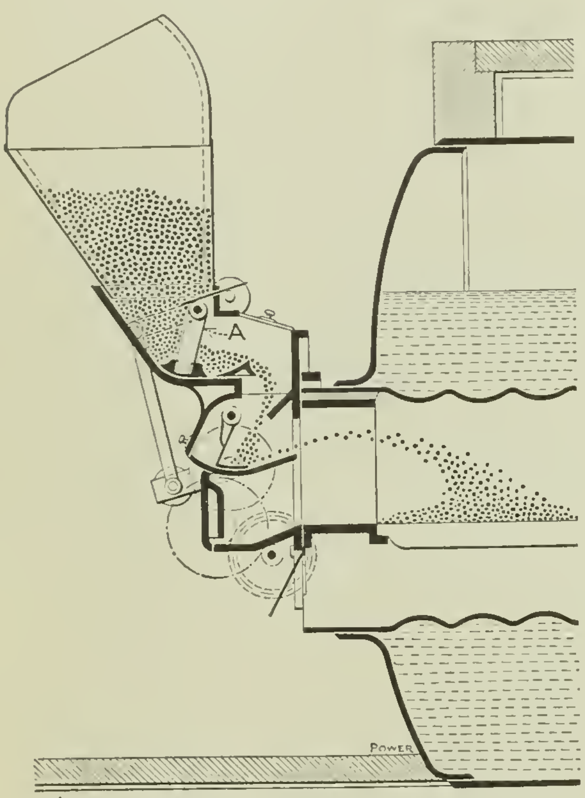


FIG. 4. STOKER MADE BY C. H. WECK

ciprocating-piston arrangement *C*, Fig. 2. This is said to permit a larger size of coal to be handled, run-of-mine, lump and brown-coal briquets up to 2¾ inches being available. The baffle moves continually and the feed is regulated by the simple turning of a screw controlling the movement of the piston *C* from nothing to the maximum.

In the Proctor type the coal is periodically flung upon the grate by a pivoted plate, usually spring actuated. This plate, because it performs at least the projecting part of the work of that tool, is called the shovel. On one end of the shovel shaft is a toe engaging a cam wheel which has a number of protuberances, usually three or more, and is turned from the driving shaft. A lever on the other end of the shovel shaft is connected with one or two strong helical springs. When one of the protuberances of the cam comes in contact with the toe the shovel is thrust back away from the fire and the spring stretched. When the cam lets go. the spring throws the shovel toward the grate, hurling the coal, which has fallen before it, onto the fire. In consequence of the different hights of the protuberances upon the cam the shovel is drawn backward and the spring stretched to different degrees, throwing the coal successively onto different parts of the furnace and preserving a uniform fire bed. The rises upon the cams may be adjustable so that the stoker can be adapted to different grades of fuel, greater spring tension being needed for the larger sizes. They can throw sorted coal and run-of-mine up to 3¼ inches, in which they have an advantage over the type already described.

Illustrative of the Proctor type is the stoker built by Munckner & Co., of Bantzen, Germany, and shown in Fig. 3. The coal falls into the funnel in which there is a ring pusher, driven by the vertical shaft, which gives it a turning movement back and forth, pushing the coal forward in the direction of the boiler.

At each stroke of the pusher a determinate quantity of coal falls over the overflow nose *N* on the throw plate *P* in front of the shovel *S*, the guide *L* assisting in landing it within range of the stroke. The overflow nose *N* keeps the coal from dropping on the wrong side of the shovel.

In the stoker of C. H. Week, Dolau near Greiz, shown in Fig. 4, the coal is sent down to the shovel by a hinged pusher *A*. Passage is afforded for lumps of four or five and a half inches in size; the quantity fed may be adjusted by means of a handwheel during operation.

In the "Katapult" stoker, made by J. A. Topf & Sons, of Erfurt, and shown in

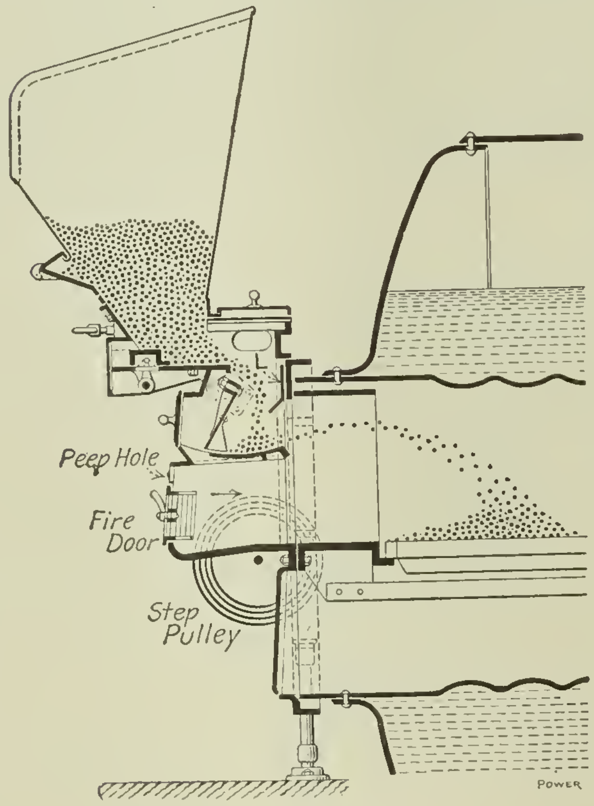


FIG. 5. "KALAPULT" STOKER

Fig. 5, a relation is established between the movement of the feeding pusher and the shovel-operating cam whereby the amount of coal fed varies with the throw, being greatest for the longest throw and least for the shortest. This takes account of the fact that the combustion is most intense at the back part of the grate and also of the obvious certainty that some of the coal always falls short of its destination. The fuel is dropped in front of the shovel for its entire width instead of being allowed to fall in a heap.

The deflecting plate *L* is made adjustable. Coal up to fist size, as well as briquets, can be used.

The trouble seems to be not so much with handling large sizes within reason as from the tendency of the finer stuff to pack, especially if it is wet. In the "M. A. N." stoker, Fig. 6, made by the Augsburg-Nürnberg Machine Company, an agitator *A* is provided just above the

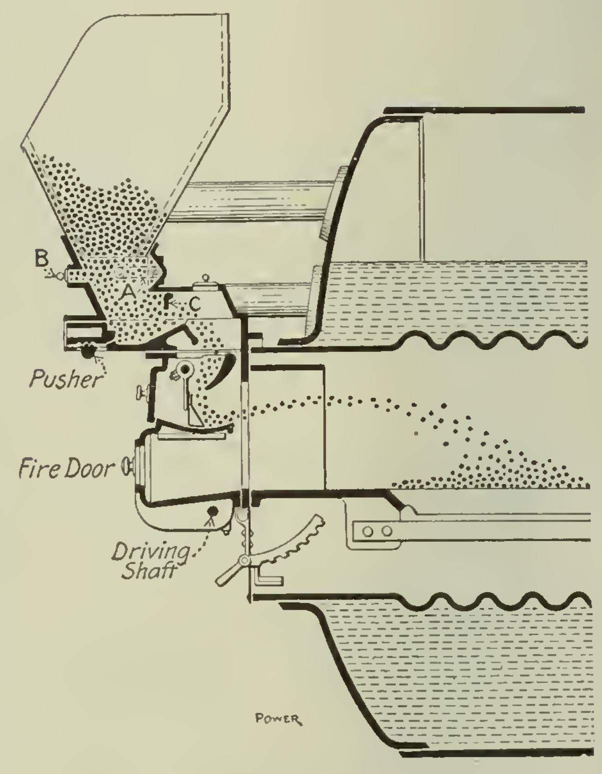


FIG. 6. "M. A. N." STOKER

throat of the hopper and a poke hole *B* in the front of the funnel. A gate *C*, adjustable for fuel of different sizes, is placed where it will restrain the falling coal and place it more directly under the control of the pusher.

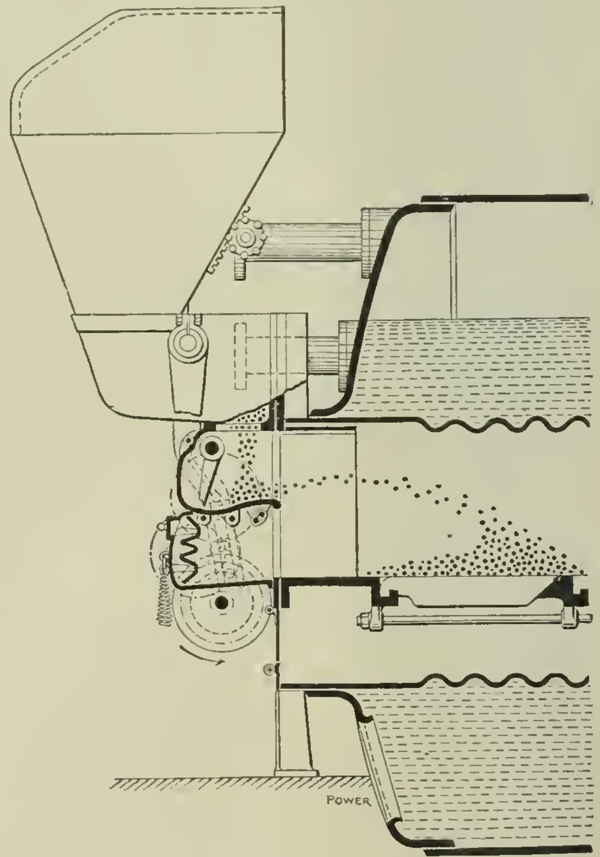


FIG. 7. STOKER MADE BY RUF & CO.

The Seyboth stoker, made at the Zwickauer foundry of Emil Selbmann, Zwickau, embodies a feed roll with many cavities whose dividing walls have edges which break up the large lumps. By this means irregular mixtures of coal or briquets can be used. It is pointed out that one advantage of equalizing the size arises from the fact that large lumps are thrown farther than smaller ones and require a more forcible impetus. The mode of varying the throw of the shovel is somewhat different from that employed in the machines already described. Instead of having a series of projections or rises, the cam is an eccentric disk, each revolution of which corresponds to one throw of the shovel. By a gradually changing lever movement the same is brought into contact with the tension toe on the shovel shaft earlier or later, thus putting the springs through a long cycle of variations in tension and apportioning the distance to which the coal is thrown upon the grate by a series of small gradations. A stoker of this type is also built by the Esslingen Machine Works in Esslingen; and the "Cyclop," made by Mehlis & Behrens at the Cyclop Machine Works at Berlin, contains also the rotary-crusher feature. The separated throw plate is also used in the stoker made by the Dingler Machine Company, of Zweibrücken.

The stoker of Ruf & Co., Bautzen, Saxony, Fig. 7, differs from the others in having the throw plate beneath the shovel made in two parts, the front one of which is hinged and by its inclination determines, in connection with the varying force of the shovel push, the distribution of the coal. It may be easily adjusted while the furnace is in operation. The varying impetus is obtained with the usual cam and toe arrangement. The pusher is of a form designed to prevent clogging and is almost entirely relieved of the pressure of the coal in the hopper; lumps four inches and more can be handled.

There may be mentioned another type of throw stoker which has lately appeared in which the shovel is not pivoted above but beneath the stoking plate, of which the shovel forms to a certain extent a part. This system is used in the Seemer stoker, made by the Kaiserslautern Iron Works in Kaiserslautern, Pfalz.

Less than one-half a horsepower is required to operate any of these stokers when crushing rolls are not included.

In our own country this type of furnace is of comparatively recent introduction. A description of that made by the Erie Foundry Company appeared on page 700 in our issue of April 13, 1909, and of the Vulcan, made by the Vulcan Furnace Company, in our issue of January 11, 1910. A still later type, made by the Parsons Manufacturing Company, of New York, in which the fuel is injected intermittently by air blast, is described on page 2046, November 15, 1910.

Control of Indirect Heating System

By H. R. Rogers

Leakage through the walls and doors of the plenum chamber produced too high a temperature in the mixing chamber and made it almost impossible to maintain the desired temperature.

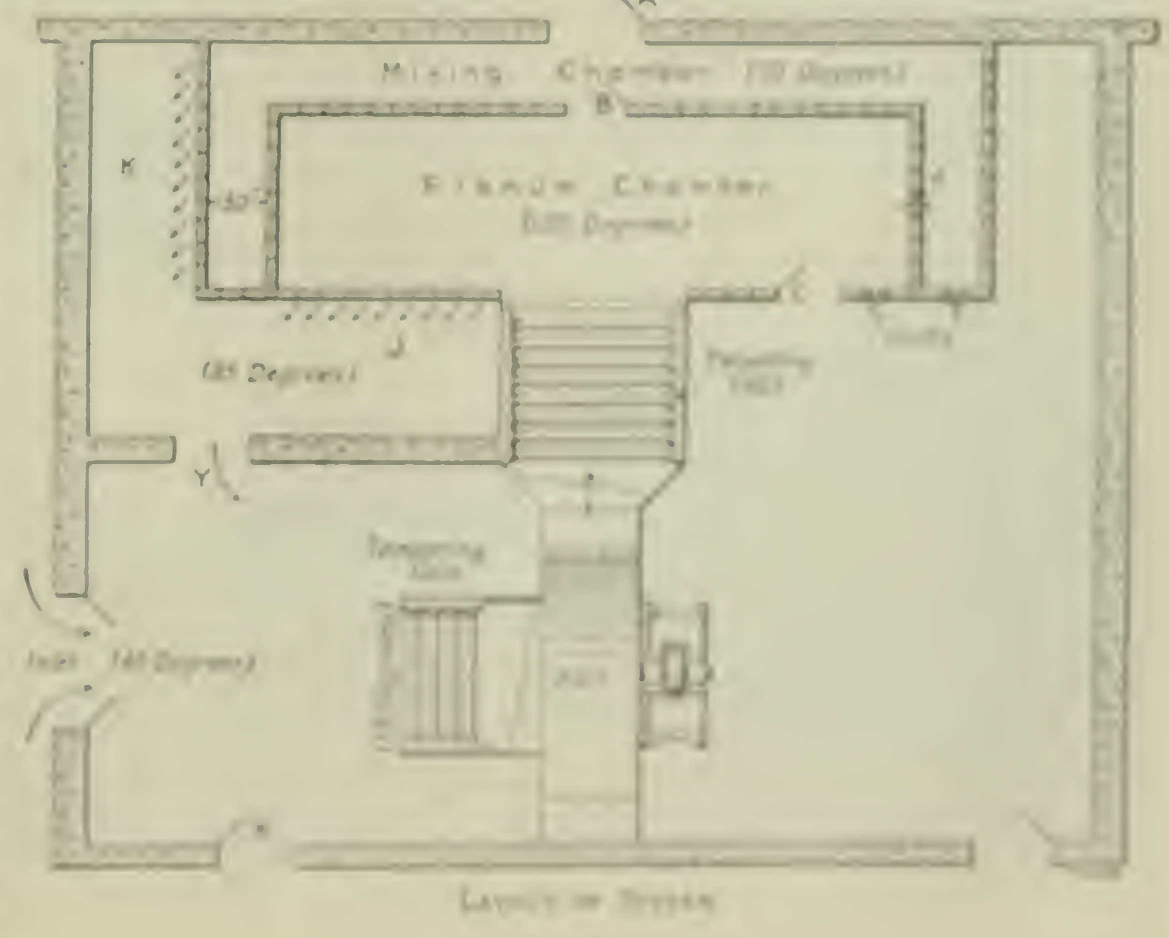
The cubical content of a certain building was about 800,000 cubic feet, and the capacity of the fan was about 40,000 cubic feet per minute; this gave a change of air every twenty minutes. The average outside temperature was 40 degrees and the temperature maintained inside was 68 to 70 degrees. The accompanying sketch shows the plan of the plenum chamber, the mixing chamber and the fan inlet; also the temperatures are indicated as observed after it was discovered that the system was not fulfilling the requirements.

The plenum chamber was about 14x32x12 feet, with four brick walls and a concrete floor. The mixing chamber was 30 inches wide, surrounding three sides of the plenum chamber and having an outer door at *A* through which to enter the mixing chamber, and an inner door at *B* to enter the plenum chamber. As the latter door was found to leak badly, it was taken out and the aperture was bricked up and the same door installed at *C*, where the leak could not affect the tempered air.

The tempered air passed under the plenum chamber (directly under *H*) to reach the mixing chamber. But it was found that the floor of the plenum chamber at *H* had not been completed up to the edge of the reheating coils, and there existed a crack about three inches wide and nine feet long. This proved to be one cause for the temperature being too high in the mixing chamber. At the place indicated by the small arrows *J*, it was found that the 4-inch brick wall leaked at almost every joint, the current of air coming from any of these leaks being strong enough to extinguish a lighted match, and the pressure in the plenum chamber was barely ½ inch.

The temperature carried in the plenum chamber was at times as high as 120 degrees Fahrenheit, and the outside temperature was usually 40 degrees. It was impossible to keep the proper temperature in some of the rooms, especially those that had 12-foot ceilings. The temperature in those rooms would reach as high as 90 degrees, as they were situated only about 50 feet distant and were receiving the air direct from the plenum and mixing chambers, and the velocity of the air into them was approximately 325 feet per minute. The dampers in the plenum and mixing chambers were controlled by an apparatus for regulating the temperatures, but as this was found to be in perfect working order, the lack of control could not be laid to it.

It may be noted from the sketch that air would be drawn through the door *Y*, which was proved by hanging a thermometer directly in front of the temper-



Layout of System

ing coils, when it was found that the temperatures ran as high as 58 degrees, with an outside temperature of 40 degrees. The air would go through the fan and either under or through the reheating coils, and the reheated air that did not go through the hole in the floor at this point went into the plenum chamber. Enough air, however, passed through the hole to raise the temperature in the mixing chamber to 70 degrees, even after the steam was shut off from the tempering coils.

With the air coming in at 70 degrees, the heat from the occupants and from the lamps raised the temperature to 80 degrees at times, about 12 degrees too high to be comfortable.

To remedy the matter a door was placed at *Y* and kept closed, after which there was no perceptible leak through *J* and *K*. Before this door was hung and kept closed, the pressure in the plenum chamber and the suction of the fan would cause all the air that came through the leaks to be reheated and recirculated.

The hole in the floor was stopped up in a permanent manner and ports were made into the plenum and mixing chambers, as shown at *S* and *T*, and thermometers were placed there. It was then found that 120 degrees could be maintained in the plenum chamber and 55 degrees in the mixing chamber when the outside temperature was 45 degrees, and there was no trouble in controlling the temperatures in the rooms where there had previously been difficulty.

If those who are experiencing trouble in maintaining temperatures would hang thermometers in various places, they might learn a great deal. I consider it just as essential to have a thermometer in the plenum and the mixing chambers as it is to have a pressure gage on a boiler, for without these it is impossible to be sure of just what is going on, especially when some ventilation is required and very little heat is needed.

It is bad practice to build plenum chambers with 4-inch walls unless they are plastered on both sides with a coat of cement, as the difficulties mentioned are apt to occur, and without the thermometers no one would be the wiser.

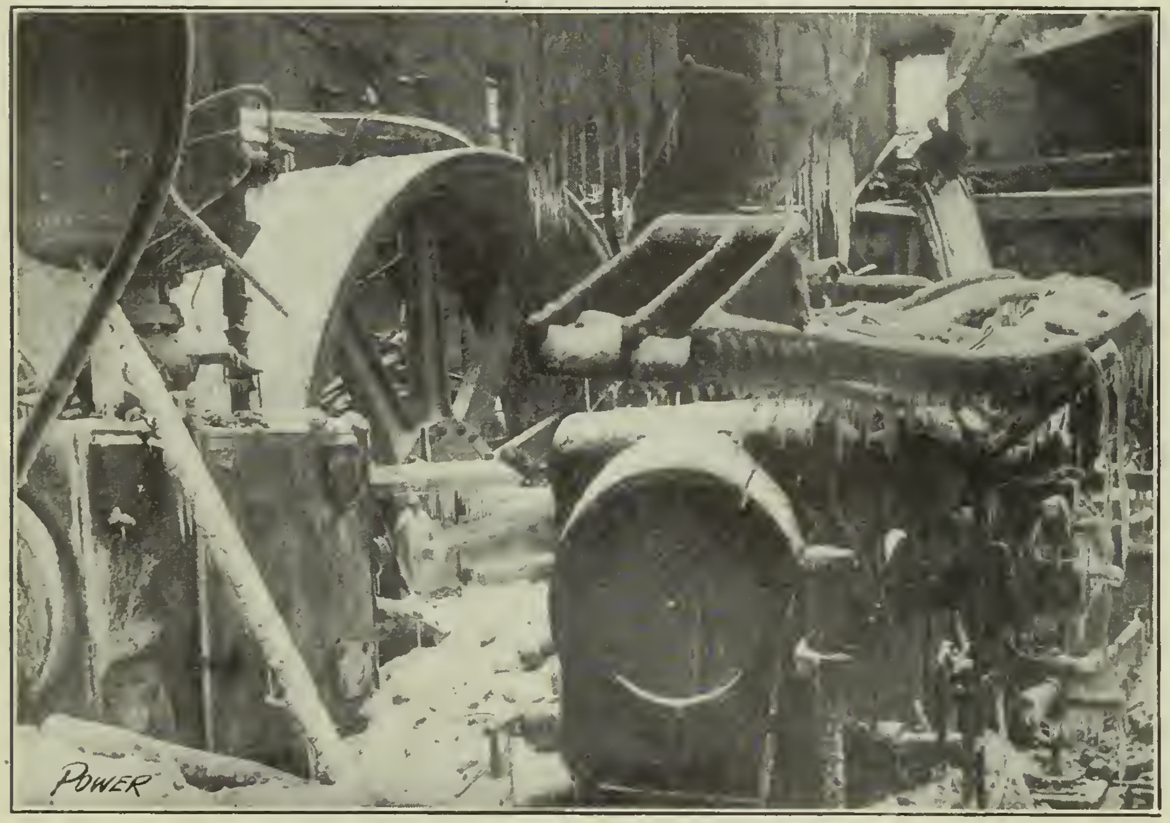


Fig. 1. One of the Corliss Engine Units

Minneapolis Power House Burns

About 6:45 a.m., Friday, January 6, fire broke out in the engine room of the Main street station of the Minneapolis General Electric Company and rapidly reduced the generating side of the station to a mass of scrap. The fire, as near as can be ascertained, originated in the northeast corner of the building near the incoming feeders from the other stations which operated in parallel with this plant, and was the probable result of a short-circuit of some of the electric wires at this point.

In escaping from the fire two men were injured, one of them seriously but not fatally. The floor and roof of the building furnished most of the inflammable material and this, falling on the machinery, had the effect of concentrating the heat. Massive engine frames were in many cases cracked like glass, and it is estimated that the machinery is practically a total loss.

The plant contained one 1000-kilowatt direct-connected unit, two 1200-horsepower and one 700-horsepower belted Corliss machines, and a 1500-kilowatt Curtis turbo-generator. It operated also two waterwheels of approximately 2000 horsepower capacity, and contained one 1000-kilowatt motor-generator, which formed a connecting link between this station and the others in the system.

Notwithstanding the complete destruction of the engine-room side of the house, the boiler plant, containing ten 350-horsepower Stirling boilers, was not injured. A substantial fire wall separated the two parts of the building and it was due to this fact that the boiler room escaped.

Some extremely good work was done by the Minneapolis General Electric Company in making temporary connections whereby normal conditions in the lighting service were resumed. The city was without lights on the night of Friday, but, the following night, lights were burning as usual except in the case of about 1000 open arcs which had been supplied from the Main street station, using old-type Brush dynamos. These will be out of service until they can be replaced by magnetite arcs.

Fig. 2. Remains of the Building

An Industrial Plant Boiler House

By Warren H. Miller

The details of design of boiler house and water softening plant. Fire-tube boilers were selected because of low steam pressure and the hardness of the water. Simple coal and ash handling arrangement. Concrete blowoff sump.

While this boiler house was primarily designed for the sole purpose of making and distributing steam, it has many features of interest and value to those engaged in the design of combined boiler and power houses for industrial plants. About larger manufacturing establishments, comprising big acreage and many buildings, the conditions are considerably different from those of the big city power houses, where ground space is limited and where the ash must be shipped away in gondola cars. For the latter type of plant some sort of conveyer for coal, and elevator for ash are the standard details, but for an industrial-plant boiler house, both can be replaced by simpler and cheaper devices. Probably the most economical way in which to serve coal to the boilers is to haul it in the cars up a trestle of about 5 per cent. grade and dump it into a bin which permits it to flow out in front of the boilers by natural slope, which, for buckwheat, is 33 degrees. Similarly, the easiest way in which to dispose of the ash is to collect it in cars in an ash trench in front of the boilers and haul the string once a day, dumping the ash on low or swampy ground about the works. Such a trench can be made very cheaply of concrete with manholes at each boiler, and steel dump cars can be gotten just about long enough to space one in front of each boiler. Following out these ideas, the boiler house, a cross-section of which is shown in Fig. 1, was designed. It will accommodate either fire- or water-tube boilers of 250 horsepower size. While the water tube is shorter by nearly three feet it needs this amount of extra room in the back alley because of the rear caps, etc.

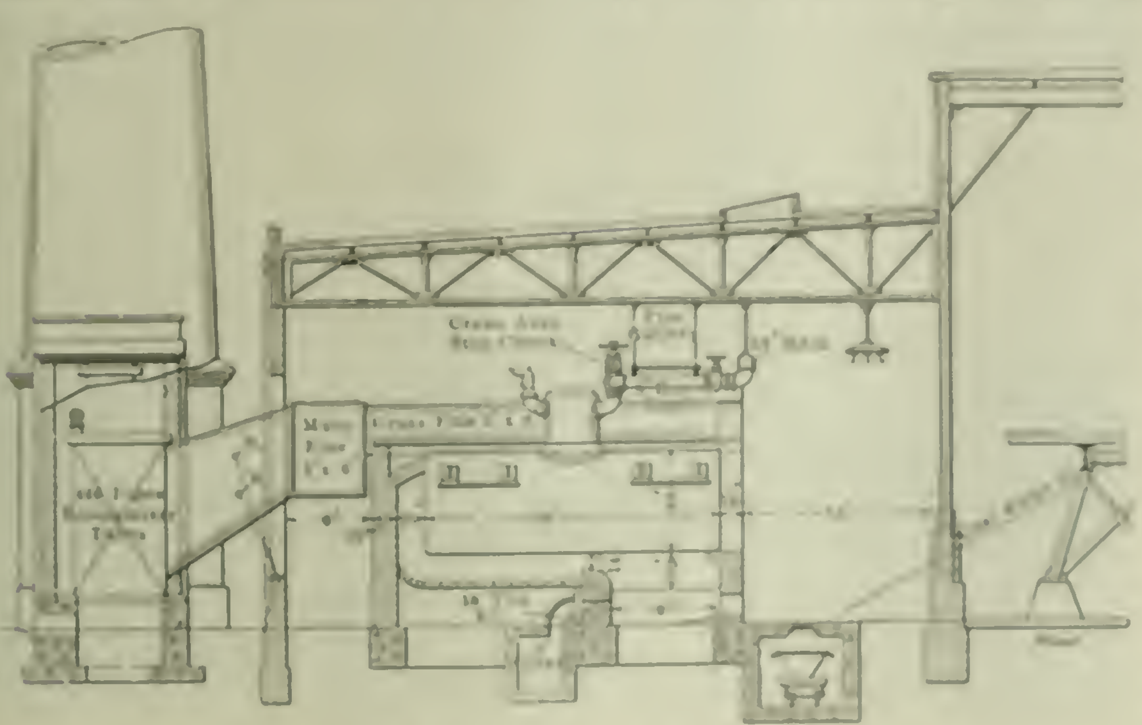


Fig. 1. Cross-section of Half of Boiler House

Coal Trestle

The trestle is a structural-iron affair with 24-inch I-beam stringers. It was adopted after much argument because of uniformity with other trestles about the works, but there is no question but that a concrete trestle would be cheaper and more durable. It has often been the experience in using iron bents in coal bins that they rust quickly from the sulphates in the coal unless dug out and repainted at least once a year. The all-steel trestle costs about $10 a running foot and the concrete pier trestle, with steel I-beam stringers, costs a little over $8 per foot. The hight of the top of the rail on the trestle should not be over 13 feet; the distance from the center line of the trestle to the face of the wall should be 11 feet. The bin walls were made by raising the foundation piers 7 feet above grade and making a retaining wall of them. Each pier was 5 feet wide with an intermediate wall 1 foot wide carrying no column. This arrangement left two doors in each bent 3 feet 8 inches wide. A 3-inch channel was cast vertically in the face of each concrete pier, thus giving a slide for the doors, so that the amount of the coal slope can be adjusted at will. The pressure of coal is very considerable, and it becomes a live load whenever a car is dumped; the descending coal produces a great shock. It is capable of bulging an ordinary 8-inch brick wall if dumped against it to any hight, or bending 4x12-inch yellow-pine bin boards, if the span is over 8 feet between posts.

The floor of the bin is of concrete, smooth finished and pitched each way to a gutter running along the boiler fronts, which also catches the hose water from wetting down ashes. Another scheme for draining the coal bin is to build a blind drain of brickbats laid in a trench running down the center of the bin. This drain is covered by the floor, except for a square opening in the center of each bent. This opening just holds four bricks laid loose. Such a drain will dispose of all rain water which may get into the coal, and will never have to be dug up like a tile drain when laid under concrete.

Ash Handling

The ash trench is 6 feet by 5 feet 2 inches in cross-section, with a 7-inch reinforced-concrete roof and 9-inch plain walls, made by setting up interior forms and pouring concrete between them and the sheer walls of the excavation. The roof was poured before the wall forms were struck, in order to avoid the liability of the earth pressure bulging the walls in. The 30-pound rails of the 36-inch industrial track are laid on sills in the cement. The dump cars used were manufactured by Wickham & Mayer; each is of 2 cubic yards capacity and cost about $80. Using a 2-foot spacing link, their length is such as to place one of them in front of each boiler, with a spare in each of the two alleys. Each car stands directly under a cast-iron 24-inch street manhole, cast in the concrete roof of the ash trench. After the fires have been cleaned, the heap of hot ashes and clinkers is wet down with the hose, the manhole cover lifted with a slice bar and the ashes hoed into the cars below. Each car will hold three cleanings and constitutes both ash bin and conveyer and is far cheaper than either. For 18 cars, serving as many boilers, cost only $1200. They are hauled at 7 o'clock, morning and evening, by the work's electric storage-battery locomotive. The approaches to the ash trench are down 3 per cent. grades from the street level, one straight and the other curved on a radius of about 60 feet. A six-ton locomotive can haul five cars up such a grade, and a ten-ton can take 8 or 12 of them up.

Boilers

The boilers were chosen fire-tube because of the low steam pressure, 80 to 100 pounds, and because of the hardness of the feed-water supply which contains over 18 grains of solids to the United States gallon. There was no hope of softening this below four grains each with the best water-softening equipment that could be devised, because the water was one of the "impossible" variety, such that by the time enough lime and soda have been put in to make all the impurities soluble, there is so much in that the boilers foam to a degree beyond all safety for the engines. While evaporation, capacity and economy of upkeep are, in the long run, about equal with fire- and water-tube boilers of first-class make, the cleaning account of the former is undoubtedly much smaller, being only a three days' job for three men in a 250-horsepower boiler, whereas the water-tube of the same size takes five men a little more than a week. It is the writer's belief that the water boiled is the most important consideration of all. About 90 per cent. of all the accidents and repairs about boiler plants are primarily due to the water and its quality, and yet it is often the last thing considered. The boilers cost about $26,000 for sixteen, against $41,000 for an equal number and grade of water-tube. They are 84 inches in diameter and 20 feet long; the shell is 7/16 inch thick; the joints are triple-riveted butt-strap. The main steam outlet is 8 inches in diameter; the feed, 2 inches; the surface blow, 2 inches; the bottom blow, 3 inches, and the equalizer 2 inches. Each boiler has two 4-inch pop safety valves. The boilers are set in batteries of four so as to have one 5x3-foot cross-connection flue to each pair of boilers. Since, if one boiler were let down and opened, the draft of the other boiler would be broken, dampers were put in by running a dividing plate from the front wall a short distance down the flue, thus parting it in halves; in the passages thus formed the dampers were swung.

Flues and Economizers

The main flue is 5x6 feet in section throughout. It was possible to keep to this size by placing the chimneys in the center of each side of the boiler house, with the economizers on each side of the chimneys. The arrangement of the boiler house is eight boilers on a side, with foundations for four futures. The flue is built for the entire twelve with a dead damper beyond the eighth boiler which can be closed while the future boilers are being connected in. As two boilers are directly opposite the economizer entrance, no section of the main flue is used by more than four boilers at once, whether direct into the chimney or indirectly through the economizer.

The economizers are for six boilers each, but, at present, four feed through one economizer and four down the flue into the other. The location of the four economizers on opposite sides of the chimneys and entirely outside of the boiler house is an arrangement often used by the writer because of the numerous advantages it affords. It costs little if any more than the arrangement of locating the economizer above the main flue, or of backing it up against the back wall of the boiler house, and it gives not only free access to the economizer on all sides, but also plenty of light and air in the alley behind the boilers.

It would seem that few outside of the firemen on the job really appreciate how valuable light and ventilation actually are. Here are located all of the blowoff valves and cocks, surface blowoffs, equalizers, back-cleanout doors and flue-cleanout doors, and, if the boilers are water-tube, here also are all of the thousands of tube caps, which must be cleaned, replaced and tested. If this alley is a dark tunnel and a sweatbox, as is the case if the rear wall is left blank and the economizers backed up against it, these things will be looked after and repaired by the light of a few lanterns or kerosene torches, and will be one of the "meanest" jobs about the boiler house. But, with the economizers outside, there are light and air in the tunnel; there is room about the economizer itself to take out a cracked header or a defective tube, and there are air and light overhead to handle the scraping mechanism and to clean the blessed thing whenever it needs it, which is about every six months at least, and the job takes about two weeks of steady work. As to difference in cost, wide and massive foundations for boiler-house wall, requiring special concrete forms, are avoided; the solid brick wall of the boiler house, which would have to be faced with firebrick, is replaced with window frames and a 12-inch panel wall which is cheaper, and, in addition, one side of the economizer may be covered with the sectional coverings which come with the economizer, so the difference in cost will not be very great—far less than the real advantages that it gives in the work of making steam.

Chimneys

The chimneys, 9 feet in diameter and 125 feet high, are built of radial brick; have common-brick bases which extend up as far as the economizer tops, and are lined with firebrick for 30 feet from the bottom. The flues enter each side, and the direct bypass from the main flue to the chimney enters the brick neck, joining the chimney with the economizer houses on each side of the chimney. Competitive bids were received on reinforced-concrete and radial-brick chimneys. The latter type was chosen in spite of the lower cost of the former. The appearance of the concrete stack is hardly in its favor, as it is impossible to avoid the effect of separate rings caused by each successive batch of concrete, and these rings spoil the unity and column-like appearance which is the chief beauty of a chimney. The durability of the concrete chimney is also probably less than that of the radial-brick, but this remains yet to be proved, as the oldest concrete chimney in America, to the writer's best knowledge, is not over ten years, and is lined from top to bottom with firebrick, making it more expensive than a radial-brick chimney. While a number of poorly built concrete chimneys have had to be taken down, there should be no hesitation in using them at the present time, if price is the first consideration. The radial-brick chimneys for this plant cost about $2700 each. The economizers cost $13,000, erected, for four containing 440 nine-foot pipes each. Their capacity is 1250 horsepower with feed water at 180 degrees and flue gases at 410 degrees. The foundations, setting and houses, made by carrying up the walls above the economizer tops and putting on a roof, cost under $5000 for the four, including the electric drive.

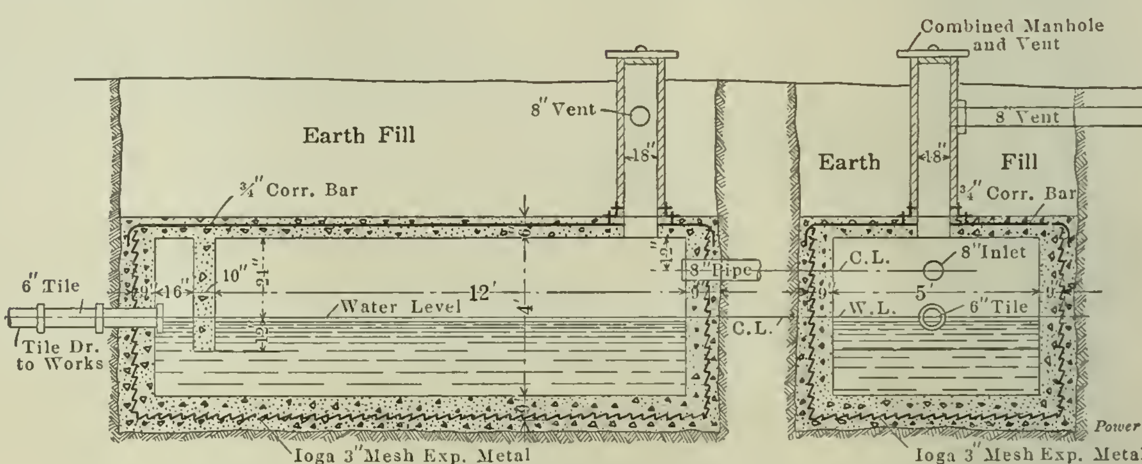


Fig. 2. Details of Reinforced-concrete Blowoff Sump

Grates

The coal burned is buckwheat anthracite, containing much slate, costing about $1.10 a ton and containing 20 per cent. ash. To burn it a pinhole grate and fan blast are required. Two three-quarter-housing, bottom-discharge, Sturetvant 8x12-foot fans supply the blast through reinforced-concrete air ducts, with openings in the bridgewall into the ashpit, controlled by cast-iron swing blast doors. One of the fans is driven by a Sturtevant 10x12-inch heavy-duty fan engine, running at 150 revolutions per minute and the other by a 40-horsepower induction motor. Either fan will furnish the blast for all of the boilers, so as both steam and electric drive are available, it is almost impossible for the fan equipment to be shut down.

Auxiliaries

The fans, engine, motor and three large 15 and 10½ by 18-inch, duplex, boiler-feed pumps are all located in one house under the care of a water tender, who also looks after the water-softening plant adjacent. The arrangement is very simple and compact, and is made possible by simply putting in a relief valve from the boiler-feed discharge main into the suction main. Each fireman tends water for his own boiler by his stop checks, and the feed pumps are run just a little above the intake of all the boilers that may be on. They use about 300 gallons per minute. Any excess that they do not use is discharged back into the suction through the relief valve.

Water-softening Plant

The water-softening plant, like many properties of this company, is characterized by the utmost simplicity. If you reduce water softening to its simplest terms, you need two tanks for combined treating, agitating and settlement, two filters to remove any solid particles not settled out, and a pump to move the water. In this plant, treating 300 gallons of water per minute continuously, there are two iron tanks 20 feet in diameter by 30 feet high, with a 10-inch electrically driven centrifugal pump with a 10-horsepower motor, situated between the two tanks. This pump fills them alternately, taking 20 minutes to do it, adds the softening compound with a single turn of the motor, agitates by sucking from the top of the water level and delivering into the bottom for one hour. The tank then settles for three hours and is ready for use. A 6-inch connection, 2 feet above the bottom, is opened into one of the filters into which the water enters by a pocket in the side, and overflows at the top. The water then passes down through alternate 12-inch layers of sand and excelsior to a hole plate a foot above the bottom of the filter, which is 6 feet deep by 12 feet in diameter. From here the boiler-feed pump sucks the filtered and softened water for steaming purposes. As there are two tanks and two filters, the water in one is always being used while that in the other is being treated and settled. Seven tankfuls per a 24-hour day is the total available output. It is the simplest possible water-softening apparatus. An extra 20x30-foot tank was added later to provide extra settling and storage capacity. This tank is also used as a reservoir for preliminarily heating the feed water to 100 degrees by passing it through the gas-engine water jackets in the power house. The water itself is of villainous quality, containing 18 grains of solids per a United States gallon, and requiring the unusual proportions of 120 pounds of soda and 70 pounds of lime per tank. Only treated water can be used in the gas-engine water jackets or otherwise they would immediately scale up.

Fig. 3. General View of Boiler House, Fan House and Water-softening Plant

Steam Distribution

The problem of distributing the steam to the various departments is solved by the usual "ring," crossing over the boiler house at each end by four 10-inch extra-heavy bends. A division gate valve, with Crane drip pockets duly trapped, is set at each four boilers, with a 10-inch outlet rising from a tee at each division valve. These lead out to the three main process departments and to the power house (for steam spares, exciter and air compressors). The connections from the boiler drums to the steam main consist of 8-inch extra-heavy pipe bends set horizontally and plain 8-inch angle valves coming into the main from the underside—a good flexible arrangement, and one that is self-draining for anything but wet, foaming steam. In the pipe gallery is also run the 6-inch feed-water ring with its direct connections from feed pumps and bypasses through the economizers. Out of the power section is also taken the 6-inch connection for the boiler-house auxiliary plant and the 6-inch connection for the mechanical shops. The 6-inch connection to the auxiliaries is set in a corner of the ring between a big department section and the power section, and protected by a special division valve, so that, in case of trouble with the power section, it can be carried by the departmental section.

Blowoff System

The blowoff system consists of a 2-inch surface blowoff and a 1½-inch equalizer pipe for each boiler, together with a 3-inch bottom blow. The latter are of the Hancock type, which have the very commendable feature of a protruding pilot on the valve disk, which pilot fits inside the seat ring so closely as to push back any pipe scale or hard scale that may be coming through just as the valve is closing. The steam of the blowoff can still get past the pilot and scour the seat clean before the disk comes down on it, a long-felt want, as more blowoff-valve seats are ruined by small particles of scale getting under the disk just as it closes than by any other cause. In addition to this a 3-inch iron, straight-way asbestos-packed cock is put on the blowoff ahead of the valve. It is always open except just before opening the valve, when it is closed, the valve opened and then the cock. The reverse order is followed in closing the blowoff.

A screw ell is put on between the cock and the valve to give it swing, and as the valve is of the angle type, flanged, it can thus be easily removed for repairs without disturbing the main. The latter is of 6-inch extra-heavy pipe with extra-heavy fittings, the whole main being kept above the concrete floor of the rear alley so as to be easily reached in case of clogging or other trouble. The meanest job in existence is digging up a leaky blowoff main full of hot steam and hard fouling, and in this plant it was kept entirely above board. The blowoff main leads by an 8-inch bull-head tee and connection under the economizer to a concrete blowoff sump, often used by the writer in industrial plants.

As this muddy and scaly blowoff water is at 350 degrees, nearly a third of it flashes into steam to restore the thermal equilibrium the instant it passes the blowoff cock and its temperature falls to a little above atmospheric, or 212 degrees. The volume of steam thus released amounts to about [illegible] cubic feet in blowing down a single gage, and as this is a whole lot of steam, it will not do to turn it into the tile drain system of the works, down a sewer, up a downspout or any other place where it is sure to do harm. The heat of this blowoff water is also so great as to crack drain tile for 60 to 100 feet of its length, and this in time would cave in because of the weight of the earth above and clog up. Therefore, if there is a number of boilers to blow down, and there is no empty swamp or ditch to blow into, a large sump is a necessity. It should be always half full of cold water so as to cool down the incoming blow by mixture, and it should have a vent for the escape of the blowoff steam and a trap to prevent any of the steam from getting into the tile drain system of the works. Such a sump, of reinforced concrete, costing from $200 to $300, is shown in Fig. 2. It is absolutely effectual in performing the functions outlined above and has been used a great deal in various boiler-plant installations by the writer. The steam vent should not be less than 8 inches for 250-horsepower boilers, blown one at a time, as, at that, the pressure developed in the sump is three or four pounds per square inch. If the sump is buried near the economizers, the best lead for the vent is up into the neck between the economizers and the chimney, so that the waste steam goes up the chimney.

Structural Features

The roof truss, of the Warren girder type, is rather light for hanging heavy piping subject to waterhammer shocks, heavy pipe galleries, etc. The writer would have preferred the Pratt-Howe truss, with diagonals in tension all the way across, and reversed at the gusset taking the pipe hangers, but accepted the truss shown in deference to the fetish for "standardization" which possessed the works management. The roof construction is also standard for this works, consisting of I-beam purlins spaced about 5 feet, so that notched 2x4-inch hemlock joists could be laid in between the purlins and give support for a flat board centering. The reinforcement of ½-inch rods is laid both ways across the upper flanges of the I-beam purlins. Then the concrete roof is poured 4 inches deep and finished with an asphalt and gravel roofing. In two weeks the centering can be struck by simply knocking the joists out from the lower flanges of the I-beam. All of it can be used over again.

The hight of the bottom of the roof I-beams of the coal-bin monitor should be 22 feet above the top of track rails on the coal trestle. This hight is needed, especially in smaller plants, for the way train in collecting empties often backs a box car up the trestle. As the runway of this car will be 13 feet 6 inches, all of 7 feet is needed above for clearance. The total hight will thus be 35 feet from the floor. As the roof trusses over the boilers need not be over 22 feet from floor to bottom of truss chords, and the trusses will be about 5 feet 6 inches deep, there will be 7 feet of monitor window space available, lighting both bin and firing alleys, and also obviating the necessity of skylights. These latter are always more or less of a nuisance, but the broad band of vertical sashes along the monitor will give ample light and need never leak down on the firemen below. If every third sash is replaced with a louver, as was done in this house, good ventilation is obtained for locomotive smoke, ash, dust, etc. The walls are of red brick, laid up with red mortar, with 24x16-inch pilasters and panels of 12-inch red brick. The window sills, lintels, water table and copings are of reinforced concrete, smooth finished, and the economizer* houses and fan house were worked up in the same architectural construction.

Electrical Lighting

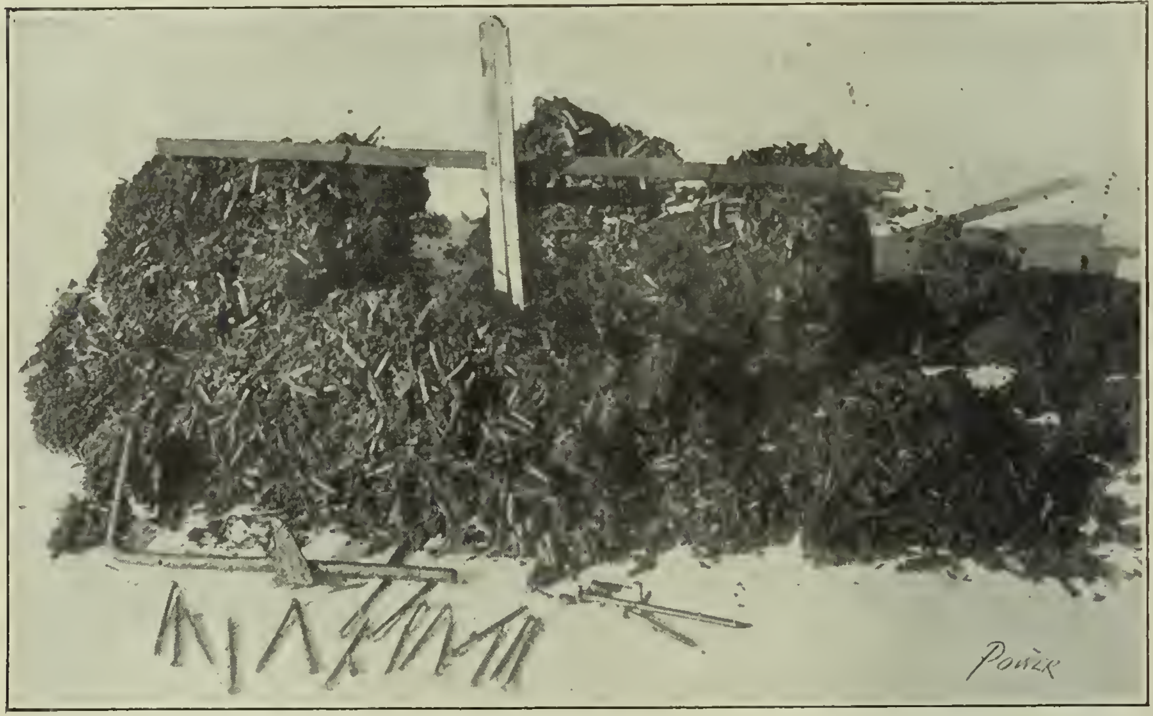
The lighting takes 60 amperes with metallic-filament lamps. There is a row of Harter slag-glass four-light clusters with enameled-steel shades, ½-inch conduit stems, 3-inch black iron canopies and sheet-iron outlet boxes with canopy covers. The clusters hang in the center of the firing alleys from the bottom chord of each roof truss. They are connected by ¾-inch galvaduct conduit, running along on forged hook clamps on the bottom flanges of the purlins just above, and a ¾-inch condulet tee gives outlet at each truss. Each alley has two circuits each way from the center, alternate clusters being in each circuit. The whole is controlled by a two-wire, eight-circuit ironclad switch and cut-out box. There is also a separate circuit of four lamps in each rear alley, so that this subway will not be in Stygian darkness all night, and also to give connections for portables when cleaning out and scaling boilers. Along the pipe gallery runs a third circuit with a lamp at each water column, lighting water gage, steam gage and try cocks. All of these lamps were originally tungsten filament, taking a total of 30 amperes, but they all perished in a short time, in spite of their stable position, and were replaced by the more durable metallic filaments.

*See Power, July 27, 1909.

Junk Shuts Down Large Pumping Engine

By R. C. Turner

The half bushel of iron borings, rods, nails and other junk shown in the accompanying photograph were found riding on top of the piston in the low-pressure cylinder of the large triple-compound vertical pumping engine installed in the water works at Atlanta, Ga. The cylinders are 36, 64 and 90 inches in diameter, and when running condensing the pump has a capacity of 20,000,000 gallons in 24 hours.



Fifty-nine Pounds of Junk Taken from Low-pressure Cylinder

The machine has been in commission about six months but has been in operation only about half of the time. On December 1, the head on the intermediate cylinder cracked in three places and had to be replaced by the manufacturers. After this repair was made, the pump operated for about ten days when valve trouble developed on the low-pressure cylinder. The steam valves are of the poppet type and are located in the heads. After opening up this cylinder one of the valves was found to be stuck and the stem badly bent.

It is supposed that the ports in the head of the intermediate cylinder had not been blown out properly when the casting was made, and that most of the junk came from this source. It is indeed surprising that the pump continued to operate as long as it did.

Increasing the Capacity of Boilers

By H. R. Callaway

> *To meet the demand for boiler units of greater capacity it is suggested that the output of a horizontal water-tube boiler may be increased to approximately 300 per cent. by increasing the length of the first pass, and providing a large combustion chamber, with sufficient draft to enable a thick enough fire to be carried.*

Among the many factors to be considered in the design of a central station is the provision for as large a capacity as possible per square foot of ground area. This is particularly important when the station is to be located in a large city where ground values and taxes are high.

In the engine room great economy has been effected by the development of the steam turbine. Although the point most often advocated in its favor is its economy of steam consumption as compared to the reciprocating engine, the turbine's superiority is much more marked in the matter of space saving. Unfortunately, as yet there has been no parallel development for the boiler house, and if economy of space is to be attained in this part of the power plant, it must be accomplished with the present boiler equipment. To this end a great many plants have been designed with the boilers arranged in two and even three tiers, but it is impossible to go any further in this direction.

In view of these facts, it is evident that the logical way in which to increase a station's capacity is by forcing the boilers to handle much greater overloads than have yet been attempted. In some cases as high as 200 per cent. of rating has been developed with water-tube boilers operated by mechanical stokers and with forced draft, but with the present design such a rating cannot be attained in everyday operation.

In looking over the field of boiler equipment with this purpose in view, natural-draft outfits of all descriptions and also hand-fired boilers are at once eliminated. The possibility of forcing a boiler to 250 or 300 per cent. of rating with natural draft or with hand firing is remote. The amount of coal burned per square foot of grate for, say, 300 per cent. of rating, would probably amount to between 100 and 125 pounds per hour, and obviously no fireman could handle any such amount as this. Even if coal could be shoveled fast enough, it would be necessary to open the doors frequently, with a corresponding loss of efficiency through the introduction of cold air. Furthermore, in order to obtain a rate of combustion as rapid as this, it would be necessary to carry a very thick fire, and no chimney could furnish sufficient draft to burn coal at this rate unless the flue temperatures were very high, in which case the efficiency of the unit would be low and the object of forcing the boilers would be defeated. Therefore, in order to maintain such a high rate of combustion, forced draft and some method of mechanical stoking are essential.

As already mentioned, as high as 200 per cent. of rating has been obtained with ordinary settings. In certain tests in which this figure was reached a 650-horsepower Babcock & Wilcox boiler was fired by a gravity underfeed stoker with forced draft. Although the boiler was designed to deliver 650 horsepower, the baffling and combustion chamber being proportioned for this load, a rating of 1200 horsepower was reached with only a small drop in over-all efficiency. A set of curves plotted from these results show conclusively that a much higher rate could have been attained if the combustion chamber had afforded sufficient space in which to completely burn the hydrocarbons. There seems to be little doubt that the stoker could have been operated at a much higher rate with very little, if any, drop in the efficiency, but the boiler was undoubtedly taxed to its limit and the conclusion seems to be that alterations in boiler design would enable the same unit to be forced to an even greater extent. In the unit under consideration the length of the first pass along the bottom tubes was 7½ feet out of a total length of 18 feet of tube. It might be practicable to increase this length to 9 feet, thus obtaining a 20 per cent. greater area of cross-section for the first pass.

In order to provide a larger combustion chamber the boiler might be raised two feet higher, which, in this case, would have given a 40 per cent. volumetric increase to the furnace. At 1000 horsepower the velocity of the gases through the tubes, although varying to some extent at different points, approximated 24 feet per second throughout. At double this horsepower, which would correspond to slightly more than 300 per cent. of rating with the same proportions of air and coal burned, and assuming that the efficiency remained nearly constant, the velocity of the gases would be about double, or 48 feet per second. If, however, the area of the first pass were increased as previously mentioned, this figure would be cut 20 per cent., giving a velocity at the entrance to the first pass of 40 feet per second. The second and third passes would of necessity be decreased in size, thus tending to produce a greater velocity in this section of the boiler; but, on the other hand, it has been well demonstrated that an increase of velocity of the gases is productive of an increased rate of heat transfer through the boiler tubes, in which case the gases would be cooled at a higher rate and their volume correspondingly diminished. Accordingly, the velocity at the back end of the boiler would probably drop to nearly the same rate as that obtained in the first pass.

Assuming that the increased rate of heat transfer was not proportional to the increased velocity in the first pass, the effect would be to make the middle and upper tubes of the first pass do a greater proportion of the work of evaporation than is the case at present. It is well established that between 75 and 80 per cent. of the evaporation in water-tube boilers of this type takes place in the first pass, and it is probably true that one-half of this amount is contributed by the two lower rows of tubes. In view of this, an increase in temperature in the upper part of the first pass would surely result in the upper tubes of the first pass and all the tubes in the second and third passes doing more nearly their proper share of the evaporation. If the velocity of the gases were greatly increased, as would probably be the case throughout the boiler, and the heat transfer increased, at least to some degree, it is scarcely likely that the flue temperature would be raised enough to seriously affect the efficiency of the unit. The increased velocity and greater volume of gas would increase the resistance offered by the tubes but this could be taken care of by a stronger draft.

In order to evaporate water at such a rate and consequently burn coal so rapidly, the fuel bed would probably have to be between 4 and 6 feet thick, which would make it necessary to have a greatly increased draft in any case. A fuel bed 3 feet thick has been successfully carried by the type of stoker used in the tests referred to with a draft of from 2 to 3 inches and there is no reason to doubt that one considerably thicker could be maintained. It would require experiment to determine with any degree of accuracy how great a draft would be required, but probably 8 to 10 inches of water would answer.

In Professor Nicolson's researches on heat transfer with increased velocity of the gases, he advocates draft-gage pressures of 20 inches of water, but these would be utterly impracticable as it would be impossible to keep the coal on the grates with such a heavy pressure. In the tests mentioned it was found that while the temperature of the combustion chamber varied very little under different load conditions, the temperature at the middle of the first pass varied, roughly, 200 degrees between normal rating and 100 per cent. overload. As this rise in temperature at the middle of the first pass was proportional to the rise in load throughout the test, it is reasonable to assume that the same law would hold up to 300 per cent. of rating. In this case, the temperature at the middle of the first pass would be 400 degrees higher than when the boiler was operated at 650 horsepower. This added temperature would make it necesary for the upper part of the first pass to do considerably more work, and it is scarcely probable that the temperature in the second pass would be much higher than under normal conditions.

It seems, on the whole, quite feasible to so arrange a boiler that it will absorb economically the heat evolved from coal burned at such a high rate. Then the problem would be to burn the coal with a good enough economy to make this excessive overload worth while. The impossibility of doing this with hand firing is obvious, and the stoker which will accomplish the desired result must not only furnish the coal at this tremendous rate but must also coke it thoroughly before it becomes ignited, in order that the hydrocarbons and other volatiles may be distilled off and pass through the zone of maximum heat in order to be completely consumed. Otherwise, smoke will result and with it a loss of efficiency.

The necessarily intermittent operation of hand cleaning with its checking of the fire could not be permitted, so the stoker, to meet these conditions, must be of the self-cleaning type and the ashes must be removed without the admission of cold air. As the whole object of the scheme herein outlined is rapid and continuous operation, the importance of automatic cleaning of the stoker grates is evident.

The phase of this problem, which is not only the most difficult but also the most important aside from the stoker design itself, is that of securing the proper proportions of air and coal. As the amount of coal fired per hour is increased, the amount of air should be automatically controlled in such a way as to increase proportionately; that is, if the allowable amount of excess air has been determined upon for the coal used, it should be possible to so arrange the mechanism of the stoker that this ratio of excess air is maintained constant regardless of the load conditions. This is a problem the solution of which has not heretofore been reached for these extreme conditions because such overloads as those considered have not been tried.

Design of Steam Power Plants

By William F. Fischer

Factors to be considered when designing a power plant, including the selection of a site, the construction of foundations and building and utility of general layout.

Location of Plant

After the available capital has been determined, one of the first questions to be decided is the location of the plant; this depends upon several factors. In order to avoid danger from floods, the plant should be located at a suitable elevation above high-water level. The ground should be nearly level with ample room for future extension, coal storage, outbuildings, etc.; and as all extra blasting, piling and concrete-foundation work involve a considerable expense a site is desirable where excavations can be made readily at minimum cost. Where firm hard-pan, clay, gravel or rock is found within a few feet of the surface and where only slight grading is required, the cost of foundation work may be kept within a reasonable figure. Piling on soft or marshy ground is necessarily expensive, and causes more or less anxiety as to the security of the structure.

There should be an abundant and never failing water supply for boiler feed and condensing purposes, and this water, especially that for boiler feeding, should be pure and, if possible, free of cost, except for pumping. A water-side location is preferable, with a pumping head not over 18 to 20 feet.

The fuel supply must be absolutely reliable and should be delivered to the premises, at the lowest rates attainable by rail or boat, in order to prevent the additional expense of carting. In certain sections of the country it is not well to depend altogether upon river transportation, as there may be seasons when the river is either too low or too swollen, making navigation difficult or impossible. It is well to make arrangements, if possible, with the nearest railroad to run a spur to the plant or, better still, the plant may be located near both a railroad and a waterway.

Sufficient storage capacity is essential so that a full supply of fuel may be procured during the season of lowest prices. By this practice much money may be saved. As an extra precaution this storage capacity should be sufficient for the winter load or to carry over a period of any long strike that may occur at the coal mines or on the transportation lines.

The cost of removing ashes from the plant, whether by rail, water or cart, is another factor to be considered.

An important factor governing the location of the plant is the ease with which power may be transmitted from the generating source to the point of demand. In the case of electric-light and street-railway plants, the most desirable location is, undoubtedly, the electrical center of the entire district to which power and light is supplied, providing the location is convenient in the other respects heretofore mentioned.

Another point to be considered is the fire risk. In this connection the surroundings should be investigated with a view to ascertaining the liability of fire from adjacent buildings.

Type of Plant

If there is a probability of the plant being enlarged in the future, the best arrangement is to place the engines and boilers back to back in parallel rows with a division wall between, separating the engine and boiler rooms. With this arrangement the steam piping is direct and the main steam header may be made comparatively small and be divided into units by placing valves at proper intervals. Then part of the header can be shut off whenever necessary without interfering with the successful operation of the station. Where the engine and boiler rooms are placed end to end the steam main may be inadequate if additional engines are added at one end and additional boilers at the other. Also, to accommodate the additional units the plant must be extended in both directions, thus greatly increasing the cost.

As a rule, the boiler-room floor is on a level with the outside ground, and the engine-room floor, especially where large engines are used, is usually from 6 to 10 feet above the boiler-room floor, with a basement beneath it. Where the engine-room floor is on a level with the outside ground, it is necessary, where no basement is provided, to build a pit for the condenser and construct pipe trenches for the exhaust steam and circulating-water pipes. Where large engines are employed it may be necessary to construct a pit for each flywheel. Such pits, however, ought to be avoided wherever possible, as the vibrations of the engines tend to cause the concrete lining to crack and allow water to enter the pit. Pipe trenches should also be avoided, for the pipes are not as accessible as when suspended from overhead beams in the engine-room basement.

In large plants a basement is usually provided under the boiler room for the accommodation of pumps, blowers, air ducts, etc. The boilers in such cases are usually equipped with ash spouts, leading to the basement where the ashes are emptied directly into ash cars or conveyers.

Where land is cheap, very little consideration is given to compact arrangements, but where land is expensive, it is sometimes necessary to place the boilers on two or more floors, one above the other. An example of this kind may be seen at the Metropolitan street-railway power station at Ninety-sixth street and East river, New York City, where the boilers are placed on three floors, one above the other.

The Building

The building should preferably be of fireproof construction, the walls being of brick, concrete or stone, and the interior faces finished smooth or painted. The finished wall may be painted or calcimined with cold-water paint, although in some large stations glazed tile is used.

No wooden ceiling or sheathing should be permitted in power-plant construction. However, brick walls with steel trusses supporting a wooden roof covered with tar and gravel, or with some fireproof material, is the practice in many of the smaller stations. Metal roofings should be avoided as they entail a cost for painting and maintenance not incurred with a slate, tile or concrete roof; but in all cases a tile roof laid in cement or concrete is to be preferred.

In the smaller stations the roof trusses and tracks for traveling cranes are frequently carried directly by the brick walls of the building, but in the larger stations these are always supported by steel columns resting on their own foundations, the walls carrying only their own weight. Concrete floors with a granolithic finish are usually laid around the engine foundations and vitrified brick laid in a bed of concrete is very durable for boiler-room floors on to which hot cinders are frequently raked from the ashpits.

In all cases it is preferable to separate the engine and boiler rooms by a division fire wall. Doors in this wall should be of the self-closing "underwriters' pattern," hung on sloping tracks or hangers. Doors of this type may be placed on one side of each door opening (preferably the boiler-room side), and held open by fusible links, which melt or fuse at a certain temperature. All windows exposed to fire from without should be protected by suitable fireproof shutters. Fire hydrants should be provided at suitable points, both outside and inside the building, with adequate lengths of hose in accessible places and connected at each hydrant ready for immediate use.

The building should be designed to conform to the equipment and in no case ought the mechanical layout to be cramped to suit the building conditions, unless absolutely necessary. Utility is the primary consideration in power-plant design and architectural features secondary. In designing a power plant care must be taken to provide one or more doors of sufficient size to admit the largest piece of machinery, or the largest part of a machine; otherwise it may be impossible to get the machinery in and out of the building.

Ample space is essential around all engines, pumps and similar machinery so that the pistons may be removed without moving the machines from their foundations. A clear space of sufficient width to remove the tubes is necessary in front of each boiler. Where it is absolutely necessary to economize in space in front of the boilers, large windows may be placed in the wall, one in front of each boiler, and of such size as to permit the removal of the tubes. A space 4 to 6 feet wide should be allowed between the backs of the boilers and the nearest wall. This space is necessary in order to get at the blowoff piping and the cleanout doors.

If economizers are to be installed, sufficient space must be provided for their operation, cleaning, repairs, etc. Sometimes, however, separate housings are provided for economizers.

To avoid mistakes, the building plans and specifications should not be completed until all the important points of the mechanical layout are decided upon and approved by the owner or engineer in charge of the work.

Foundations

With but a few exceptions all soils become compressed under the weight of a building, and allow the building to settle a certain amount. Therefore, the main object is not to prevent settling entirely, but to insure its being uniform.

As many soils, such as sand, gravel and clay, may vary greatly within a comparatively small area, it is well to determine its character and bearing power at several different points by borings or excavations. The building code of New York City specifies the following as the maximum permissible loads per square foot for different soils: Soft clay, one ton; ordinary clay and sand together, in wet and springy layers, two tons; loam, clay or fine sand, firm and dry, three tons; firm, coarse sand, stiff gravel or hard clay, four tons, or as otherwise determined by the commissioner of buildings.

Sand, if confined or kept from spreading, will support safely a considerable load, as shown by an experiment made some time ago in France, where clean river sand which was tamped in a trench and kept from spreading supported safely 100 tons per square foot.

When proportioning the foundations in power-plant work, several practical considerations must be taken into account. For example, the allowable pressure on the soil per square foot of area is considerably less for tall chimneys and similar high structures than for low massive structures; for, in the former case, any slight inequality of bearing power and consequent unequal settling might endanger the stability of the structure, while in the latter case no serious harm would result.

All machinery foundations should be constructed absolutely independent of the walls of the building; but where two or more foundations for individual units are within a short distance of one another, they may be bonded together, in which case the combined mass and increased area will render them more capable of withstanding greater strains. If loose rock is found when excavating, it should be removed, and all solid rock, unless absolutely level, should be dressed off in steps with vertical risers and horizontal treads so that the pressure will be exerted everywhere in a vertical direction. Solid rock may support almost any load likely to be imposed upon it, but care should be taken in order that the load per square foot of surface does not exceed one-eighth of the crushing strength of the rock.

Where the soil is of a yielding nature, piling or grillage must be used to support the foundations. Spread foundations of reinforced concrete are frequently used in place of piling where the foundations are spread over a large area, but where the ground is very soft and marshy, piles should always be driven to support the foundations. The durability of piles in ground constantly saturated with water is beyond question, as piles have been found in a perfectly sound condition after the lapse of many centuries. All piles should be driven to rock or hard-pan, or to an even bearing until capable of supporting the loads imposed upon them.

In modern construction, the ground is excavated between the heads of the piles to a depth of one or more feet and the piles capped with a bed of concrete. Steel reinforcing rods may be embedded in the concrete if it is thought necessary to increase the strength of the concrete foundations.

All holes for the foundation bolts should be accurately located by template, leaving sufficient space around the bolts for a slight variation in the location of the machinery. After the machinery is set in place, the space around the bolts may be filled with a cement grouting.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

The New Ajax Engine

The new Ajax gas engine, illustrated herewith, represents a combination of progressive ideas in design and construction derived from long experience in this class of work. The entire Ajax line* has been redesigned and the scope extended to include tandem construction, as indicated in Fig. 1.

The longitudinal and cross-sections, Figs. 2 and 3, show the constructional details of the frame, cylinders and valves fairly well. The front cylinder is fitted to the frame with a liberal flange and neck and is supported on a pedestal which is free to slide on the sole plate. As the front piston serves as a crosshead, it is made longer than the rear piston and the cylinder is also extended forward to provide a correspondingly long bearing surface. The rear cylinder is exactly like the front one except for this forward extension, and the valve cages of the two cylinders are therefore interchangeable. Consequently, in case of any accident which might disable one of the rear valves, the corresponding valve and cage on the front cylinder could be transferred to the rear one and the engine operated with the front cylinder cut out. Or, if spare parts are carried in stock, one valve and cage will fit either cylinder. The damaging of a valve cage is a very remote possibility, but the feature of interchangeability is much like the Texan's gun during the period of regeneration—useless most of the time but more precious than a diamond mine when the occasion did arise.

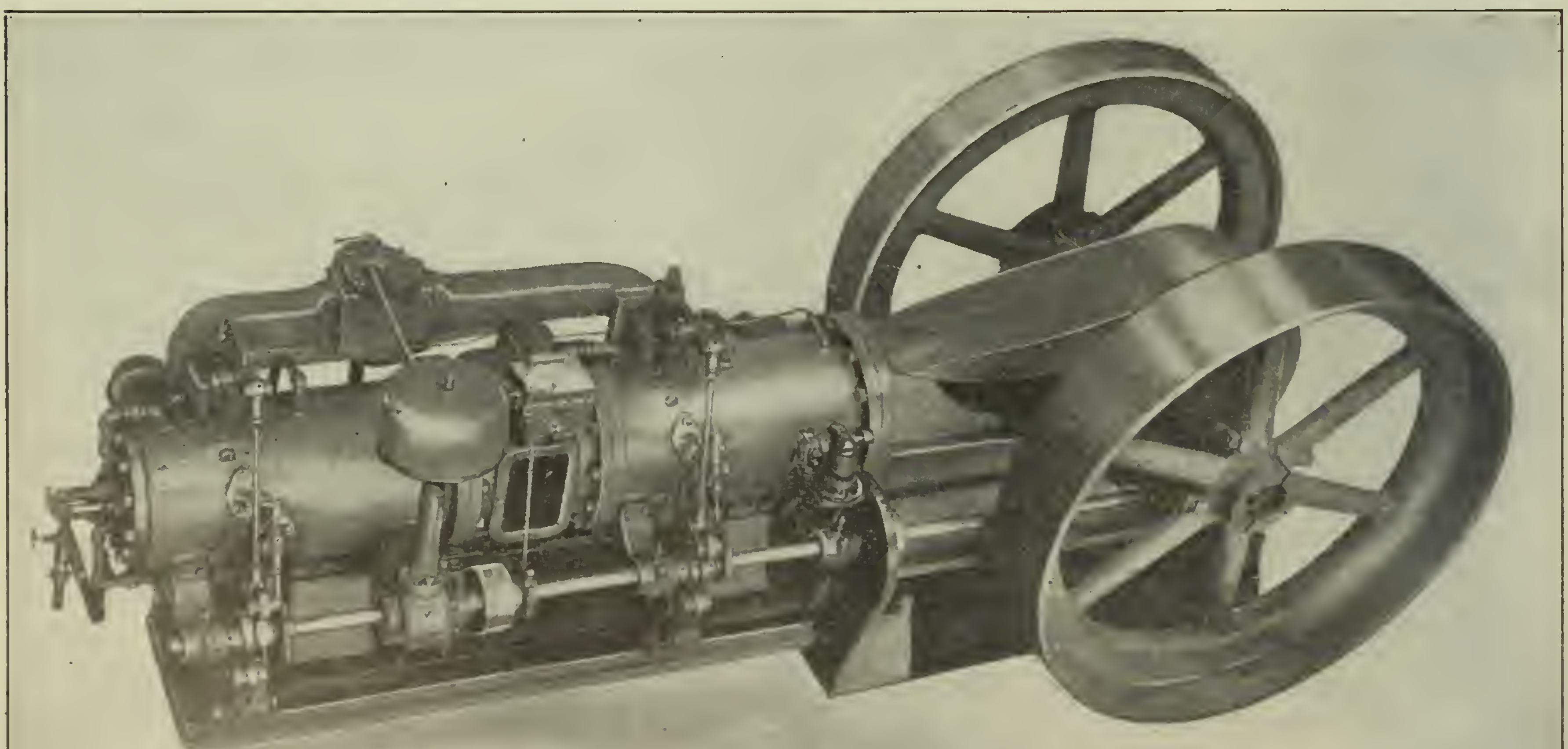


Fig. 1. Tandem Single-acting Ajax Engine; New Type

The rear cylinder is mounted on a pedestal exactly like the front one. The distance barrel between the two cylinders is made with openings large enough to allow the stuffing box in the front cylinder head to be removed without disturbing the general structure. The distance barrel is split lengthwise and attached to the cylinders by bolts (instead of studs and nuts; consequently, it can be taken out entirely, giving access to the rear piston and cylinder and allowing the head of the front cylinder to be removed, without disturbing any of the pipe connections or cam-shaft mountings.

The piston-rod stuffing box is split lengthwise into two equal parts and held together, independently of the pocket in the cylinder head, by transverse fillister-head screws. Fig. 4 illustrates this construction. The half box at the left is

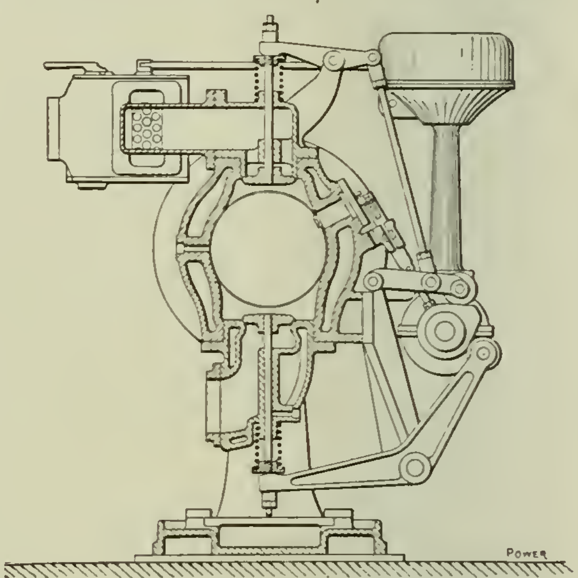


Fig. 2. Cross-section of Ajax Engine

shown with the rings in position. These are of rather unusual construction. Each main ring is made with a circular recess around one edge and a small ring of square cross-section fits into this recess, the two forming a compound ring. Both the inner and outer members are cut into three equal pieces after being turned to size, and the inner ring is doweled in

*Built by the Ajax Iron Works, Corry, Penn.

its recess in such a position that the three cuts in it do not come in line with those in the outer ring. A coil spring around the outside of the outer ring clamps the parts around the piston rod.

The construction of the piston and rod is shown in Fig. 5. The ends of the rod are turned down to form long necks, which are threaded at the ends, and the shoulder where the diameters change is beveled to 45 degrees. This bevel fits a 45-degree seat at the mouth of the hole in the front piston and in a flange which is bolted to the rear piston; this flange, or cap, is shown separately at *F*. The rod and flange are held together by a heavy nut which is held in place by a set screw, and the rod is held snugly in its seat in the front piston by a similar nut. This construction, it will be noted, relieves the screw threads of all stresses due to the working pressures; the only work the threads have to do is to pull the rear piston forward idly during the suction strokes—the beveled shoulders take the thrusts of explosion and compression.

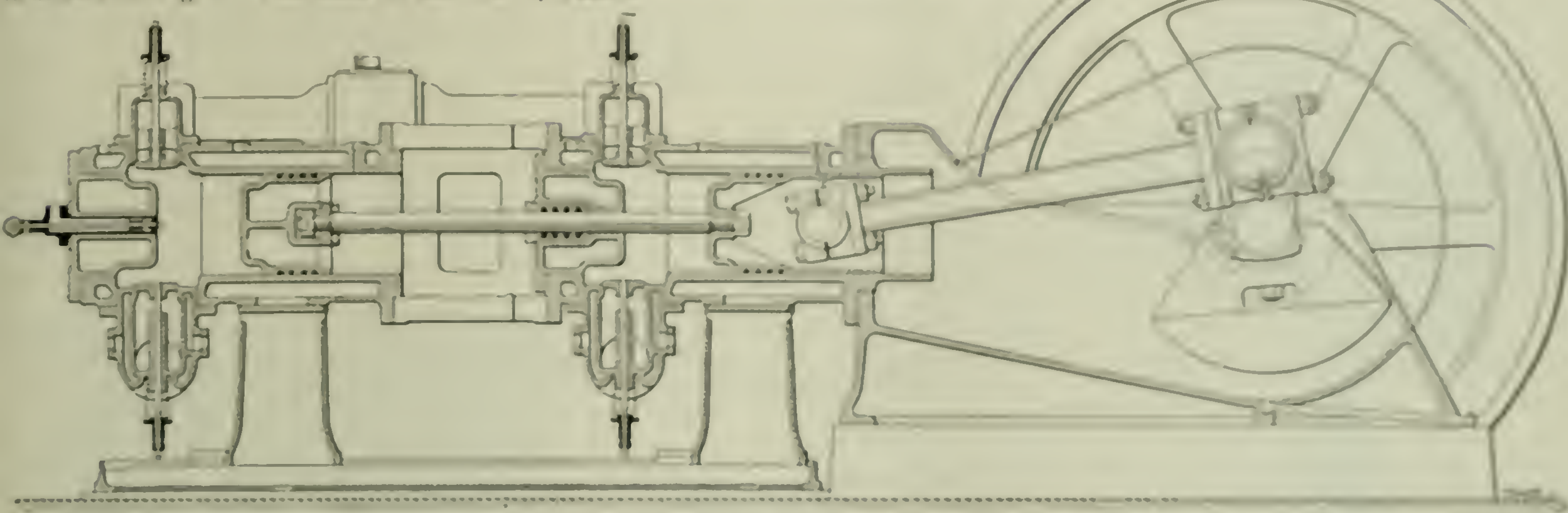


Fig. 3. Longitudinal Section of Ajax Tandem Engine

The connecting-rod construction is so clearly shown in Fig. 3 that description is unnecessary. A practical feature of the crank-pin box is that the two parts are exactly alike and therefore interchangeable. The balancing weights of the crank are fastened to the ends of the crank cheeks by massive studs and nuts, and the nuts are housed in a little pocket in the weight, as shown in Fig. 3.

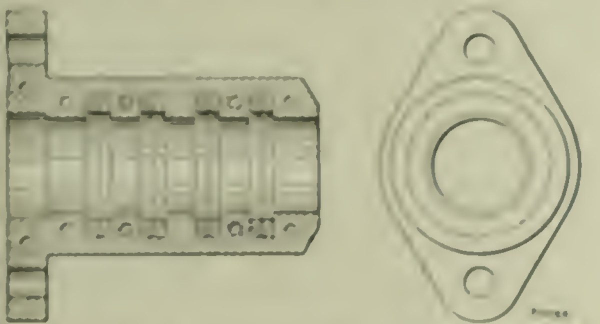


Fig. 4. Piston-rod Packing

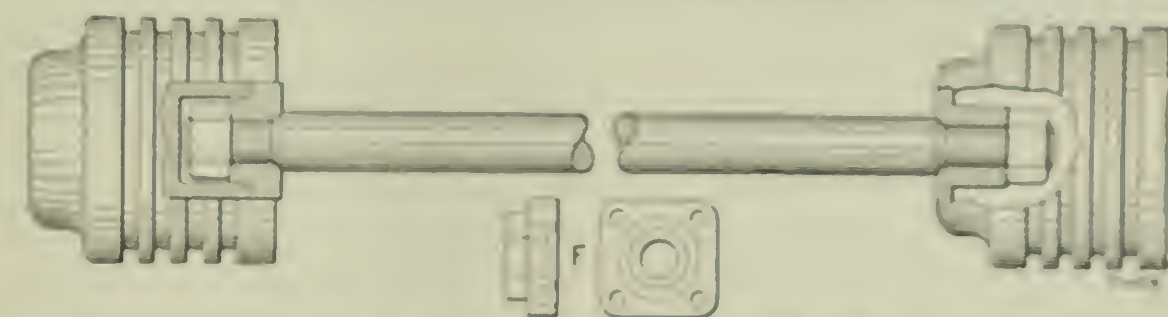


Fig. 5. Ajax Pistons and Piston Rod

The valves are of the ordinary poppet type, with the heads slightly crowned. They are opened by the usual arrangement of cams, rollers, push rod and rocker arms. The exhaust-valve cage is water-jacketed very thoroughly, as Figs. 2 and 3 show, and the walls are of uniform thickness at all points. Fig. 6 shows the inlet and exhaust valve cages, complete with valves and springs. The mixing chamber is located midway between the inlet valves of the front and rear cylinders, as may be seen in Fig. 1, and contains a combined mixing and throttling valve which is controlled by the governor. This valve is of the multiported cylindrical form and is oscillated by the governor to vary the port openings according to the load demands. A plug cock in the gas entrance to the mixing box is adjusted by means of a handle to get the proper proportion of gas to air.

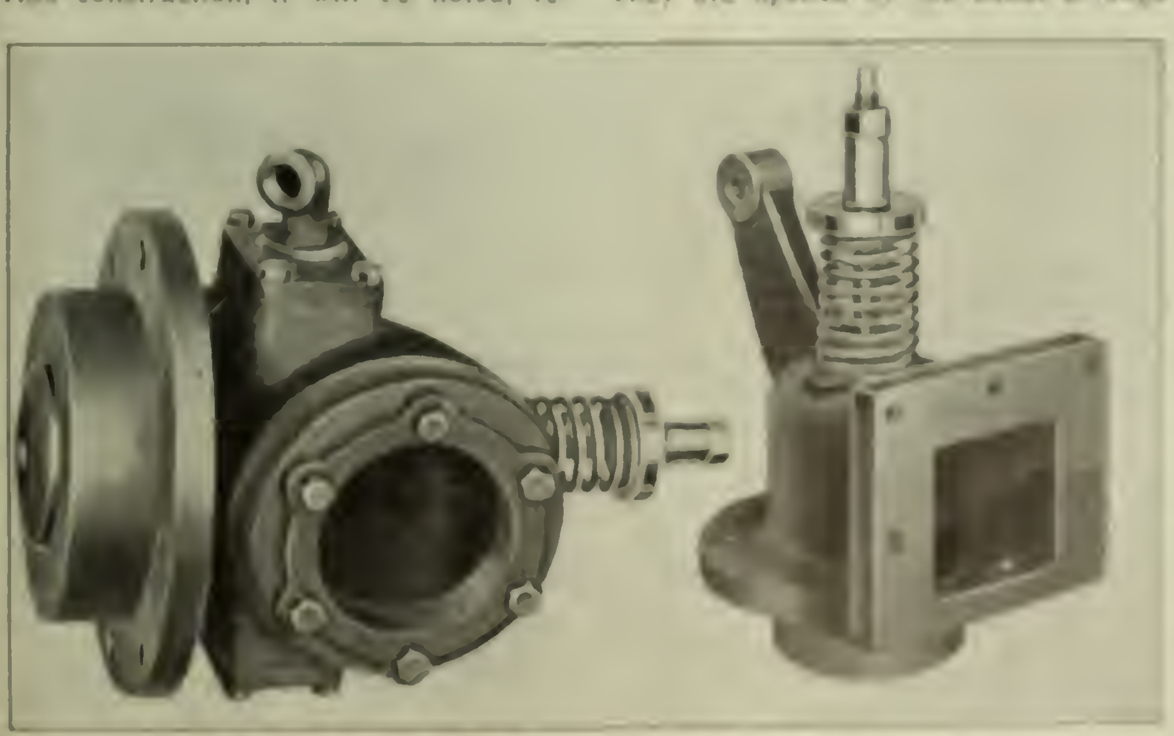


Fig. 6. Exhaust and Inlet-valve Cages and Valves

The governor, Fig. 7, is a modification of the Hartung type and is provided with a thumb-screw adjustment by means of which the speed can be changed while the engine is running. It is gear driven from the cam shaft.

Make-and-break igniters are used and they are of the simple mechanical type, tripped by cams and push rods. Current for the igniters is supplied by a magneto generator, which is mounted on a bracket on the side of the forward cylinder and is belt driven by a pulley on the cam shaft; this arrangement is shown in Fig. 1.

The main features of the engine which reflect care and forethought on the part of the designer are these: The engine frame, which is of the double-wall box type, is provided with an oil groove all around the bottom edge to catch waste oil from the various bearings; the water jacket of the exhaust-valve cage is so constructed that the cooling water enters near the bottom on one side and must

FIG. 7. THE GOVERNOR

pass upward to the top of the valve before it can get out; all wearing parts of the governor run in an oil bath; the mixing and throttling valve is mounted on ball bearings and copious lubrication is provided between the periphery of the valve and the wall of its cage; the cam shaft is divided into sections, coupled together at points corresponding to divisions in the main structure; all of the moving parts are on one side of the engine and all of the piping is on the other side; all

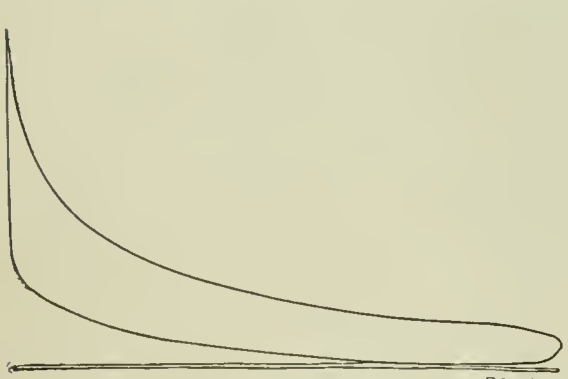


FIG. 8. AN AVERAGE DIAGRAM. SCALE 275 POUNDS AS PRINTED

cams, rollers and pins are hardened; every pair of rubbing surfaces is lubricated, including pivot pins and rocker hubs; the proper settings of the ignition timer and the gas cock for starting and running are marked plainly on those parts; an auxiliary safety attachment on the governor will cut out the ignition current if the speed should go beyond the maximum advisable rate; either cylinder can be cut out of action while the engine is running, leaving the other cylinder to do all the work. This last-named feature is of more value than it might appear upon first thought. In places where an engine has to carry less than half load for a considerable part of the day, cutting out one cylinder during that part of the run effects a very important saving of fuel.

The indicator diagrams, Figs. 8 and 9, are representative of the performance of the engine; they were selected by the writer from a large number of diagrams in preference to some which were more symmetrical but which did not truly represent average performance, as these do.

The engines are built in single-cylinder form for small outputs, single tandem form for medium sizes and twin tandem for the larger outputs.

A Narrow Escape from Gas Poisoning

According to a New York daily newspaper, the night engineer of the Newton (N. J.) Gas and Electric Power Company recently had a narrow escape from death by gas poisoning. The story is to the effect that the engineer, who was alone in the power house, was taking a reading of the gas pressure in the main when he felt the sudden dizziness and weakness in the knees and back which indicate dangerous poisoning by carbon-monoxide gas. Realizing what these symptoms meant, he managed to crawl to the telephone, call up the day engineer and gasp "Help" in the telephone, before he lost his senses.

The day engineer, fortunately, recognized the voice and after getting into as few clothes as he could venture out of doors in he rushed over to the station. He found the night engineer unconscious

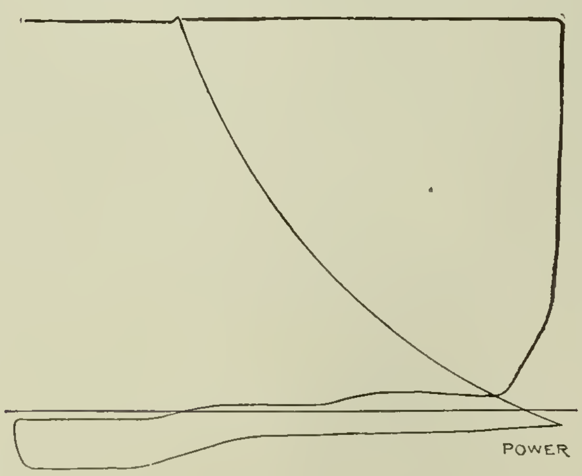


FIG. 9. AN AVERAGE STOP DIAGRAM. SCALE 13.6 POUNDS AS PRINTED

near the telephone, dragged him out into the fresh air and summoned a physician to attend him. Then he had the gas shut off the main that supplies the power house.

After two hours of hard work, the doctor succeeded in reviving the night engineer, and he has entirely recovered from the effects of the poisoning.

LETTERS

Sounds in Gas Engines

A knock in a gas or gasolene engine is often extremely hard to locate, as the same sound can be generated in several ways. A loose flywheel is sometimes responsible; yet it may be that the ignition is advanced too far, or there is pre-ignition from incandescent carbon, short-circuits or an overheated engine due to derangement of the cooling system. Lack of lubrication or using the wrong oil will cause a knock, but it is not such a distinctive sound as something loose or broken. Too rich a mixture or water in the combustion chamber will often cause uneven running which produces a sound that slightly resembles a knock.

Worn bearings will frequently cause an engine to pound in a most alarming way. Care should be taken not to set up a badly worn bearing too much; there is danger of throwing the whole shaft out of line and ruining the remaining bearings.

Sometimes when the compression is not uniform in all the cylinders of a multicylinder engine it appears to have a slight knock while in reality it has not; the cylinders with the better compression give stronger power strokes than the weaker ones, and this causes irregular running which is usually attributed to loose parts.

Hissing sounds are mostly due to loose igniters, loose or broken spark plugs, a cracked exhaust pipe, looseness in the exhaust manifold, open compression-relief cocks or worn gaskets.

The correct amount of good oil in the cylinders and bearings and plenty of hard grease or graphite paste in the gears and on other rubbing parts will prevent wear and the resultant noises.

A. L. BRENNAN, JR.

New York.

The largest installation of Diesel engines yet ordered is that which is being built by Franco Tosi, of Legnano, Italy, engineer, and he has entirely recovered. for the city of Rome. The order comprises two Diesel engines of 1000 horsepower each, and three of 2000 horsepower each, to operate on the two-stroke cycle. The engines will run at 136 revolutions per minute and be direct connected to three-phase generators of 8200 volts. The contract includes the operation of the engines for ten years by the manufacturers. The plant will furnish electricity for the city, pending the development of the water power of the River Aniene, which will not be completed for a couple of years, and probably used as a standby after the completion of the hydraulic works.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Through Fire and Water

Electrical apparatus is generally considered to be less rugged than some other classes of machinery, but the accompanying illustrations indicate that it can pass through severe ordeals without irreparable damage. The pictures are those of two Bullock motors taken from the ruins of the *Los Angeles Times* building. After the explosion and fire which recently destroyed the building these motors were removed from the basement where they were lying in five feet of water. The printing presses to which they were attached were completely destroyed and had no value except as scrap iron. The motors, however, were not badly damaged and were practically the only articles of value saved from the ruins. In the adjustment of losses made by the Fire Underwriters Association, 99 per cent. of the total insurance was allowed, the 1 per cent. saving being based almost entirely on the value of the motors. The insulation of the machines was destroyed, but the commutator bars and cores, brush holders, bearings and frames were in good condition.

SIXTY-HORSEPOWER DIRECT-CURRENT MOTOR AS IT CAME FROM RUINS

TEN-HORSEPOWER DIRECT-CURRENT MOTOR AS IT CAME FROM RUINS

The motors attracted considerable attention and excited much comment because of the fact that they were the only pieces of machinery saved from the ruins. The larger motor is a 60-horsepower, 500-volt machine, and the smaller one is a 10-horsepower machine. They are now being rewound in the shops of the manufacturer and will be used to drive new presses in the new building which is soon to be erected.

The Fan Motor in Winter

It is the popular opinion that the range of usefulness of the electric fan motor is limited to the summer months and that its sole utility lies in its application as a means of reducing the temperature of a room or an office. This is not true, however, and slowly but surely the public is beginning to understand that the usefulness of the fan motor is by no means confined to the hot days of summer, and that, paradoxical as it may seem, the electric fan blows hot or cold; and incidentally while it is blowing hot it cuts down the fuel bill. Following are a few of the more important applications of the fan motor to winter use:

The efficiency of the hot-air heating system may be greatly increased by placing a fan motor in the cold-air box to force the air through the registers to all parts of the house. On particularly cold days, when the wind is so strong that it forces the air through the furnace into the rooms without having become heated, a fan motor placed in the cold air box, after having closed the slide which permits air to come in from the outside and opening the slide which lets the air in from the cellar, will cause an appreciable rise in the temperature of the room, without making any increase in fuel consumption.

As is very often the case, the house contains one or more rooms which under certain conditions are difficult to heat. This difficulty can be overcome by placing a fan motor in front of the hot-air register, or over it in case the register is located in the floor. This plan will prove more efficient if the register and fan motor are covered by a box or hood of some kind which will cause the fan to draw air from the pipe only, and not from the room.

Another service to which the fan motor may be applied to advantage in winter is preventing the accumulation of frost on the show windows of stores. The air from the fan motor directed against the glass of the window will keep it practically free from frost. This application of the motor is a boon to merchants who have heretofore lost during cold weather practically all the advantage which their window display would have afforded them.—*G. E. Review.*

An Excessive Magnet Drag

By Richard Clemens

We have at our power plant a 200-kilowatt, direct-current, 250-volt Thompson-Ryan generator, direct connected to a 20x22 McEwen simple automatic engine, running at 180 revolutions per minute. This dynamo has 14 balancing field-magnet coils, with 14 other field coils, making 28 coils in all. When the dynamo was installed we had an experience which may interest some readers of POWER.

The installation of the plant being complete, we began an acceptance test of the engine and generator, using three large barrels filled with salt water as a rheostat to put the load on the generator. The engine was started, and everything seemed to be going very satisfactorily. The voltage stood at 250 with no load, and compounded to 270 as the load was increased up to 700 amperes. After running for an hour or little more, the water in the barrels began to foam and boil over, and in adjusting the terminals to reduce the load, an attendant accidentally short-circuited the generator, which knocked out the circuit-breaker. The engine regulated well, but when the breaker was reclosed the voltmeter showed only 200 volts.

Careful tests showed that the speed was normal, the brush yoke was in the proper position, the rheostat in the field circuit was undamaged and the connections were all sound. Then we began a systematic search for the trouble. We investigated the various connections around the machine, the connections the armature leads; in fact, everything but the right one. The magneto showed no grounds of any kind, or short-circuits. Finally, we tested the polarity of the entire twenty-eight field-magnet coils, not once but several times; but nothing was wrong with the polarity. For two days we kept this up, trying first one thing and then another. We called up the manufacturers, for they had a representative there to see the test, but their suggestions did not remedy the trouble.

On the following Sunday morning I got into communication with an old friend who had been on the road for years and, fortunately for us, he had had a similar experience. He advised us to take the machine apart and examine the dowel pin which holds the field coils in position. This pin is situated right at the bottom of the yoke ring and in order to get at it we had to remove the armature; sure enough we found the pin bent almost to a right angle. The heavy armature current due to the short-circuit when changing the terminals at the water rheostat had reacted on the field magnet with sufficient force to bend the pin and shift the position of the whole ring of coils. We replaced the bent pin with two of larger size, at the same time wedging each coil by placing a liner behind it. When the machine was put together again and driven at normal speed, the voltage went up to 250, and when the various loads were put on, the machine compounded perfectly.

CORRESPONDENCE

"Be Sure You're Right," etc.

The incident related in a recent issue of Power about the sweeper advising the engineer to pull the generator switch instead of using a brake on the engine flywheel reminds me of a somewhat similar scrape the other fellow got into once. In this plant, which is combined hydraulic and steam, we have a little trouble in pulling our peak load with water power alone, and in conjunction have a cross-compound condensing engine driving a 500-kilowatt generator and exciter to tide us over the rush. The main-drive pulley on the line shaft runs on a quill; so does the generator, both being connected by clutches to the main shaft. The exciter is belted direct to the main shaft.

One evening as the peak-load period was approaching, the engineer started the engine and coupled it to the main shaft, and this started the exciter. Overlooking the generator clutch, he went to the switchboard and put the exciter in parallel with the one already in service. Then he closed the generator-field switch, but with all the resistance cut out of the rheostat the voltmeter would not budge. Supposing that the fuses on the transformer were out of business, he proceeded to test them out, but found them all right. He pounded on the voltmeter with his fist until the glass cracked, but the hand still refused to move. By this time the load on the waterwheel had increased until the speed had dropped off so the lights began to get dim, but pulling his hair produced no useful results. The superintendent fortunately arrived on the scene about then and advised him to throw in the generator clutch.

Abe Fout.

Iowa City, Ia.

Identifying Alternating and Direct Current

Referring to H. Priestley's query on this subject, in the December 6 issue, I suggest that by attaching to the socket a plain carbon-filament bulb, turning the current on and holding one pole of a magnet close to the bulb, he can tell what kind of current is flowing in the circuit. The lamp filament will be attracted or repelled (according to which pole of the magnet is used) and will remain in the attracted or repelled position until the magnet is withdrawn, if the current be direct current; the filament loop will vibrate toward and away from the magnet if the current be alternating.

Another simple test, if no magnet is available, can be quickly made by screwing an attachment plug in the socket instead of a lamp and submerging the two terminals of the plug cord in salted water. If the current be direct, one of the terminals (the negative) will gas freely. A lamp should be connected in series with one conductor of the plug cord to prevent accidental short-circuiting.

There are in the market several inexpensive testing contrivances, but when these are not on hand just as positive results can be obtained by the methods described.

Alex. Dolphin.

Jamaica, N. Y.

There are several ways to determine whether the current in a lamp socket is direct or alternating. One way is to hold the poles of a horseshoe magnet close to the lamp bulb. If the current is direct, the filament will be drawn toward one of the magnet poles; with alternating current, the filament will vibrate between the two magnet poles. Another way is to wet a spot on a white pine board and stick the ends of two wires in the wet place about two inches apart, the wires being connected to a plug inserted in the lamp socket. If the board turns green around one of the wires, the current is direct and the wire producing the discoloration is positive in polarity. If there is no discoloration, the current is alternating.

If there are any arc lamps on the circuit it is easy to tell which kind of current is passing. Direct current will produce a blue tinge at the upper part of the arc and a pure white light below it. But this, of course, is not identifying the current at the lamp socket, as Mr. Priestley wishes to do.

An ordinary pocket compass also will indicate the character of the current. It is only necessary to place the compass on a wooden table or box, away from any large pieces of iron or steel, and hold a wire horizontally above the compass, parallel to the normal position of the needle. Direct current in the wire will deflect the needle to one side; alternating current will either cause it to quiver or have no visible effect on it—probably the latter. The wire can be one of two leads from the circuit to an incandescent lamp.

J. E. Bates.

Spokane, Wash.

[The foregoing letters were received before the January 3 issue went to press, but not quite early enough to be printed with the other letters on this subject that were published in that issue.—Editor.]

Static Electricity around Printing Presses

Will some readers kindly suggest through this department of Power the most practical way to overcome the static electricity that causes so much bother around printing presses?

A. W. Fish.

Argos, Ind.

Some figures are given in the annual report of the electricity department of the Manchester Corporation which show the progress made in recent years toward cheapening the engines, boilers and other machinery and plant used in the generation of electricity. For example, the costs per kilowatt erected at Dickinson street, Bloom street and Stuart street stations are respectively $98, $84.50 and $85.50. Most of the machinery at Dickinson street is not that originally erected in 1894. On the basis of the old machinery the cost would have been much higher. A reason for the exceptionally low cost at Stuart street may be found in the two large turbines there, which are considerably cheaper than reciprocating generating sets. Stuart street has also the advantage of large units, which means economy both of capital outlay and fuel and operating costs. Thus the fuel cost per unit generated is 0.288 cent at Stuart street and 0.394 cent at the other two stations. The total operating costs, including repairs, but not capital charges, are respectively 0.428 and 0.690 cent. Distribution, management and capital costs must, of course, be added, the total cost per unit averaging 2.28 cents, and the revenue 2.52 cents. Excluding capital charges, the total cost amounts to 1.22 cents. —*The Engineer.*

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Welded Steel Products

The tank shown in the accompanying illustration was made in Germany, and is used for the transportation of compressed Pintsch gas, used for lighting railroad coaches, the pressure carried ranging from 18 to 20 atmospheres. A riveted tank cannot be used for this work, as the constant racking and straining cause leaks which would be very serious in handling an inflammable gas. The tank is made of heavy plates with welded joints and the cost of manufacture is approximately the same as with riveted work, while the resulting product is infinitely superior. Welded work of this character is not a new product, but has been turned out in Europe for the last ten years, extremely complicated shapes being produced, while in the United States there is to my knowledge no concern able to produce work of this kind.

WELDED-STEEL TANK CAR

In Europe, plate welding has advanced to the stage where nothing is too difficult and it is used for the production of seamless cylinders and tanks of any practicable size. The water legs of boilers are readily produced; sulphite digesters, used in paper-pulp mills, of one-inch plate have been made 7 feet in diameter by 30 feet long, and larger. The bodies of buoys to be charged with compressed gas and which serve as floating beacons are another product of the plate-welding process, which is also used for producing corrugated fire boxes and boiler flues with the Galloway tubes welded in place. Steam headers and the military masts for warships, ornamental electric light and trolley poles, are other products, as are seamless tank cars for the transportation of fluids and the rotary kilns for cement mills.

In this country the welding of plates has been guarded as a secret process by the one boiler-making concern which uses this method of manufacture. The process has been closely guarded and the concern has been blindly asleep to the fact that an extension of the process was feasible to other parts of its boiler, and with the proper plant would cost them less than their present riveted work.

Besides, there is no real secret about the process they use.

Over ten years old, and nothing doing yet, in America.

WILLIAM DENISON.

Cleveland, O.

Reinforcing a Cracked Steam Cylinder

A rather novel repair of a transverse crack in the outside shell of a steam-jacketed, high-pressure cylinder of a vertical, triple-expansion pumping engine, working under 180 pounds steam pressure, and carrying this same pressure in the jacket, was carried out as follows:

In this case the heads were secured to the cylinder by means of studs tapped into the cylinder heads, and the problem was to tie the two heads together, with the cylinder between them without shutting down.

First wrought-iron bars of the same diameter as the studs were cut so that the combined length of any two of them was about an inch less than the distance between the projecting ends of a stud in the upper head and the one in line with it in the lower head. These were threaded as shown in the accompanying illustration.

Next some hexagonal iron pieces, of the same size as a United States standard nut for this size bolt, and a little more than twice as long as the hight of a standard nut were tapped to fit the studs and the bars. Finally turnbuckles were made of the same size hexagonal iron and tapped for right- and left-hand threads. Then, after screwing one bar into each end of the turnbuckle far enough to make the total length of the three pieces about equal to the distance between the ends of the studs, and screwing one of the hexagonal iron pieces onto the other end of the bars until the ends came flush with the hexagonal iron pieces, the whole was put in place and the hexagonal iron pieces screwed onto the studs, thereby partly unscrewing them from the bars. This had the same effect as the gaskets as the original ones had. Finally, by turning the turnbuckle, the desired strengthening effect was obtained and the cylinder has not given any trouble since.

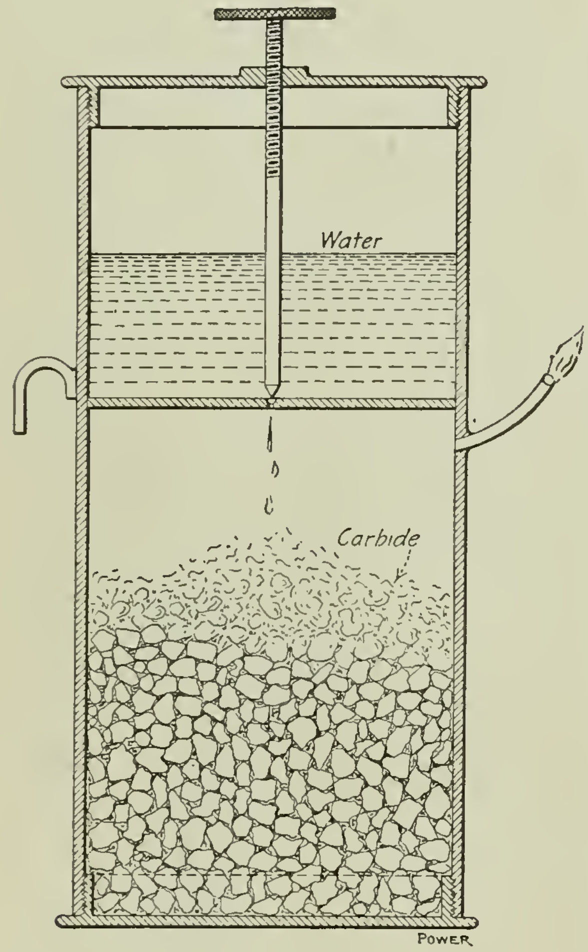
METHOD OF STRENGTHENING CRACKED CYLINDER

L. C. [illegible]

Buffalo, N. Y.

Acetylene Gas Lamp

The accompanying sketch represents a cross-section of a carbide-gas lamp that is very handy around the engine room. It was made from a piece of 1¾-inch brass tubing. The top and bottom caps and water stem were taken from the top of two old glass oil cups, the hole in the bottom cap being plugged. The burner



Section through Lamp

is a small piece of brass pipe taken from an old lubricator, and the hook is a piece of copper wire. The lamp will burn about two hours with one filling of carbide.

E. A. Heiny.

Springfield, Ill.

An Experience in Boiler Cleaning

On taking charge of an electric-lighting plant, in which were three 72-inch by 18-foot horizontal return-tubular boilers, I found them in bad condition. The best of the three boilers was badly scaled, but was capable of carrying the load alone, except on Saturday night. Either of the other two could carry the load Sunday night and until the lighting load came on Monday night.

The feed water was so bad that a boiler had to be washed after each week's run. Because of these conditions it was the custom to run the best boiler, No. 3, during the week, fire up one of the others to help on the Saturday-night load and carry the Sunday load on it while No. 3 was being washed and fired up again in time for the Monday-night load.

This process required the filling and firing up of two boilers each week, one of which was run but two days, so that its setting was cold each time it was fired. No boiler compound had been used and very little effort had been made to prevent further formation of scale, or to remove the old scale.

I immediately began using a boiler compound and set to work to remove the old scale from the boilers. A careful internal examination of the boilers was made and the assistant engineer was set to work getting off the scale from one of them. He spent an entire day at it and got off scale enough to show he had been at work, but it was hard work and a flue cleaner was purchased and by its aid about 500 pounds of scale was removed from each boiler.

After I had had charge of the plant about a month, boilers Nos. 1 and 2 would carry the load as easily as No. 3 had formerly, but as No. 3 received the same attention it was still the better boiler.

From this time on, the practice of firing up two cold boilers a week was discontinued and the fresh boiler that was cut in for the Saturday-night load carried it alone until the next Saturday night. This gave six days' time in which to cool, clean and repair No. 3 after each run, and as it was the most economical boiler it was used every other week, and a saving was made in several ways.

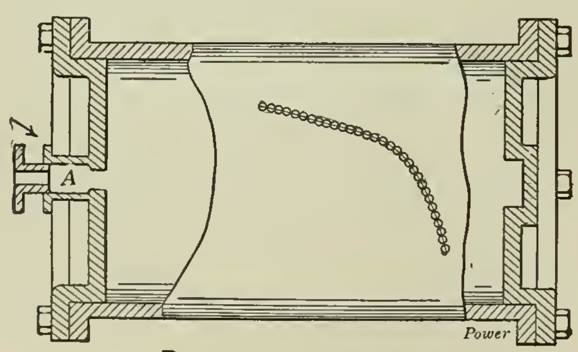
G. E. Miles.

Salida, Colo.

Cylinder Troubles

At one time a cracked cylinder was repaired in the engine room without removing it from the engine frame.

An electric drill was used to drill holes through the crack, which holes were tapped and a copper plug dipped in iron cement screwed into each hole, as shown in the illustration. Then the job was gone over with a hammer and filed smooth both sides.



Plugged Cylinder

An accident revealed a defect in an engine that had escaped detection for some years. The connecting rod was of the marine type, and one morning, when under light load, the heads flew off of the bolts, allowing the connecting rod to drop. It went through the floor, striking a joist on the outward stroke, and buckled the piston rod; on the return stroke the cylinder-head stuffing-box glands were also broken.

The stuffing box shown had not been bored out true with the cylinder, and one shoulder was nearly all on the bottom. There was a brass collar in the stuffing box that had been worn, there was no shoulder, and it had worked nearly into the cylinder.

We rigged up a device through the cylinder with a rod centered at the end of the cylinder and centered with the crank shaft at the other end, and secured a tool to the rod; then a crank was placed on the projecting end of the rod at the cylinder end and the stuffing box was rebored.

After finishing the repairs I noticed an occasional and peculiar knock in the engine which puzzled me for some months. I examined the stuffing box and found that the new throat collar that we had placed in it was a pretty loose fit, and when the piston was on the outward stroke the end packing contracted and the steam forced the collar against the packing. When the piston started on the return stroke the collar came back with a knock.

William G. Walters.

Stratford, Canada.

Valve Stem Broke

In the electric-light and power plant where I am employed as engineer, a boiler-feed pump failed to pump.

After going over the pump and testing the steam valves, I tried the gate valve on the discharge pipe and found it quite loose. Taking off the bonnet, I found the stem broken and the disks stuck on their seats. After removing the disks and replacing the bonnet the pump worked all right. It is these little things that, when found, help to simplify power-plant difficulties.

J. E. Dawson.

Cumberland, Md.

Put Shims under Knock-off Block

I have charge of an 18x36-inch Corliss engine, making 80 revolutions per minute, and the load varies from no load to 200 horsepower.

When the load was all thrown off, the governor would throw the knock-off cams so far back that the cam levers would strike the bolts that hold the springs on the steam hooks and that would cause the governor to jump and the engine to race.

To overcome this trouble I removed the knock-off blocks and cut out liners the size of the block from 1/16-inch sheet iron and drilled a hole in them for the screw and secured them under the blocks. I then readjusted the governor rods, and have had no trouble since. The governor works nicely, and the engine runs just the same with no load as with a full load.

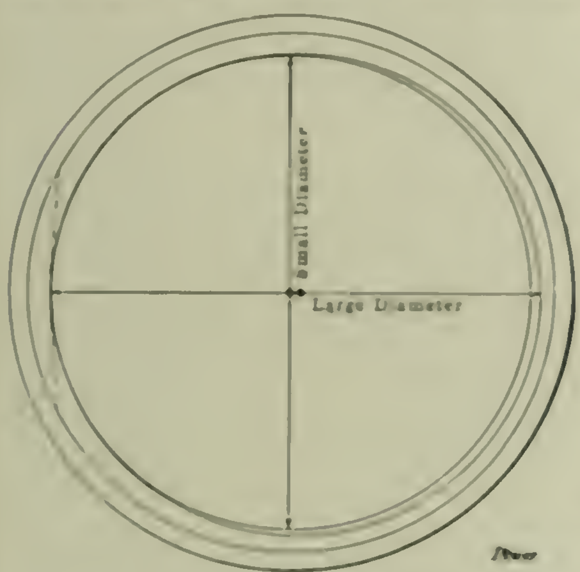
George H. Lee.

St. Louis, Mo.

Truing a Crank Pin

The subject of flat and badly scored crank pins is of interest to most engineers. A crank pin cannot well be taken out and trued up in a lathe, and it, therefore, falls to the lot of the operating engineer to devise some means of remedying the trouble, and the file is usually called into service.

The first thing to know is what size the finished pin is to be. The calipers



Two Sizes of Pin

are put on the flat pin to find its smallest diameter, which will be the largest diameter of the trued-up pin. Most of the wear is found on one side of the pin and consequently if the pin is filed true in the manner suggested, the center of the pin will be changed, thus shortening the piston stroke a little. However, this would not be very noticeable, and in a pin 1/16 inch out the difference in the stroke could easily be taken care of. If the pin were filed all around and the same center retained, the pin would be smaller than it would be if filed, using the new center; see illustration.

A piece of wire should be filed to precisely the same length as the finished diameter of the pin. The crank-rod boxes should be rebabbitted and bored, using the wire as a gage. The boxes should be left as they come from the lathe without any scraping, as one-half of the box is to be used as a templet while filing the pin. A sharp bastard file will rasp off stock pretty fast, commencing at the heaviest part of the cut. One-half of the pin should be roughed down and practically finished before starting on the other side, often using the half box as a templet and filing down the high places untill a good bearing is obtained. The pin must also be filed as square with the crank as possible. Red lead should be used in the templet to mark the high spots when filing and should be used quite sparingly as too much lead will not show a true bearing. The least possible amount applied with the finger to just mark the high places will be enough.

After both sides of the pin have been brought down to a fairly good finish and as round as possible, the pin should be polished with emery cloth held in a clamp, such as is used to polish shafting. This clamp is made of two pieces of 3-inch stock with a section bored out about the size of the pin, and a piece of leather tacked on for a hinge.

The boxes should then be scraped, oil grooves cut, put together and not keyed up too tight at first, until the pin has fitted itself to the box a little. Then key up until a proper adjustment has been obtained.

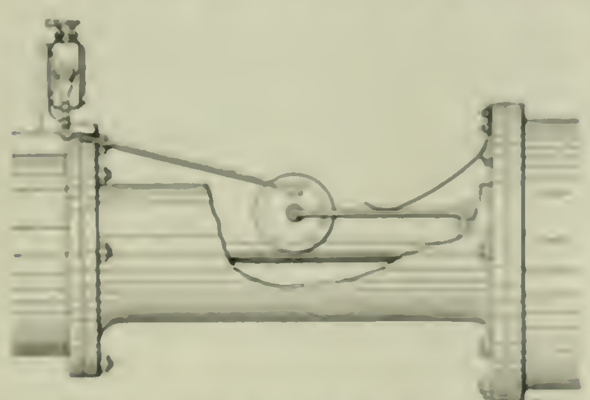
Charles H. Taylor.

Bridgeport, Conn.

Attaching a Force Feed Lubricator to a Pump

A question was put to me recently in reference to attaching a positive feed lubricator to a pump of which the only exposed moving part is the piston rod, the distance between the stuffing boxes being such as to leave no part of the piston rod not passing through the stuffing boxes to which connection can be made to obtain motion for operating the oil pump.

One method would be to put a grooved roll on the top side of the rod, and keep



Lubricator Attached to Pump

the roller in contact with it by means of a spring, the motion for the lubricator to be derived from the roller. The accompanying sketch gives an idea of the plan I would suggest. The roller should be made of some material that will make a good frictional contact with the piston rod, and also withstand the heat.

George J. Little.

Passaic, N. J.

Cemented Cracked Pipe

A [illegible]-inch cast-iron pipe was used as an intake from the river to the condenser-pump house. It was built in the form of a siphon and a piece 12 feet long cracked about half way around at the junction of one end and the flange.

The surface was cleaned with muriatic acid, washed with water and dried. Then an iron cement was applied and allowed to stand four hours. Although the line has a 12-inch vacuum, it has since given no trouble.

E. H. Lane.

Kansas City, Mo.

Measuring an Indicator Diagram

A fairly accurate method of measuring the area of indicator diagrams, when a planimeter is not at hand, is shown in the cut, and works out as follows:

Extend the exhaust line AC, and at the point A, which is the intersection of AC with a vertical line drawn through the end of the diagram, fasten a pin through the paper to hold one end of a thread.

The other end B is placed in such a position that the sum of the areas D and E is as near equal as possible to that of the areas F and G.

After this position has been obtained to the satisfaction of the eye, another pin is placed at the point B, the thread wound around it and the operation is again performed at C until the area of H is equal to the area of C.

In this manner the original diagram is supplanted by a triangle ABC of approximately the same area, which can be calculated by the following formula:

Position of Thread on Diagram

When AC equals the base and BK the altitude

$$Area = AC \times \frac{BK}{2}$$

After a little practice very close results may be obtained with this method, rough though it may seem.

[illegible]

New York City.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Two Hundred Horsepower Horizontal Boilers

I notice in the issue of December 13 an inquirer wants to know if horizontal tubular boilers are made in sizes of 200 horsepower. I know of two plants equipped with boilers of this size, 78 inches in diameter by 20 feet long, and containing 2000 square feet of heating surface.

I have had charge of four units of the above dimensions since their installation six years ago. The shells are built of 17/32-inch sheets in three courses: have quadruple-riveted double-strap joints and are designed for 150 pounds pressure.

The repair bills on the four amounted to $18 in that time. This cost was for having the fire seams calked on the inside as they showed a slight disposition to leak at this point.

The only other defects that have shown up are three or four fire cracks at the fire seam. These have not been serious enough to need more than calking.

As regards economy, we are not fixed for making accurate evaporation tests but believe they will hold their own with the water-tube type.

Our only objection to them is the curvilinear seam over the fire. At this point we have $1\frac{1}{16}$ inches of metal between the fire and water which is too much even if the boiler is kept free from scale. There has never been the slightest tube leakage. We were told that 4-inch tubes 20 feet long would give us no end of trouble by sagging, but nothing of the kind has occurred. So far as repairs are concerned we feel that no type of boiler could show a much better record. They have had the best of care and the feed water has passed through a purifying process before entering the boilers.

From my point of view it is a most short-sighted policy for steam users to supply their boilers with water containing scale-making impurities when there are at least a dozen concerns making purifying apparatus that will remedy the trouble. Bad water in a boiler makes for poor economy in the use of fuel and high repair bills.

Some things that boilermakers do are hard for me to understand. One thing is, for instance, they put 6-inch steam outlet nozzles on a 200-horsepower boiler and the same size on a 150-horsepower. I suppose I am about the only engineer who ever put a steam-engine indicator on a steam drum or header. I was trying to find out if the pressure in the drum pulsated with the engine. Also, I had a slight suspicion that the pressure was greater in the boiler than in the drum.

J. O. Benefiel.

Anderson, Ind.

Treatment of Subordinates

Several of the articles recently published in Power bearing on the treatment of help in the power plant were very fine. I have always found that a man, perhaps by good fortune, promoted to a place of authority, who takes advantage of his position by being tyrannous with those under him, very soon gets up against trouble. An assistant can ward off lots of annoyances for the chief engineer and he will if treated right. When a man treats his subordinates considerately they take an interest in their work, if they are the right kind of men, and will be on the alert to keep things about the plant in the pink of condition. If they do not show a desire to do this with fair treatment, they should be discharged. One does not have to put on a "big air" or look over the tops of the men's heads in order to hold a place as "boss." Often, this seems to be necessary to those who occupy places which they are not fitted to fill. Sometimes a man has a subordinate who could fill his place just as well or better than he does. In such cases the man "higher up" is usually extremely jealous. I remember a remark that was made to me one time some years since by a man of this type. He said, "You should not tell those young fellows all you know, for they will soon know as much as you do." I did not tell him that that would not be much. I reasoned that while the young fellows were learning, I could be doing likewise. I think that one should always show as much consideration as possible to those who are seeking information, so long as they are men of the right character.

I believe in good men—they are just a bit scarce—a good set of men means a good organization which not only means success for the chief but success for the plant. I tell you, boys, your subordinates can do a lot toward your holding your job; the fact cannot be disputed. The man who wants to learn should always be shown as he may make a mark some day which will reflect no discredit to the one who started him off.

It is often remarked that some men cannot stand good treatment. This is true and when such a one is discovered it would be well to let him find another occupation; the engine room is no place for him—what I want is a man that I can reason with, and treat in the right way. A man that has to be driven is not the kind that goes to make up a good organization. I want help from the coal bunker to the switchboard that will take interest each in his particular part of the work.

C. R. McGahey.

Baltimore, Md.

The Double Entasis

In Power for January 3, my attention was specially attracted to the chimney of the Queen Lane filter plant, that is, to the "pot-bellied" appearance of the shaft. There is nothing in mechanics, mathematics or beauty that justifies that shape, and it seems to me that the man who can make a thing that is dead wrong look better than one that is right, or nearer right, should have his taste cultivated. Mathematicians tell me that increasing the area to meet increased load would result in a concave, rather than a convex outline; anyway, the convex cannot be right. It is plain that the reason why chimneys are built larger at the bottom than the top is because there is more weight to be carried at the bottom than at the top, and the wind pressure must be withstood. It needs no figures to show that increasing the size above the bottom adds nothing but weight and wind-pressure area, neither of which is wanted.

I do not know but that the "swelled" columns are so common that people may have learned to believe that they look best. With a plain taper one, like the one mentioned, and one concaved like some of the Constantinople shafts, I am sure few, if any, would select the convex one as being the best looking.

John E. Sweet.

Syracuse, N. Y.

Chimney Problem

Referring to L. G. Watry's chimney problem in the December 27 issue, most of the hot gases will pass up the larger opening, and the chimney with the smaller opening will not be of much service.

The best thing to do is to divide the smoke box in half, which would make a separate stack for each boiler.

Another way would be to cut out stack No. 2 and build an addition to stack No. 1 and use this stack only, which is capable of producing enough draft for both boilers.

MIKE FUKER.

Chicago, Ill.

Does the Crosshead Stop?

I have been much interested in reading the discussion of the question, "Does the Crosshead Stop?" I would like to ask a question. If the crosshead does not stop for its return trip, what becomes of it, or, in other words, where does it go?

If a person is running a race and has to return over the same ground, he must stop for the fraction of a second as he turns to retrace his steps.

E. M. COBURN.

St. Johnsburg, Vt.

Boiler Efficiency of 82.36 per Cent

There is an error in the report of the boiler test in the issue of November 29, in which an efficiency of 82.36 per cent. is claimed, and if, as was stated, a bonus was "paid immediately after the completion of the official tests" on the basis of "$1000 for each per cent. efficiency above the contract requirements of 65 per cent.," or $17,360, then the Government paid several thousand dollars more than was justly due. It is well known that it is practically impossible to obtain from a water-tube boiler of the inclined-tube type, with an ordinary furnace, in which the tubes are directly above the fire, hand firing and soft coal, an efficiency above 76 or 77 per cent. Any higher figure indicates that an error was made either in the test or in the computation of the results. The errors that may occur in the test are the following:

1. Error in the calorimetric determination of the heat value of the fuel, giving too low a result.

2. "Stealing of coal" by the fireman.

3. Error in weighing the coal or the water.

4. Leaks of water from the boiler.

5. Error of judgment in estimating the quantity and condition of the fuel on the grate at the beginning and end of the test.

It does not appear from the record of the test that any of these errors were made. The heat value of the fuel per pound of combustible, 15,683 B.t.u., is within the range of what is found generally with Pocahontas coal, which runs usually between 15,600 and 15,900. The error in the figure given is not likely to be more than 1 per cent. There is also a possible error of 1 per cent. in the weight of water fed to the boiler, as it was weighed in tanks when very hot (the official record giving the temperature as 183.57 degrees), and must have lost some weight by evaporation from the surface of the three or four tanks and as it flowed from an upper tank to a lower one. These are only minor errors, but they may possibly account for $2000 of the bonus. The great error, however, is in the computation and it amounts to not less than 6.5 per cent., corresponding to $6500 bonus.

According to the record, the water evaporated under actual conditions per pound of coal as fired was 10.30 pounds. The weight of water fed was 129,218 pounds and the weight of the coal fired was 12,545 pounds. The coal contained 1.70 per cent. moisture, and the ash and refuse was 2.36 per cent. of the dry coal, making 12,006 pounds of combustible. The average feed-water temperature was 183.57 degrees, the steam pressure, 188.00 pounds, gage, and the superheat 98.70 degrees. Using the Marks-Davis steam tables, these figures give a factor of evaporation of 1.1391, which multiplied by 129,218 gives 147,192. The official report gives 157,312, a difference of 10,120 pounds, or 6.8 per cent. error. The economic results as reported and as corrected are as follows:

Equivalent Evaporation from and at 212 Degrees	Reported	Corrected
Per pound of coal as fired	12.[illegible]	11.[illegible]
Per pound of dry coal	12.[illegible]	11.[illegible]
Per pound of combustible	13.[illegible]	12.[illegible]

The efficiency, corrected, is calculated as follows: The calorific value per pound of the dry coal, as reported in POWER, being 15,202 B.t.u., and that of the combustible 15,683.8 B.t.u., the efficiency of the boiler is

$$12,283 \times 970.4 \div 15,683.8 = 75.86$$

per cent.

The efficiency of the boiler, including the grate is

$$11,040 \times 970.4 \div 15,202 = 73.81$$

per cent.

The reported efficiency, 82.36 per cent., is 8.55 greater than this, showing an error of

$$8.55 \div 73.81 = 8.6 \text{ per cent.}$$

as compared with 6.8 per cent. error in the equivalent evaporation from and at 212 degrees.

The capacity developed in the test is

$$147,192 \div (8 \times 34.5) = 533.3$$

horsepower

instead of 570 horsepower as reported, and the water evaporated from and at 212 degrees per square foot of heating surface,

$$147,192 \div (8 \times 4070) = 4.51 \text{ pounds}$$

instead of 4.82 as reported.

In all cases where a very high efficiency is reported as the result of a boiler test it is well to check the figures by making an approximate heat balance.

We have not sufficient data for a complete balance, but an approximate one may be made from the following:

Heating value per pound combustible, 15,683 B.t.u.
Probable analysis of the combustible, 91C, 5H, 4(O + N + S)
Air per pound combustible for maximum economy, say, 21 pounds
Dry gas per pound combustible for maximum economy, say, 22 pounds
Specific heat of gas, 0.24
Temperature of flue gases, 471 degrees; of fire room, 90 degrees
Specific heat of water vapor, 0.48
Moisture in coal, referred to combustible, 1.84 per cent.
Moisture in air at 90 degrees, assuming 60 per cent. saturation, [illegible] pound

Heat absorbed by the boiler per pound combustible, corrected figures, 12.283 × 970.4	11,[illegible] B.t.u. =	7[illegible] per cent.
Heat lost in the dry gases, 22 × (471 − 90) × 0.24	2,0[illegible] B.t.u. =	12.[illegible] per cent.
Loss due to moisture in coal, 0.0184 × (212 − 90) + 970 + (471 − 212) × 0.48	2[illegible] B.t.u. =	0.1[illegible] per cent.
Loss due to moisture in air, 21 × 0.0[illegible] × (471 − 90) × 0.48	1[illegible] B.t.u. =	0.[illegible] per cent.
Loss due to moisture formed by burning hydrogen of the coal, 0.05 × 9 × (212 − 90) + 970 + (471 − 212) × 0.48	548 B.t.u. =	3.49 per cent.
	14,294 B.t.u. =	91.[illegible] per cent.
Loss due to radiation, to C burned to CO, to unburned hydrocarbons and to fuel lost through the grates	1,389 B.t.u. =	8.[illegible] per cent.
Total	15,683 B.t.u. =	100.00 per cent.

The corrected efficiency, based on the combustible, of 75.86 per cent., is a very satisfactory and creditable result, but it is not more than might be expected from such a boiler with Pocahontas coal, when the "high percentage of CO_2 (12.46 per cent.) was obtained by close supervision of the draft." The figure indicates not only that the setting was in good condition, but that the firing was good.

It is difficult to understand why a bonus was offered for each per cent. of efficiency above 65 per cent. That figure would be an exceedingly low result for any good type of boiler using Pocahontas coal, hot feed-water and with expert firing. The difference between 65 and 75 per cent. means a bonus of $10,000. Why should the Government offer to pay such a large bonus for a performance that is no higher than might reasonably be expected? Why should a bonus ever be paid on the performance of a standard apparatus, such as a water-tube boiler with an ordinary grate, when the dimensions, heating and grate surface, etc., are all specified in the contract? Unless the price of the boiler without the bonus was lower than the ordinary or normal price it appears that the Government is "out" the whole amount of the bonus, $6500, on account of an error in computation of the results of the test, and nearly $11,000 on account of an error of judgment in drawing the specifications and contract.

William Kent.

New York City.

Automatic Nonreturn Valves

I noticed an inquiry from Louis J. Corilla in the December 20 issue in regard to "Automatic Nonreturn Valves."

For the past three years I have had charge of forty 10-inch and ten 4-inch valves of this type and have never noticed a failure to close. Several times in this time one has failed to open, but the trouble is always due to a gummy deposit on the plunger of the valve, which can easily be cleaned off by simply removing the valve bonnet and using cool oil and fine sand paper. They do not chatter, neither do they wire draw the steam. As for their value, I simply state that there should be a law making their use compulsory in plants of any size. We have had several tubes blow out, but we did not know anything about it in the engine room until it was all over. In one plant of four water-tube boilers I was shut down once by a feed pipe breaking off at the drum where we had no nonreturn valve. I also know of a 5000-kilowatt plant being completely shut down two times for the want of these valves. The only thing to guard against is this gum on the plungers, and two hours per year per valve will take care of this.

E. H. Lane.

Kansas City, Mo.

Accumulators for Furnace and Boiler Capacity

In the editorial, "Accumulators for Furnace and Boiler Capacity," in the November 29 issue, we read the following:

"It has been one of the first precepts of a boiler room to keep the pressure constant, but it is a question if the boiler pressure cannot be allowed to vary through a considerable range with less damage to the over-all efficiency than would result from the constant manipulation of the damper and the slice bar necessary to hold it constant. At the pressure ordinarily carried, a considerable pressure drop will produce a comparatively insignificant change in the initial temperature, and it is the temperature range which affects the efficiency!"

For one, I am sorry that the writer of the paragraph just quoted did not go a little more into detail relative to constant boiler pressure and its attending advantages or disadvantages as the case may be; therefore, I am in hopes that this writing may bring out some more points along this line.

In the first place, just what are we to understand by "the over-all efficiency"? Second, what would be the allowable variation in boiler pressure? Third, if a considerable variation is permissible, it seems to me the allowable range would be governed somewhat by the nature of the steam in use; that is, saturated or superheated.

The temperature of saturated steam at 130 pounds gage, 145 pounds absolute, is 355 degrees and the total heat in the steam above 32 degrees is 1190 heat units. With a gage pressure of 115 pounds, 130 pounds absolute, the temperature is 347 degrees, and the total heat in the steam above 32 degrees is 1187 heat units. We note by these figures that with a drop of 15 pounds pressure there is a drop of only 8 degrees in the temperature of the steam and a loss of only 3 heat units. Now, if in these two cases the steam is flowing through a superheater and is getting 100 degrees of superheat in the first instance, it seems to me that in the second case the cooler steam—even though a large number of pounds may be passing in a given time—will take up sufficient additional heat units, not only because the temperature of the steam is lower but also because the temperature of the hot gases circulating is increased, due to the stronger draft made necessary by the increased demand for steam, to make the final temperature of the steam the same in both cases. If these statements are correct, it would seem that a variation of at least 15 pounds in the steam pressure would not affect the final results when superheated steam is used.

It would seem, too, that with saturated steam and a variation of only 8 degrees, the economy would be affected but little, if any; yet, my experience is not in accord with the theory stated, as the following will show:

In a certain power plant, running 16 hours per day, two firemen were employed, working eight hours each; one would carry the steam pressure at or near 110 pounds throughout the entire eight hours, with but little need for the use of the slice bar, the damper being handled by a regulator. The other man, working his shift under precisely the same operating conditions as to load, length of time, etc., would have the steam pressure anywhere from 90 to 110 pounds, would use the slice bar much more than the other man did and burned 500 pounds of coal more; and it made no difference which shift this man worked, the results were the same.

Now, while looking into the matter a little further and from another viewpoint, we will grant the statement, as probably correct, that the "over-all efficiency is not affected by a considerable variation in the range of boiler pressure!" However, it seems to me that there are other conditions, aside from the effect on the efficiency, produced by permitting a considerable variation in the range of the boiler pressure, which are not favorable to continuity of service and which should make it desirable to carry the pressure as nearly uniform as possible. Of course, the intervals of these variations will determine somewhat the deleterious effects produced.

It is well known that with every change in steam pressure there is a corresponding change in the contour of the boiler, the effect being more marked in the lap-seam boiler than in the butt-joint type, with detrimental results in the latter case as well as the former. Then, too, with the fluctuation in the steam pressure, there must be a variable furnace temperature, with more rapid deterioration of furnace walls and boiler, due to excessive contraction and expansion, than would be otherwise if the temperature were more uniform.

I am well aware that it would be a hard matter to determine the effects produced by some of the conditions mentioned above; however, I am desirous of bringing out the ideas of others along this line, for I believe it will be beneficial to those of us who, as yet, have a great deal to learn.

A. K. Vradenburgh.

Albany, N. Y.

Handling Men

I was interested in J. M. Row's letter on the above subject which appeared in a recent issue. It contains some sound general advice, and, if followed, no doubt it would result in financial benefit to both employer and employee. I wish to say here a few words about the different systems of handling help, and, as fairly as I can, compare the results obtained. The three plants discussed are each of about 5000 kilowatts capacity.

The first is a plant, one of a chain, supplying power for street-railway service. It is in charge of a chief engineer who has under him three assistants, three oilers, five firemen, four cleaners and coal passers and one repairman and his helper. The salary of the chief is fair, but that of the rest is low. The main duty of the assistant is to watch the switchboard, keeping the voltage steady, throwing in the circuit breakers when they come out, and reading the wattmeter and to note the temperature of the feed water hourly. He does no repair work and must not be absent from the switchboard even to start an extra engine, which is done by the oiler. In fact, his work is simply that of a switchboard tender, a job which could be very satisfactorily filled by a bright fireman. Yet the assistant engineer must hold a first-class engineer's license. The repair work is looked after by a repairman of steam-fitting experience only, under the direct supervision of the chief. His hours correspond to those of the chief's, except that he is subject to calls at all hours of the night. As these, however, are extra time for him, naturally he is called to attend to those things only which are absolutely necessary to keep the plant running.

The condition of the plant as to orderliness and cleanliness is above reproach, and the casual visitor would readily believe that this is a model plant. The steam pipes from the boilers to the engines and their auxiliaries, however, pass through a basement tunnel, which cannot be seen from the engine-room floor, and, indeed, its dimensions are barely discernible even when fronting it in the basement; but its presence is positively made known by the large number of steam leaks. It stands to reason that one ill-paid repairman and a helper, plus the chief engineer, who, of course, cannot be expected to do more than supervise the work done, cannot possibly maintain a station of this size in sound condition. Consequently, the whole equipment from the governors of the engines to the blowoff valves suffers. Yet no man can point to anything that is very much out of repair. It is, no doubt, needless to say that it is not one single piece of apparatus in a large plant that is the cause of low economy, but the combined total of a lot of little things, each of which may be only a little bit out. And here are the figures to prove this in the case of this station:

Average number of pounds of coal consumed per kilowatt per hour, 3.6; labor per kilowatt per hour, 0.11 cent; cost of fuel and labor per kilowatt per hour, 0.6752 cent.

Yet this station has all the help necessary to maintain it in first-class condition, if the system of managing the help was changed only slightly, as is proved by the next case.

This plant is another street-railway power station, of about like equipment and capacity. It is operated by a chief engineer and two assistants, four oilers, eight firemen and five coal passers. Out of this gang, ordinarily, there are available for repairs and cleaning up, about five men. The chief engineer's wage is fair; that of the rest of the men is good. When the assistant engineer comes on his watch he finds written on a sheet of paper a list of the repair work necessary to be done that day. All the spare help report to him, and it is his duty to divide the work among them according to their abilities. He sees that all do their portion properly, and that each uses the required stock to the best advantage and without waste. It is surprising the amount of repair work that can be done in a few hours by the men, who soon become highly trained. Jobs that 90 per cent. of other power houses would send for outside help to do, are here thought very little of. Of course, they have all the necessary tools, such as drill, lathe, shaper, etc., to do their work with. The result is highly efficient apparatus, but not a very good-looking plant. By the latter is meant that the visitor will find the paint scratched off nuts and the surrounding metal, and, here and there, a chunk of asbestos covering off some of the steam lines. But he will find no leaks, either steam or water, nor will he see any clattering apparatus, which has to hustle to make good. The log-book figures for this station are as follows:

Pounds of coal per kilowatt per hour, 2.5; labor per kilowatt per hour, 0.16 cent; cost of coal and labor per kilowatt per hour, 0.552 cent. The coal costs 20 cents per ton more at this station than at the other.

Taking all of the figures, such as cost of repairs, etc., this station delivers the same amount of work as that in the first case, at a saving of $175 per week.

The next case is that of an electric-light station which is seven years older than the two samples considered above, but outstrips both in economy of operation. It is presided over by a chief engineer who, after giving much intelligent thought to the handling of his help, developed a system which, in my estimation, is nearly perfect. It is never essential for him to ask, "Who did this, or who did that job?" And none can evade responsibility by stringing that oft repeated excuse, "The other fellow don't do it." He has all of the men in competition with one another, and he has a method of rewarding those who try to do their best, without showing favoritism to any.

To describe the system fully in this letter would take too long, and to attempt to describe it briefly would not do it justice. Suffice it to say now, that his method is somewhat similar to that used in the second case, but, in addition, every man has a certain task for which he is held responsible. For instance, one assistant engineer is responsible for the general good behavior of one engine; he must see that the boxes are properly keyed up, all lost motion in the valve gears taken up, etc. Again, one oiler, though he must look after and keep clean all running apparatus, is responsible for the bright work on one engine only. It will easily be understood that one assistant tries to keep his engine running as well as, or better than, the other's engine, and that one oiler tries to outshine the other. This competitive system, carried from assistant engineer to coal passer and directed by a tactful chief, who knows how to maintain it, works wonders, as the following figures prove:

Pounds of coal per kilowatt per hour, 2.34; labor per kilowatt per hour, 0.13 cent; cost for coal and labor per kilowatt per hour, 0.5319 cent.

WILLIAM POWELL.

Ashland, Mass.

The Chief and His Subordinates

There often seems to be a feeling of resentment on the part of the chief when he is approached by an assistant who is striving to rise to a higher place in his chosen profession. During my short career as an engineer I have found but one chief who was willing to explain things in detail.

I well remember an experience with one of those men who do not have time to listen to the operating engineer's suggestions.

The plant consisted of one 150- and two 100-horsepower tubular boilers, carrying steam at 120 pounds gage pressure; one 18x42-inch Corliss engine; one 100-kilowatt alternating-current and one 2000-volt direct-current series arc machine, belted to a line shaft.

I found the flues half full of soot and after a little talk with the fireman was able to get him busy with the flue cleaner. Then, I rigged up a device for blowing the flues and had them blown morning, noon and night. When the fireman found that I was working for his interests, conditions began to improve, insofar as our end of the plant was concerned.

The chief never found fault with me at any time, for if he had I would have looked for another job right away. I am always willing to listen and want to learn all that I can, and it is the height of my ambition to be a chief and if ever I attain that position, I will spare no effort to be worthy of the trust placed in me.

M. V. MILLER.

Fort Snelling, Minn.

Blowoff Piping

In the issue of POWER for December 20, I noticed a letter by Edward Hamilton describing the blowoff arrangement in his boiler plant. That this arrangement is a satisfactory one is due to the manner in which the blowoff pipes are protected from the heat, and to that only, as a little consideration will show that his so called circulation pipe in no way affects the result. If the connection is made as shown in the sketch that accompanied his letter, that is, into the steam space of the boiler, all the circulation that such an arrangement would give would be that due to the condensation of the steam in the small riser, which would be of no practical value.

Had this pipe been made the full size of the blowoff connection and then carried into the boiler above the first row of tubes and below the water line, the results would be different.

O. B. [illegible].

[illegible], Penn.

A Method for Getting High CO_2

Orosco C. Woolson sends in the following belated discussion of the paper upon "Combustion and Boiler Efficiency," presented to the recent meeting of the American Society of Mechanical Engineers, by Edward A. Uehling.

To secure practical benefit from any CO_2 recorder it is necessary not only to have the apparatus properly installed, but to have its readings correctly interpreted, taking into account potent conditions which might exist, abnormal or otherwise, and which would prove a puzzle to many, and even to an expert should he be lacking in a keen appreciation of such conditions.

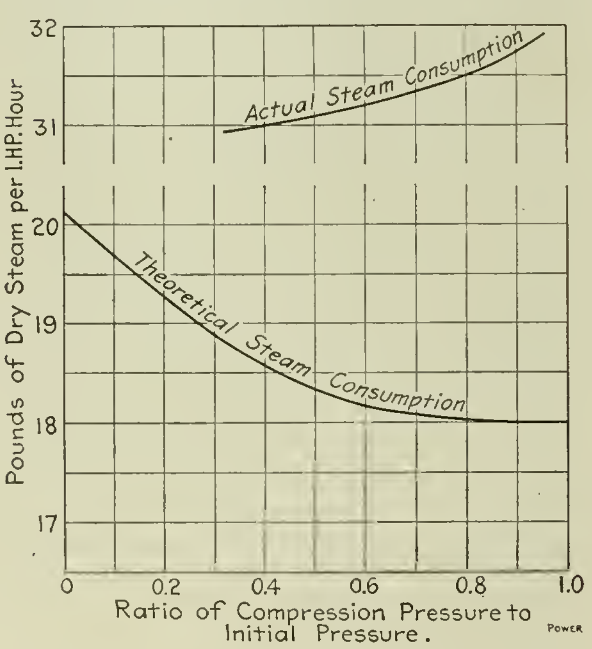
To get at the business end of the question so that results shall show on the right side of the ledger is, in my estimation, a difficult thing to accomplish, and unless some other explanation can be offered for so many CO_2 recorders being out of business in different power houses, I am forced to the conclusion that we are attempting to establish a too refined apparatus for determining what is required to obtain the greatest value from our boiler plants except for expert testing.

I have an invention of my own which I have tried for some years to put into everyday practice. I have secured no patent on it, yet I will magnanimously permit any member in good standing in the society to appropriate it, to wit:

Say to your chief engineer, "Bill! the longer I live the more I find, by gracious, out and I find, by gracious, that it's time to raise your salary and I am only astonished that I did not find this out before, but don't think, Bill, this is philanthrophy on my part. I am going to make a CO_2 recorder out of you at about $300 per year, but I want you to save me $600 a year in fuel by devoting more of your time to the boiler room. Your assistants are quite capable of watching those automatic cutoff and turbine engines with their fine adjustments go around, but you know as well as I do that the fire room is lacking that careful and intelligent adjustment which it should have to secure the highest degree of 'actinism' possible, and, Bill, if you don't get on to that word, actinism, just look it up, for it's part of my CO_2 invention, and I want you to study up and produce for me the greatest actinic value that bituminous coal can accomplish. And, by the way, let me say this to you, don't let me catch you in the fire room with your coat off doing the work I am paying others to do, but you just use your brains that I pay for and notice whether the firemen, or, more properly speaking, the furnace tenders, keep their fire doors closed continuously or whether they are up to the same old trick of their youth of jerking the fire door open every time they walk up to the boiler. You have noticed, Bill, that that fire door is provided with a large peep hole that will admit of surveying the interior of the furnace all right, and, inasmuch as I paid for that hole, I want you to get the money's worth out of it; otherwise my CO_2 invention will record a minus mark against you. Now, Bill, you get busy and do as I suggest and the extra salary is yours at the end of the year and I shall be saving money myself. One thing more, Bill, if you find after careful investigation you think it would be better, all around, to build a trestle alongside of our boiler house sufficiently high to admit of spouting the coal direct into the magazines of those furnaces instead of dropping the coal clear down to the fire-room floor, for the sake of lifting it up again to feed the furnaces, just let me know, and we will see if we can't accomplish still further good results; but, as I remarked before, you get busy on the boiler room and you will find that what Mr. Uehling says is beginning to be recognized as essential for good results, is true."

Compression in the Steam Engine

The *Sibley Journal* for December contains a contribution by Prof. R. C. Carpenter upon the subject of "Compression in the Steam Engine." The article is in the nature of a review of what has been done to settle this controversial question and contains the results of a test conducted by the author several years ago upon the high-pressure cylinder of a triple-expansion Corliss engine at the Sibley College experimental laboratories.



THEORETICAL AND ACTUAL STEAM CONSUMPTION

Three sets of runs were made at a vacuum of about six inches with constant pressure at the throttle, constant cutoff and varying compression, the degrees of compression being 42.8, 66.3 and 87.2 per cent. of the admission pressure. The steam consumptions on these runs were respectively 31.03, 31.3 and 31.7 pounds per indicated horsepower-hour. The increase in the water rate with increased consumption is here so slight as to have very little effect upon the economy of the engine, but, nevertheless, it is opposite to what a theoretical treatment of the subject would indicate.

The accompanying chart shows the actual steam consumption as plotted from the tests and the theoretical steam consumption of the engine working without cylinder condensation. The slopes of these curves are opposite, although the theoretical curve shows a very slight improvement in economy after the ratio of compression to initial pressures passes 60 per cent. The discrepancy is undoubtedly due to losses the exact nature of which is not well understood and, as Professor Carpenter remarks, "It is evident that further investigation is necessary to find out what is the matter with our theory."

It is proposed to make further investigations along this line in the laboratories of Sibley College with a view to throwing light upon the discrepancy between the predicted and the actual results, which information should go far toward settling the controversy which is now being waged between the adherents and the foes of compression.

In the annual report of *Lloyd's Register*, recently issued, reference is made to the use of internal-combustion engines for marine purposes. With this type of engine there is considerable difficulty in effecting the reversal of the direction of rotation of the engine, and when these engines are used for marine purposes the astern motion of the screw has usually been obtained by the use of toothed-wheel gearing. Comparatively recently there has been a development in the Diesel oil engine for marine work. A two-stroke cycle has been successfully adopted, and the reversal is effected in the engine itself, the crank shaft being directly coupled to the screw shaft. The Diesel oil engine is now being fitted to three fairly large vessels being built on the Continent under the supervision of the surveyors of *Lloyd's Register*. One set is being constructed on the older principle of the four-stroke cycle with single-acting cylinders, and will be of about 450 indicated horsepower. Another set is being made on the two-stroke cycle, also single acting, and is intended for a twin-screw vessel, the power being about 900 indicated horsepower on each shaft. The third set is being made on the two-stroke cycle double-acting system, each cylinder providing two impulses per revolution; this also will be fitted in a twin-screw vessel, the total power being about 1800 indicated horsepower. In each of these cases the engines will be directly coupled to the screw shafts. A set of internal-combustion engines is being constructed under the society's survey in this country for a vessel of about 260 tons.

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Notice!

The publishers of the paper called *Steam* have written us protesting against the statement on the first page of the year that POWER was made up of a lot of papers, including one called *Steam*, and asking us to place the matter right before our readers, which we are glad to do here and now.

POWER bought its rival, named *Steam*, a long time ago and carried the name as part of its own title for more than eight years.

The new paper calling itself *Steam* took that title—which it had a legal right to do—but this cannot prevent us from truthfully making the statement we did.

Certainly we can hardly be expected to apologize because our esteemed contemporary used a second-hand name that we had dropped.

Conservation of New York State Water Powers

The recent proposal of Governor Dix to abolish the New York State Water Supply Commission and the renewed activity on the part of the New York Board of Trade toward the flooding of a portion of the State forest preserve again bring to the front the important question of conserving the water powers of the State. According to official reports the water power now in use in New York State, excluding the Niagara and the St. Lawrence rivers, which are international streams, amounts to six hundred and twenty thousand horsepower, while the surveys show that there is eight hundred and eighty thousand horsepower still undeveloped. The principal reason for over half the total available water power of the State being undeveloped is the uneven stream flow; many streams which overflow their banks and waste millions of gallons into the sea every spring, shrink to mere rivulets during the dry summer months. Therefore plants located on such streams would require auxiliary steam equipments having a capacity nearly equal to the maximum power demand.

In 1907 the Water Supply Commission was created, and after three years of careful investigation submitted plans and recommendations for the construction of four great storage reservoirs to be located respectively on the Genesee, Sacandaga, Raquette and upper Hudson rivers, in addition to several smaller ones. By means of these reservoirs the stream flows could be regulated, resulting in a reduction of the great pecuniary damages caused by the periodic recurrence of floods and affording a constant flow for power purposes. It was proposed that the State issue bonds to the extent of twenty million dollars for the construction of these reservoirs and that they should be entirely under State control, the use of the water being leased for terms of fifty years to consumers at nominal charges which would be sufficient to produce a revenue to the State. A bill to this effect was introduced in the legislature but powerful influences were exerted to bring about its defeat. The power users were willing to pay an assessment sufficient to meet, in fifty years, the interest and sinking-fund charges on the bonds, but they insisted upon the right to use the water without charge and in perpetuity after the State had been reimbursed for its outlay.

Later the power users induced the legislature to pass a bill granting their demands through an amendment of the "River Improvement Act" but Governor Hughes vetoed it. The next step in this direction was an amendment to the constitution, introduced by Assemblyman Merritt, which provided for the flooding and the construction of storage reservoirs in the forest preserve, but this was worded so as to ignore any revenue to the State from the power development. This amendment must be approved by another legislature and then submitted to popular vote before it can become effective, but it is hoped that its shortcomings will have been recognized before that time arrives.

A comprehensive development of the available water powers would, undoubtedly, be a great boon to the manufacturing industries in western and northern New York. At the same time, the interests of the people at large make it imperative that such developments must be entirely under State control and produce a fixed revenue besides. This is especially important in view of the fact that water-power privileges, amounting to two hundred thousand horsepower at Niagara Falls alone, were given away to private individuals before the State awoke to the necessity of changing its policy. One of the strongest arguments in favor of State control is that it would place the water at the disposal of anyone willing to pay for it, and thus guard against monopolistic control, provided the *proper form of contract* and impartial administration are applied.

While it is conceded that the best interests of the State demand the adoption of a policy as herein outlined, the extent to which actual construction should be carried on at present demands careful consideration. Certain groups of individuals are advocating its immediate application to all the undeveloped water powers of the State; this would include the clearing and flooding of several hundred thousand acres of State forest lands. Yet there is no guarantee that a large part of the power thus made available would be used in the near future, and the people of the State would be carrying the burden of expense until such time as the utilization of all the power would make the investment self-supporting. This phase of the subject is important in view of the fact that New York City would bear nearly three-fourths of the expense and would be only remotely benefited by the results. Therefore, it is expedient that for the present, storage reservoirs be built only where there are prospects for the immediate sale of the power produced.

The Proof of the Pudding

Suppose you were the owner or manager of a mill and upon the recommendation of your master mechanic had put a device upon your boilers which produced a large saving in coal. If tests made and reported by the master mechanic were criticized as nonsensical and impossible, if engineers and physicists proved by figures that no such results were attainable and scientists demonstrated scientifically the fallacy of the principle upon which it were based—but if your coal bills were less week after week and month after month, what would you say?

You would be apt to say that "The proof of the pudding is in the eating" and to give the inventor or the vendor of the device an enthusiastic letter of recommendation.

And it is by such a process as this that the enthusiastic and sincere indorsements which inventors and vendors of devices which contravene all the laws of physics and the principles of mechanics are obtained.

In a big New England mill, some of the boilers were equipped with a device which was supposed to decompose steam by the heat of the furnace and to add its hydrogen to the available fuel. The master mechanic tested it and reported an evaporation of over sixteen pounds of water with a pound of combustible. Engineers denied the possibility of any such a performance. Those who knew demonstrated that it cost more than it was worth to produce the hydrogen, but the treasurer said, "Here are the only figures that interest me," produced his diminished coal bills and ordered more of the devices.

What are the facts?

Here was a battery of fifteen 175-horsepower boilers, aggregating 2625 horsepower, connected to a six-foot chimney one hundred and seventy-five feet high, good, by any formula ordinarily used, for only about half that capacity. These boilers are mulling along with an insufficient air supply, doing only sixty-odd per cent. of their rated capacity, with the furnaces piled full of coal and producing gas to be sent off unburned up the chimney. This device with its steam jets is put on, the master mechanic, after "lots of trouble," gets his firemen trained to fire as directed, and behold—the diminished coal bills.

Of course, the boilers are not evaporating anything like 16.69 pounds of water per pound of coal. The master mechanic is evidently not a trained testing engineer and has fooled himself. Of course, the decomposed steam, if it really is decomposed, is of no net value as fuel.

The diminished coal bills do not establish a contravention of well known natural laws nor prove the value of a device based upon an evident fallacy. They simply do prove that the efficiency of the boiler plant has been improved and that could have been done by any change which secured an adequate draft and the same amount of drilling of the firemen, and at a cost considerably less than ten dollars per horsepower.

Smoke and CO_2 Recorders

If the smoke which comes out of a smokestack were only as heavy as it is black, and would fall down in chunks on the head of the fireman who made it, firemen would lose no time in inventing some kind of device to warn them when such an eruption was about to occur.

We have steam gages on our boilers so we may not get the pressure too high and do us an injury. We have water glasses to warn us not to get the water too low, and now we want some simple apparatus to determine the percentage of CO_2 in the products of combustion and to determine their temperature so that we may be warned against the production of black smoke. Of course, we have the CO_2 meter and the pyrometer at the present time, but the cost, the delicacy and the unfamiliarity of the ordinary operator with either the instrument or the deduction of applicable knowledge from its indications have hindered the wide use of such apparatus, especially in small plants. Still, the day may come when the fireman will look to his CO_2 gage and his pyrometer as confidently and intelligently as he does now to his water glass and steam gage.

In a recent test of great importance, because it was to determine the suitability of a certain boiler for use in battleships of the United States Navy, Lieutenant Commander Dinger, one of the board of naval officers in charge of the test, in referring to the use of the CO_2 meter, said:

"The fireman soon became very much interested in the results of the gas analysis, and realized the value of so firing as to maintain as high a percentage of CO_2 as possible. This interest manifested itself very early in the tests, in the decreased density of the smoke escaping from the stack."

The foregoing remark in regard to the decreased density of smoke is of particular interest at the present time while cities all over the country are laboring to prevent smoke by the use of ordinances.

Compression as a corrective of clearance losses is gradually losing its hold. Prof. R. C. Carpenter in an article on "Compression" in *The Sibley Journal* says: "I have reached the conclusion that the loss of work caused by compression may in practice offset the gains which would otherwise be produced. The reason why the practical engine shows no improvement in economy with increase of compression is not clearly known. There is need for investigation and research of a high order before general laws or conclusions can be stated."

He quotes Professor Jacobus who, in a paper presented to the American Society of Mechanical Engineers, said: "The experiments prove that for either equal amounts of work produced or for equal points of cutoff the cushion steam in an engine should not in general be compressed as high as the initial pressure in order to obtain the best economy, but to some lower pressure, thus verifying conclusions arrived at by theory."

According to the official estimates of the Department of the Interior, the available water power in Canada is capable of developing more than twenty-five million horsepower annually; which, if produced from coal, would represent a consumption of approximately five hundred and fifty million tons per annum. This is excellent data for those individuals who are looking forward with so much apprehension to the time when the coal supply shall have been exhausted.

The pioneers of the air are sacrificing their lives freely in the cause of future navigation in the ocean of space, says the daily press. That is no reason, however, why an engineer should screw down the safety valves on his boiler to keep it from blowing off steam.

It is better that an engineer should know all about a safety valve than enough about hyperbolic logarithms to get by the examiner.

Inquiries of General Interest

Lap Crack

What is a lap crack in a boiler?

P. C. V.

It is a crack in that part of the sheet that laps over the other and extends along near the line of rivets.

Braces in Heine Boiler

Has the Heine boiler any braces and, if so, where?

B. H. B.

There are braces extending across the opening from the drum into the water legs and the flat surfaces of the water legs are supported by staybolts.

Mud Drum Nipples

If the nipples between the headers and the mud drum of a water-tube boiler are renewed and leak after repeated rolling, what can be done to stop the leaking?

M. D. N.

Get a mechanic who knows how to do tube expanding intelligently.

Advantage of Butt and Strap Joints

If a double-riveted lap seam has an efficiency of 75 per cent. and a double-strap and butt joint has the same strength, what is the advantage of the butt joint over the other?

B. S. J.

In the boiler with a lap seam the shell is never round, and as the pressure tends to make it round the sheet bends near the lap, and the repeated bending which takes place at every change of pressure, however slight, finally cracks the sheet. In the boiler with the butt joint the shell may be made round at the start and no change of pressure will alter its shape and start a crack. It is believed that no boiler having a double-strap butt joint has ever exploded.

Pump Compression Valve

If the compression valve on a duplex pump is closed, what effect does it have?

D. C. V.

The compression valve controls a passage between the steam and the exhaust port in the cylinder and when closed prevents steam from flowing from the steam port to the exhaust through this passage after the piston has covered the exhaust port. Thus considerable steam is trapped in the cylinder and compressed, shortening the stroke of the piston.

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Factor of Safety and Water Pressure

If, with a factor of safety of 5, a boiler has a working pressure of 150 pounds, how much cold-water pressure will it stand?

S. W. P.

With a factor of safety of 5, the calculated strength of the boiler would be 750 pounds, and the effect of internal pressure would be the same whether produced by steam or water. If tested by hydrostatic pressure, it would be carried to 50 per cent. above the working pressure, or, in this case, to 225 pounds.

Hunting of Engine Governor

What is the probable cause of "hunting" by a Corliss engine governor?

H. E. G.

Undue friction between the moving parts; too heavy oil in the dashpot, or oil on the belt making it slip.

Position of Eccentrics

With two eccentrics on a Corliss engine, the steam eccentric moving in the direction of rotation to open the valve and the exhaust eccentric in the opposite direction to open the exhaust valves, what will be their relative positions on the shaft?

P. O. E.

Both eccentrics must rotate in the same direction with the shaft. If the steam eccentric is directly connected, it must be set 90 degrees plus the angular movement necessary to overcome the effects of the lap and lead of the valves ahead of the crank in the direction of rotation. If the exhaust eccentric is indirectly connected to the valves, it must be set 90 degrees minus the lap and lead of the valves behind the crank.

Pounding in Low-Pressure Cylinder

In starting up a cross-compound Corliss engine there is a pound in the low-pressure cylinder which seems to be all over the cylinder. But when it is up to speed with the load on, it runs quietly. The same thing happens in shutting down after the load is thrown off. What causes the pound?

P. L. C.

It is probably caused by too high compression. When starting, the receiver pressure is low and the excessive compression in the cylinder forces the inlet valves from their seats and at the end of the stroke they fall into position with a bang. When the receiver pressure rises it holds the valves to their seats during compression and the engine is quiet.

Lap of Steam Valve

What is lap in a slide valve, and what is the object in giving lap?

L. S. V.

Lap is the distance the edge of the valve extends or laps over the port when it is in the middle of its travel. Lap is given for the purpose of cutting off the flow of steam to the cylinder before the stroke of the piston is completed, thus using steam a part of the stroke expansively.

Pressure in Water Main

If a standpipe 80 feet high is full of water, what will be the pressure in the main?

P. W. M.

A column of water one foot high will exert a pressure of 0.433 pound at the bottom. If the top of the water in the standpipe is 80 feet above the pressure gage, it will show a pressure of

$$0.433 \times 80 = 34.64 \text{ pounds.}$$

Reciprocal of 3.1416

In getting the circumference of a circle I saw a man divide the diameter by a number instead of multiplying. What was this number and how did he get it?

R. O. P.

He used the reciprocal of 3.1416; that is, he divided 1 by 3.1416 and obtained 0.3183 which he used as a divisor. Multiplying one number by another will produce the same result as dividing the first number by the reciprocal of the second. For instance,

$$4 \times 3.1416 = 4 \div 0.3183$$

Reciprocals are frequently used to avoid division as multiplication is a shorter and easier process. For instance, it is desired to divide 32 by 2.5. The reciprocal of 2.5 is 0.4 and

$$32 \times 0.4 = 12.8$$

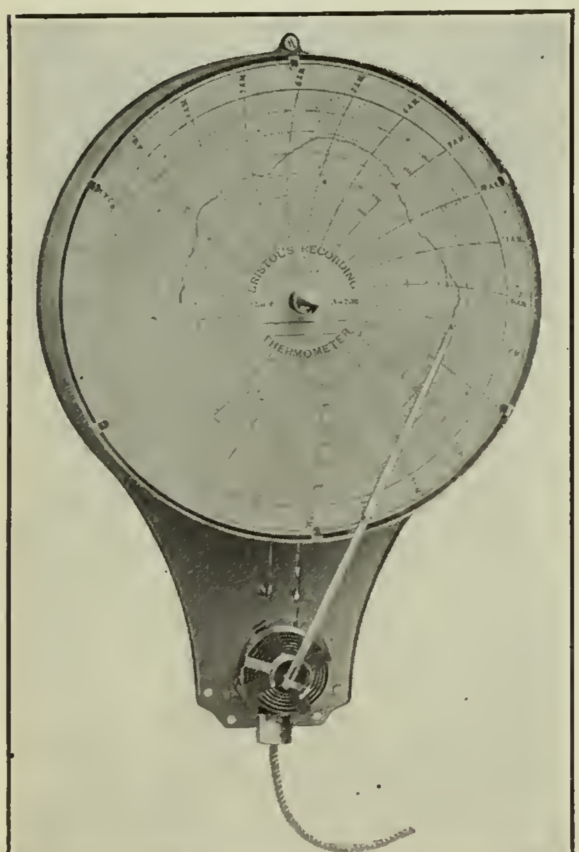
is shorter than long division.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Bristol's Compensated Gas Filled Recording Thermometers

During the last fifteen years, Bristol recording thermometers have been constructed in various different forms, depending for their operation on the expansion of a liquid, the expansion of the vapor of a liquid or the expansion of a gas. These thermometers have been used for ranges of temperature up to 800 degrees Fahrenheit, but the model equipped with flexible connecting tube between the sensitive bulb and recording instrument and depending for its operation on the expansion of a vapor or a



New Bristol Recording Thermometer

gas has not until recently been adapted for recording the lower ranges of temperature.

A new compensated gas-filled recording thermometer has recently been developed for recording the lower ranges of temperature, such as atmospheric temperature, temperatures of water, temperatures of brine in refrigeration systems, etc., and found satisfactory in numerous tests. These thermometers are equipped with a patented compensating device which automatically corrects for changes of temperature at the recording instrument.

The thermometers are equipped with a sensitive bulb and flexible capillary connecting tube and a patented pressure tube, the sensitive bulb and flexible connecting tube and spiral pressure tube all being filled with an inert gas under pressure. Changes of temperature at the sensitive bulb cause corresponding changes in the pressure of the confined gas and these changes in pressure are measured and recorded by the recording instrument. The sensitive bulb is usually about 10 inches long and 3/4 inch in diameter and the volume of gas contained in this sensitive bulb is very large in proportion to the volume of gas contained in the fine capillary connecting tube between the sensitive bulb and the recording instrument, thus making the error due to changes of temperature along the connecting tube negligible.

The important new feature of this thermometer is the patented compensating attachment for the spiral pressure tube, since a thermometer equipped with this compensator gives the same readings or record when the temperature at the recording instrument changes as it would if the temperature at the recording instrument remained constant. The need for such a compensator can be illustrated by the application of a recording thermometer for recording temperature of brine in a refrigeration system. The temperature of the atmosphere at the point where the recording instrument was installed might change, although the temperature of the brine at the point where the sensitive bulb was installed remained constant, and a recording thermometer for brine temperature should, of course, be so constructed that it would be affected only by changes of temperature at the sensitive bulb.

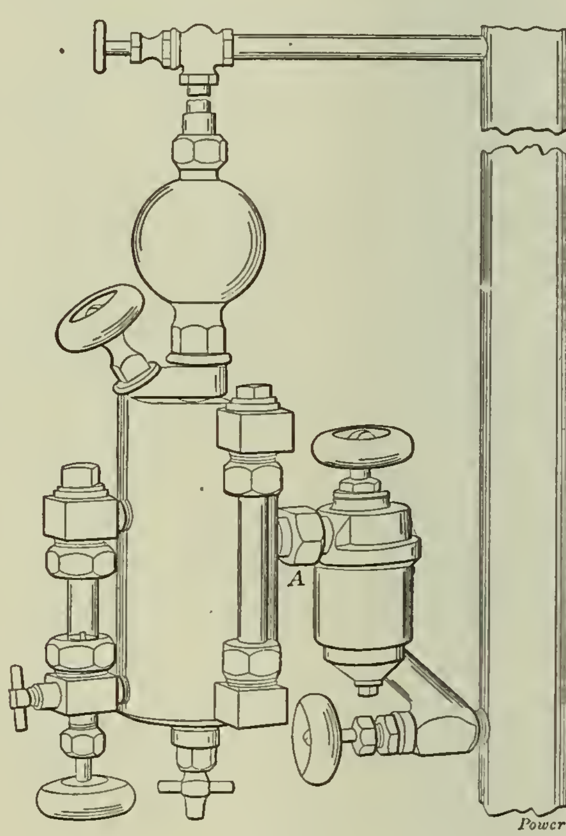
This instrument is manufactured by the Bristol Company, Waterbury, Conn.

If the wood handle has been broken from a monkey wrench, a serviceable substitute can be made by slipping a piece of hose over the wrench, then filling the hose with babbitt.

Graphoil Lubricator

The illustration shows the manner in which this lubricator is attached to a hydrostatic lubricator. The index connection *A* of the lubricator is made in various ways, so as to fit the connections of the different makes and sizes of oil lubricators.

The shutoff valve of the hydrostatic



Graphoil Lubricator

lubricator is dispensed with and the vertical and horizontal vapor pipes are changed slightly in length.

When used in connection with mechanical or simple systems of lubrication, the oil pipes are connected to the inlet connection *A* of the graphoil lubricator. This device is made by C. C. Stilwell & Co., 1215 Filbert street, Philadelphia, Penn.

A curious accident interrupted the operation of the Hudson & Manhattan power station a short time ago. The fine soot and dust from the back connections had been discharged and allowed to accumulate in the fan room beneath the boilers, and had been drawn by the fans into the air ducts and deposited as a coating of carbon upon their inside surfaces. In some unexplained manner this carbon took fire, and urged by the blast of the fans developed such a heat that the ducts were twisted all out of place, and the entire draft-producing mechanism of the station put out of business.

Features of Plant at Kodak Park Works

From the description of the oil-storage system used at the Kodak Park works embodied in the article under the above caption in the January 17 issue, the form of oil report shown herewith was inadvertently omitted.

K P 1782

Oil Report For 19

Departments	Engine Oil Gals.	Cylinder Oil Gals.	Water White Gals.	Grease Pounds	Cost For This Mo.	Cost For Average of Month
Engines in No. 31						
" " No. 1						
Air Compressor						
Millwrights						
Chemical Plant						
Roll Coating						
" Power						
Motor Oiling						
Boiler Room						
Conveyors						
Miscellaneous						
Total						

Cylinder Oil @ Per Gal.

Engine " @ " "

Isolated Plant Movement Permanently Organized

A fair start in the movement toward rescuing the isolated plant from the invasion of the central station was made at a meeting held Monday evening, January 16, at the United Engineering Societies' building, 25 West Thirty-ninth street. The attendance was large and represented the interests of the manufacturers and supply men, the consulting engineers and the operating engineers. It was voted to make the organization permanent and a committee was appointed to draw up a constitution and by-laws, the object of the organization being to collect facts and data through mutual coöperation and thus make possible a concentrated effort to advance the interests of the isolated plant.

It was suggested that the membership be divided into two classes, members and associates, the former to be made up of those who would receive the greatest pecuniary benefit from the campaign, such as manufacturers and consulting engineers, and the latter to include the operating engineers and property owners. While the latter would have equal representation in the movement, they would not be called upon to subscribe so heavily as the former. This contention is justified by the fact that the majority of engineers already pay dues in a number of organizations, and making the dues in this one light, would attract a larger membership of operating engineers.

At the next meeting, to be held in the same rooms on January 30, the constitution will be acted upon and permanent officers elected.

NEW PUBLICATIONS

The second edition of BULLETIN No. 4 of the Canadian Department of Mines is just out. The title of this work is "Investigation of the Peat Bogs and Peat Industry of Canada during the Season of 1909-10." The author is Aleph Anrep, Jr., peat expert for the Canadian government.

Reports are given on various peat bogs located in the eastern section of the Dominion, including the bog at Alfred, owned by the government. A complete description of the peat plant at the bog, together with numerous illustrations, is also given.

The bulletin is accompanied by eleven plates illustrating the Alfred bog and the equipment of the peat plant.

DYNAMO BUILDING FOR AMATEURS. By Arthur J. Weed. Published by the Norman W. Henley Publishing Company, New York, 1910. Eighty-three pages, 5x7½ inches; 64 illustrations. Price, cloth $1; paper 50 cents.

The problem of designing and building a 50-watt direct-current dynamo is taken up in detail, dimensioned working drawings are given for each piece of machine work and all important operations are illustrated. With the exception of three small castings, all the parts can be made on a small foot lathe.

The treatise should prove both instructive and useful for the amateurs and students in manual-training schools as this little machine embodies the same principles as found in larger machines. When used as a motor in connection with a set of batteries it will drive a small drill press, lathe or sewing machine.

OBITUARY

Charles Hill Morgan, prominent as a mechanical engineer and manufacturer, died at his home in Worcester, Mass., January 10. Mr Morgan was born at Rochester, N. Y., Jan. 8, 1831, of New England parentage. His father was a mechanic and from him the son received that love of machinery and mechanical engineering which has been one of his most remarkable characteristics.

His first invention of note was a system of designing and constructing cam curves for looms. In 1868 he was made general superintendent of Washburn & Moen Manufacturing Company, and for eleven years was one of the company's directors. During his service with this company he improved the continuous rod-rolling mill, designed and originally constructed by George Bedson, of Manchester, Eng.

Nine years after the construction of

CHARLES HILL MORGAN

the Bedson mills, a third mill from new designs furnished by Mr Morgan was built on the Belgian and continuous plans. This mill, the result of Mr. Morgan's studies, was known as the combination mill. The third improvement was the invention by Mr Morgan of an automatic rod reel of the pouring type.

This was completed and gave a successful test in March, 1880. The automatic "laying" reel, now in common use in nearly every rod mill in the world, was the joint invention of Mr. Morgan and F. H. Daniels, another inventor of Worcester.

After 13 years of continuous service with the Washburn & Moen Company, Mr Morgan resigned his position as general superintendent in 1887. He had previously founded the Morgan Spring Company, which came into existence in 1881, and now devoted his entire attention to its development. From the manufacture of steel springs only, the scope of the business was enlarged into a general wire-mill business.

Four years later, in 1891, the Morgan Construction Company was incorporated to manufacture rolling-mill equipment and wire-drawing machinery. The work of Mr. Morgan and his associates in this company has been most successful and their designs of machinery have been widely adopted.

Besides his executive work, Mr. Morgan found time to become interested in the Worcester Polytechnic Institute, with which he has been connected in an official capacity for many years. He was, up to the time of his death, a trustee of the corporation, as well as being one of the active workers on the shop committee of the Institute.

He became a member of the American Society of Mechanical Engineers in 1881, the year following the society's establishment. He served as manager from 1884 to 1887, and was honored by an election as president of that society for the term 1899-1900. He was also a member of the American Institute of Mining Engineers.

While an engineer of exceptional ability and wide-spread influence, he has always been unassuming and never made the least effort to obtain recognition. He had a large circle of friends in Europe, where he spent much time in travel. In 1900 Mr. Morgan was elected to honorary membership in the Société des Ingenieurs Civil de France, and he was for years a member of the British Iron and Steel Institute.

His principal monument is the large number of young men he has helped. He was never too busy to see a young man and none ever left his presence without being richer and stronger in ambition and courage.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

GAS ENGINE. Henry K. Holsman, Chicago, Ill. 980,263.

INTERNAL COMBUSTION ENGINE. Henry L. F. Trebert, Rochester, N. Y. 980,366.

ROTARY ENGINE. William Birrell and James Birrell, Carbonado, Wash. 980,402.

GAS ENGINE. Otto J. Kirchen, Hancock, Mich. 980,423.

HYDRAULIC ENGINE. August Sundh, Yonkers, N. Y. 980,449.

ROTARY CYLINDER EXPLOSION ENGINE. Clyde J. Coleman, New York, N. Y., assignor to Rockaway Automobile Company, Rockaway, N. J., a Corporation of New Jersey. 980,491.

INTERNAL COMBUSTION ENGINE. Joseph S. Cortelyou, Brooklyn, N. Y. 980,494.

STEAM TURBINE. Ellis F. Edgar, Woodbridge, N. J. 980,504.

ROTARY INTERNAL COMBUSTION ENGINE. Eric Harald Ewertz, Wollaston, Mass. 980,506.

INTERNAL COMBUSTION ENGINE. Olof Ohlsson, Södertelje, Sweden. 980,552.

TURBINE. Joseph Knight, Holyhead, Anglesey, England. 980,644.

WATER WHEEL. Frederick Overfield, Cornwall, N. Y. 980,666.

WATER WHEEL. William C. Turner, Casey, Ill. 980,708.

ROTARY ENGINE. Paul Glamzo, New York, N. Y., assignor of one-half to Anton Razutocitch, Brooklyn, N. Y., and one-fourth to Baltrus S. Yankaus, New York, N. Y. 980,771.

INTERNAL COMBUSTION ENGINE. Otto Kraus, New York, N. Y., assignor to Kraus Engine Company, a Corporation of New York. 980,801.

BOILERS, FURNACES AND GAS PRODUCERS

FIRE GRATE. Ebenezer Hall-Brown, Kelvinside, Glasgow, Scotland. 980,247.

GRATE. James Walp, Allentown, Penn., assignor to Clara C. Walp, Allentown, Penn. 980,370.

GAS PRODUCER. Charles F. Miller, Pittsburg, Penn., assignor to the Westinghouse Machine Company, a Corporation of Pennsylvania. 980,660.

POWER PLANT AUXILIARIES AND APPLIANCES

LUBRICATING SYSTEM. Leon Alleman, Rochester, Penn. 980,178.

PUMP VALVE. John J. Ballard and Frank W. Parsons, Newark Valley, N. Y. 980,184.

WATER-LEVEL REGULATOR. Joseph E. De Bisschop, New Britain, Conn. 980,214.

SELF-CENTERING SHAFT PACKING. Edmund H. Farquhar, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 980,231.

PIPE COUPLING. John N. Goodall, Portsmouth, N. H., assignor, by mesne assignments, to Goodall Manufacturing Company, a Corporation of Maine. 980,245.

TURBINE BUCKET. Ernst Kallberg, Berlin, Germany, assignors to General Electric Company, a Corporation of New York. 980,283.

DRAFT REGULATOR. Theodore G. Meas, Lansing, Mich. 980,317.

OIL-CAN INDICATOR. Charles Scurlock, Pasadena, Cal. 980,348.

HOSE CONNECTION. Ira H. Spencer, Hartford, Conn., assignor to the Spencer Turbine Cleaner Company, Hartford, Conn., a Corporation of Connecticut. 980,355.

BLOWOFF VALVE. Anthony Nicholas Anderson, Albany, Ga., and Frederick W. Frank, Wilkes-Barre, Penn. 980,392.

GOVERNING MECHANISM FOR ELASTIC FLUID TURBINES. John G. Callan, Nahant, Mass., assignor to General Electric Company, a Corporation of New York. 980,487.

JOURNAL-BOX LUBRICANT DEVICE. Charles B. Coon, Evanston, Ill. 980,492.

DEFLECTOR FOR OIL BURNERS. Frederic A. Curtis, Toledo, Ohio, assignor, by mesne assignments, to the Steel Mantle Light Company, Toledo, Ohio, a Corporation of Ohio. 980,497.

TURBINE BUCKET. Edwin W. Rice, Jr., Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 980,563.

VALVE. Walter E. Barnes, Malden, Mass. 980,585.

METALLIC PACKING. Charles O. Bullock, Cleveland, Ohio, assignor to the H. W. Johns-Manville Company, Cleveland, Ohio, a Corporation of New York. 980,594.

MEANS FOR LUBRICATION OF WRIST PINS. John K. Campbell, Hartford, Conn. 980,597.

ROD PACKING. Parmer Dorsey, Hutchinson, Kan. 980,617.

WATER-LEVEL CONTROLLER. Forest A. Ray, Boston, Mass. 980,675.

STEAM TRAP. Charles E. Squires, Cleveland, Ohio. 980,694.

MOUNTING FOR FURNACE DOORS. George H. Cushing, Westfield, Mass., assignor to the H. B. Smith Company, Westfield, Mass., a Corporation. 980,764.

BOILER FURNACE. Gustav De Grahl, Wilmersdorf, near Berlin, Germany. 980,772.

FIRE DOOR FOR BOILER FURNACES. Gustav De Grahl, Zehlendorf, near Berlin, Germany. 980,773.

ELECTRICAL INVENTIONS AND APPLICATIONS

SYNCHRONOUS DYNAMO ELECTRIC MACHINE. Jens Bache-Wiig, Edgewood Park, Penn., assignor to Westinghouse Electric and Manufacturing Company, a Corporation of Pennsylvania. 980,183.

ELECTRIC SWITCH. Arthur C. Eastwood, Cleveland, Ohio, assignor to the Electric Controller and Manufacturing Company, Cleveland, Ohio, a Corporation of Ohio. 980,221.

ELECTRIC SIGNALING APPARATUS. Roy A. Wilhite, Indianapolis, Ind. 980,380.

MOTOR-CONTROLLED SWITCH. Alfred James Barlow, Tottenham, England, assignor of two-thirds to Electromotor Equipment Company, Ltd., London, England. 980,475.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., Prof. J. D. Hoffman; sec., William M. Mackay, P. O. Box 1818, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION.

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

POWER

NEW YORK, JANUARY 31, 1911

THERE is a right and a wrong way of doing most everything. In fact, there often are several wrong ways of doing a given thing.

Usually, the discovery and use of the *one* right way only come after considerable study, experience and practice.

What a masterpiece of skill is necessary to dock successfully a great ocean liner of perhaps twenty-thousand tons displacement. Yet, the feat is accomplished every day in the year without anyone making a particular "noise" about it. The reason that the operation is successful so often is that the men intrusted with the task know the right way in which to do it as the result of years of training.

In the power plant there are a thousand and one operations, both simple and difficult, for the performance of each of which there is one *right* way.

Bring a barbarian into a plant and set him to work tightening up a one-half inch cap screw, for instance. If the screw happened to be a bit rusted and he could not turn it easily with his fingers it is only natural to expect that he would take the biggest wrench in the place to it, rather than put a "bit" of oil on the threads, start it right and use a suitable sized wrench to turn it home.

The barbarian is accustomed to accomplishing things by brute strength rather than by the use of intelligence.

The equipment under the care of some engineers lasts for a remarkably large number of years and gives efficient service during all of the time. On the other hand, the same kind and grade of equipment under men of another type has but a brief and riotous career full of wastefulness.

The reason for this is that the engineers of the former class use intelligence and care in operating the machine, not abuse and neglect. They see to it that each machine is amply lubricated and kept at least decently clean. Further, they make repairs promptly and thoroughly, realizing that "a stitch in time saves nine" and that "a thing worth doing is worth doing well."

And it pays—in the longevity of the apparatus and the uniformly good service which it gives.

Make the means selected for doing a given piece of work fit the purpose. Use efficient methods—efficient from every point of view, if possible.

In other words, use intelligent, civilized methods, not barbaric ones.

A 120,000 Horsepower Plant in France

By A. Grandjean

The St. Denis station supplies light and power to the city of Paris under several different phase and voltage conditions, as well as furnishing direct current for the railways. To meet these requirements several novel arrangements are made in the electrical equipment. The coal handling apparatus also embodies some notable features.

One of the largest and most important power plants in France is the St. Denis station of the Electrical Society of Paris. This is situated on the banks of the Seine between the towns of St. Ouen and St. Denis, and, in addition to supplying light and power to the greater part of Paris, also delivers about 20,000 horsepower to the Metropolitan railway of that city. At present the total output is 100,000 horsepower, but after the additions, which are now in the course of construction, have been completed, the station will have a capacity of 120,000 horsepower.

From Figs. 1 and 4 it will be seen that the general layout of the plant is somewhat different from that ordinarily met with. Owing to the large area available it is spread out considerably, the building covering approximately 160,000 square feet, and by having the coal bunkers in separate buildings, the hight of the boiler house is made much less than is the usual practice.

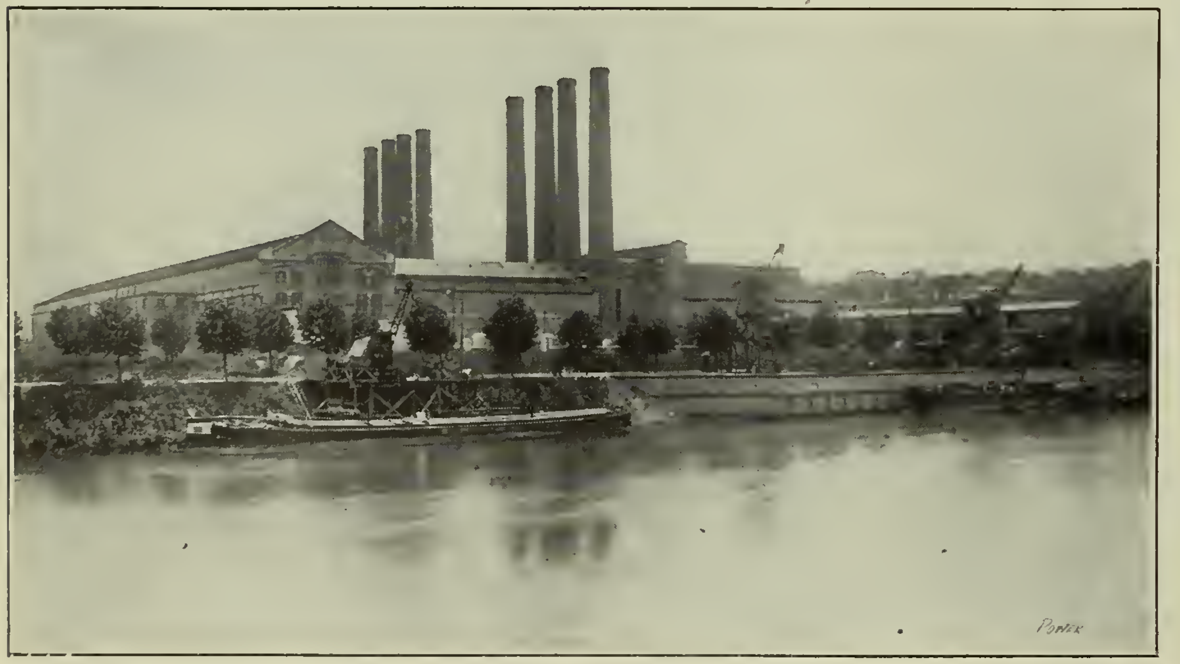


Fig. 1. Exterior View of Plant

Coal-handling Apparatus

One of the most interesting features of the installation is the means for handling coal. This is brought by scows direct from the collieries to a concrete wharf, in front of the power house. Two electrically operated traveling cranes, see Fig. 3, with clam-shell buckets pick the coal from the scows and deliver it into automatic weighing hoppers, one attached to each crane. And from each hopper it is discharged onto a conveyer, running parallel to and over the crane track. At the end of this conveyer the coal passes through a transfer hopper and is elevated to a second conveyer, running at right angles to the first and passing between the boiler houses and the coal bins of each group. This second conveyer consists of a roller chain carrying pivoted steel buckets,

Fig. 3. Method of Unloading Barges

which are hung so as to always remain in an upright position, regardless of the direction in which the chain is traveling. Each bucket is provided with a cam by means of which it may be tipped at any point in its travel. Passing over and under the aisles between each two rows of boilers and extending over and under the coal bins is a third conveyer, by which coal may be transferred from the second conveyer to the bin or to the hoppers over the boilers, or can be delivered directly from the bins to the hoppers. This ar-

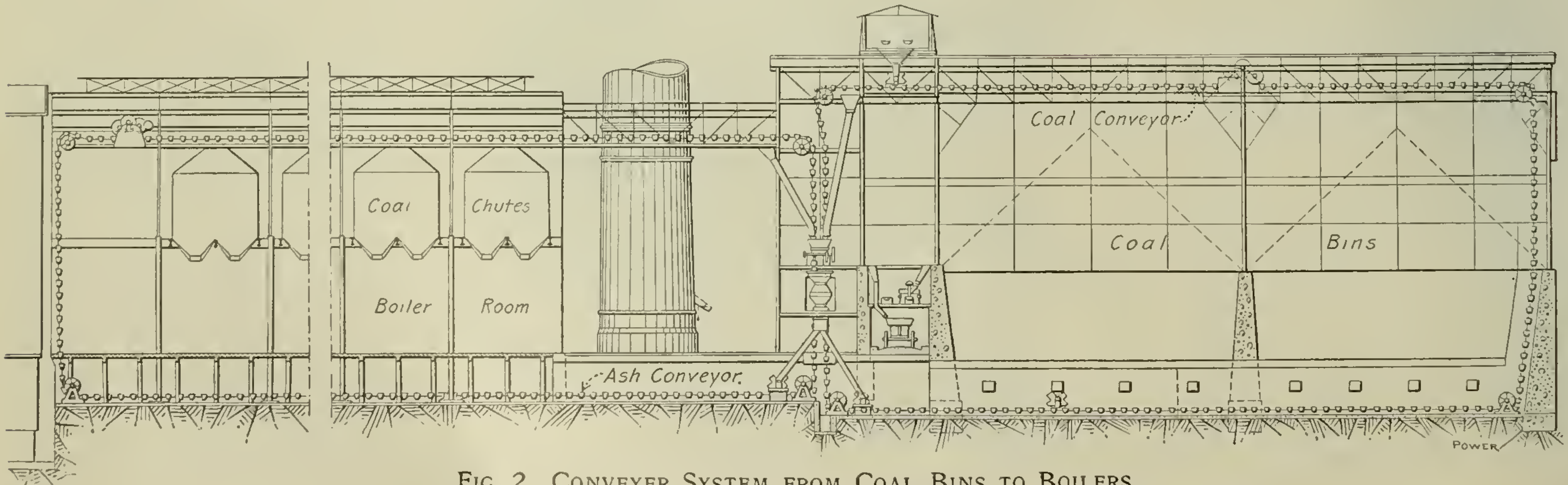


Fig. 2. Conveyer System from Coal Bins to Boilers

rangement is shown in Fig. 2. Fig. 5 is a view of the conveyer over the boilers. This conveyer in passing under the boilers is also used to carry away the ashes and discharge them into dump cars. The system has a capacity for handling 40 tons of coal per hour and, when unloading, only three men are required to each scow, one man operating the crane and two men to guide the buckets. From the time the coal has been delivered by the buckets, no further handling by hand is required. The total length of conveyer at the plant amounts to nearly 8000 feet.

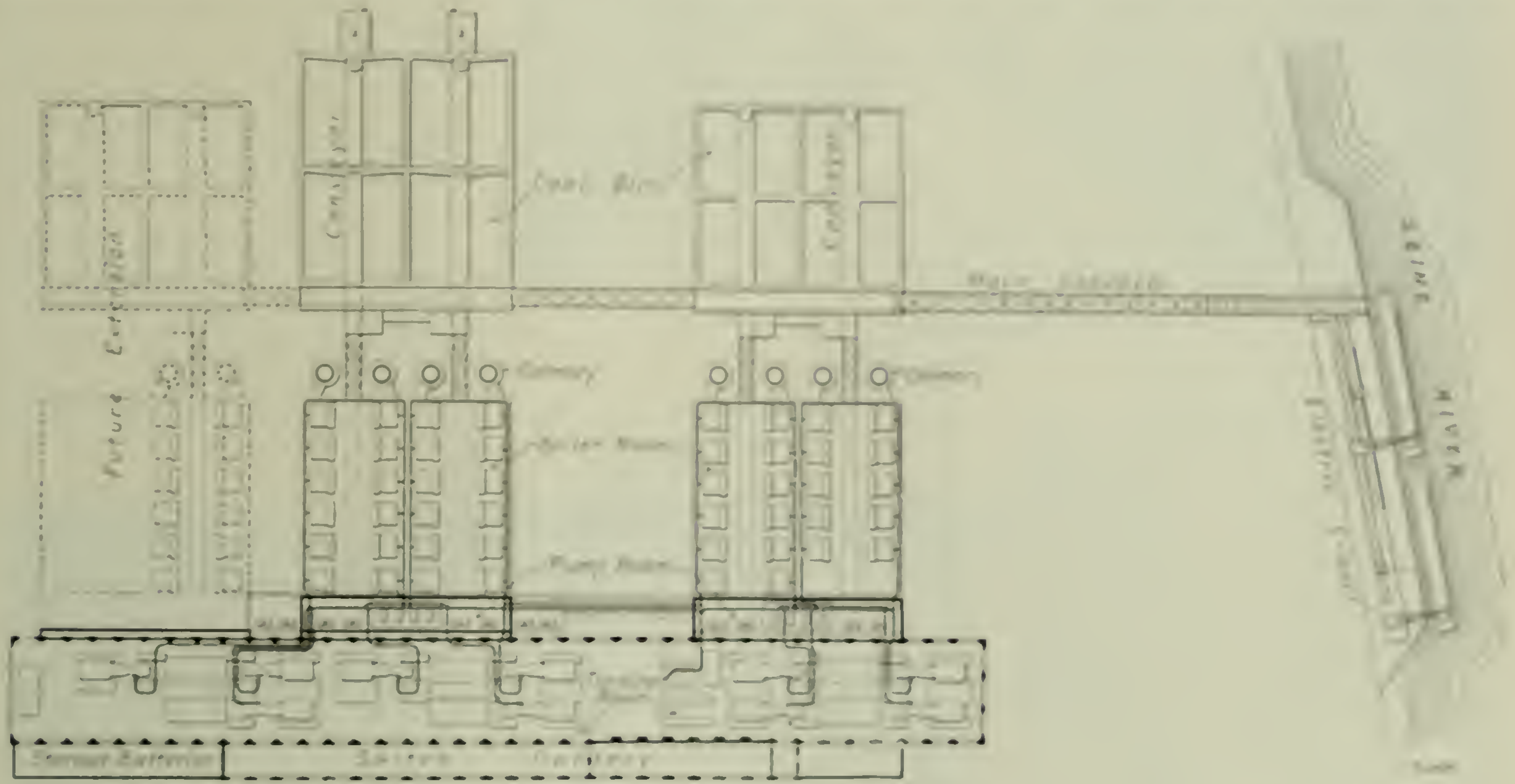


FIG. 4. GENERAL LAYOUT OF PLANT

Boilers

At present there are forty-six 450-horsepower boilers of the Babcock & Wilcox marine type, arranged in batteries as shown in Fig. 4; but when the additions now under way are completed, the number will be increased to 58. Chain-grate stokers are employed, two to each boiler, and, in addition to the draft furnished by the 180-foot chimneys, this is supplemented in four of the batteries by a forced-draft system. The feed water is heated by Green economizers located over the boilers, and Babcock & Wilcox superheaters attached to each boiler are capable of raising the temperature of the steam to 662 degrees Fahrenheit, the superheaters being arranged so that the temperature may be varied through a range of 100 degrees. Fig. 7 shows a sectional elevation through one of the boilers and Fig. 6 a view of one of the boiler rooms.

Piping and Auxiliaries

The turbines are mounted in groups, thus greatly simplifying the piping layout. Steel piping is employed for all high-pressure steam and riveted sheet-iron pipe for the exhaust steam. The condensing water is fed from the condensers by submerged pipes working on a siphon, so that the work of the circulating pumps is reduced.

The surface condensers are located below the turbines and the pump room is situated between the boiler room and the turbine room. The circulating pumps are of the vertical centrifugal type, driven by motors, and the air pumps are of the three-cylinder plunger type, also driven by motors.

FIG. 5. CONVEYER OVER BOILERS

FIG. 6. VIEW OF THE BOILER ROOM

Main Units

Some complication arose from the fact that three-phase alternating currents at about 10,000 volts and 25 cycles were required for traction purposes; two-phase

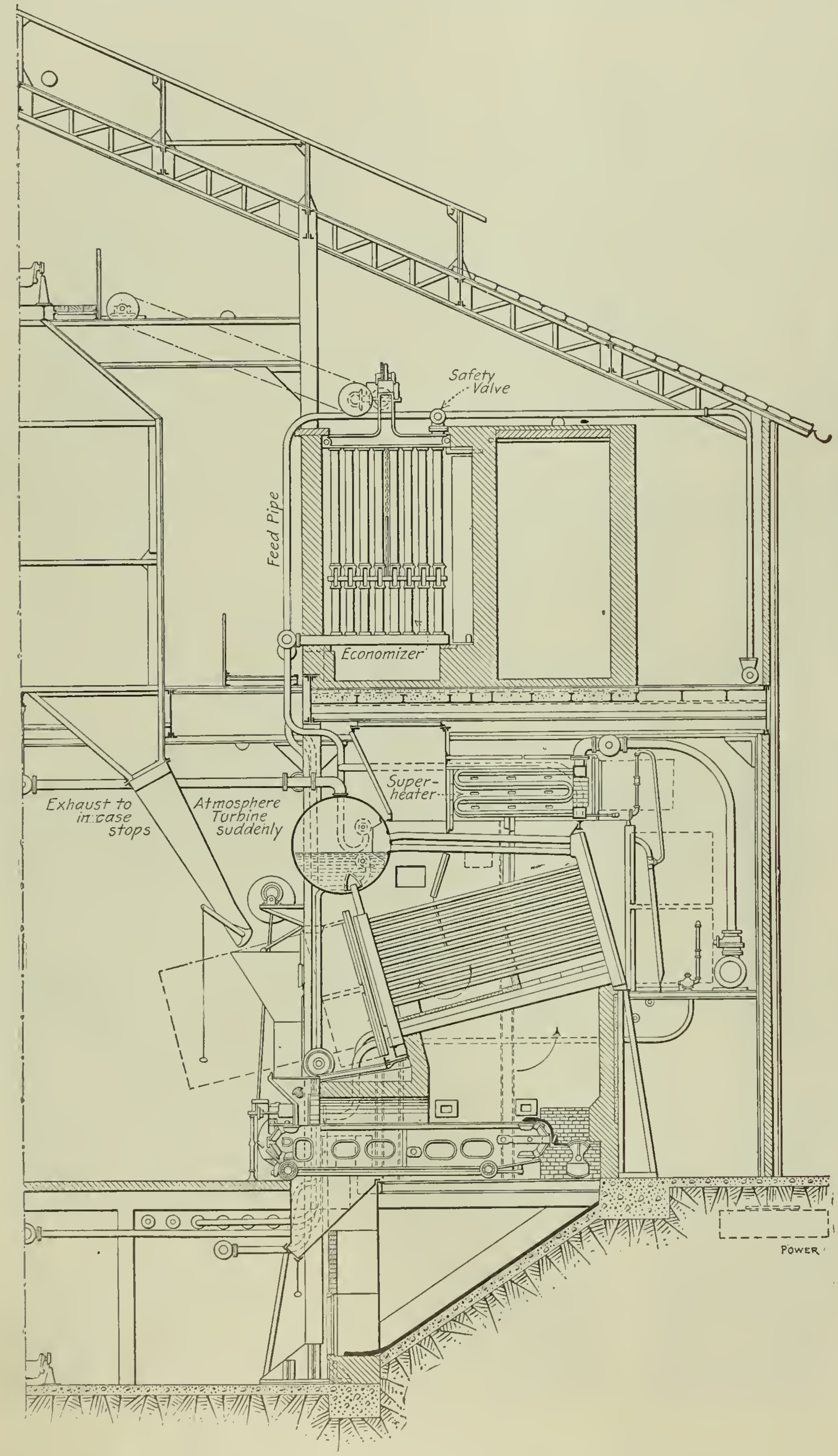


Fig. 7. Section through Half of Boiler Room

42-cycle currents at 12,300 volts for lighting; three-phase currents at 6000 volts and 42 cycles for distributions to the suburbs; direct current at 230 volts for plant service, and direct current at 550 volts for certain other traction purposes. To meet these various classes of service the following units were installed:

Four three-phase turbo-generators of 5000 to 6000 kilowatts capacity.

Four two-phase turbo-generators of 5000 to 6000 kilowatts capacity.

Two turbines, each connected to two alternators, one of which is a two-phase, 42-cycle, 12,300-volt machine and the other a two-phase, 25-cycle, 10,150-volt machine of 5000 to 6000 kilowatts capacity.

One two-phase, 25-cycle, 10,150-volt turbo-generator of 10,000 to 14,000 kilowatts capacity.

Two two-phase motor-generator sets, each of 750 kilowatts capacity, taking alternating currents at 12,300 volts and delivering direct current at 220 volts.

Two motor-generator sets of 750 kilowatts capacity, taking three-phase current at 10,150 volts and delivering direct current at 220 volts.

Two motor-generator sets of 375 kilowatts capacity, taking three-phase currents at 10,150 volts and delivering direct current at 220 volts.

One 375-kilowatt, 230-volt direct-current turbo-generator.

One storage battery of 1300 ampere-hours capacity and another of 3000 ampere-hours capacity.

Fig. 8. Switch Compartments

Two motor-generator sets for charging the storage batteries.

Two 6050- to 12,300-volt static transformers, each of 1000 kilowatts capacity.

The speed of the three-phase machines is 750 revolutions per minute and that of the two-phase machines is 835. Each turbine is provided with a Parsons speed regulator which maintains a practically constant speed in spite of the varying load, especially on those machines supplying the electric railways. The admission of steam is automatically cut off as soon as the speed of the turbine reaches 15 per cent. above normal.

In addition to the foregoing there is a special reversible motor-generator set consisting of two synchronous motors coupled together, one being fed with three-phase current at 10,150 volts and 25 cycles and the other with two-phase current at 12,500 volts and 41⅔ cycles. The three-phase motor has six poles and the two-phase motor, ten poles. As

$\frac{25}{41.66} = \frac{6}{10}$ it will be noted that both motors run at the same speed, that of 500 revolutions per minute. Therefore, it is possible, by using either of the machines as a motor or a generator to transfer available power from the three-phase machines to the two-phase circuits or *vice versa*, up to the limit of the capacity of the machine, which is 1500 kilowatts. A view of the main turbine room is shown in Fig. 9, at the right of which may be seen a large lathe used for turning down the commutators.

Switching Equipment

The high-tension switching apparatus is housed in a reinforced-concrete structure which adjoins the main turbine room. All the switch barriers and slabs are of concrete and every precaution has been taken to insure against fire. Fig. 8 is

Fig. 10. Gallery Containing Remote-Control Benches

Fig. 9. Turbine Room

a view of the oil switches, showing the track that has been provided for convenience in handling them. In the upper part of this building are located the desks containing the remote-control apparatus; these are shown in Fig. 10. The long desks on the right are for feeder control and the small ones on the left, overlooking the turbine room, are for controlling the machine switches. Each row is separated into two sections, one for two-phase and the other for three-phase currents.

On the desks are mounted signal lamps showing the position of the switches and the operation of the rheostats, these lamps being supplemented by a warning bell. With this arrangement the control of the entire high-tension switching equipment is placed under the direction of one operator. The high-tension busbars are divided into groups, the leads from each two generators connecting through oil switches to a pair of generator busbars; each pair of busbars is connected through an oil switch to a pair of feeder busbars which, in turn, connect through other switches to the feeders. These switches have time-limit control, which automatically cuts out a feeder, group or machine in the event of a short-circuit. The several sections of both the generator and the feeder busbars may be connected in parallel, the former by remote-control oil switches and the latter by disconnecting switches. This arrangement permits any section being isolated for the purpose of making repairs.

Along the side of the turbine room and raised slightly above the floor is the low-tension switchboard containing the excitation control and the various instruments. A pedestal located in front of the switchboard and opposite each unit carries a Siemen's apparatus with the wattmeters, voltmeters, ammeters and emergency interrupter for each machine. This board and the pedestals are shown in Fig. 11.

The operating force consists of three shifts of twenty men each, in addition to an engineering and superintendent's staff of eleven.

The Metropolitan Street Railway Company, of Kansas City, will install a 15,000-kilowatt, maximum rating, Curtis turbine and base condenser next summer.

Fig. 11. Low-tension Switchboard

Vacuum for Reciprocating Engines

By John H. Ryan

The experience of a refrigerating man with a young engineer who thought he could better the economy of his engine by increasing the vacuum to 28 inches.

Several years ago the firm by which I was employed built an ice plant in the Southern fruit belt, most of the output being used in refrigerating cars. As coal was expensive in that locality, the plant was designed to operate as economically as possible. The ice machine consisted of two single-acting compressors, driven by an 18 and 36 by 48-inch cross-compound Corliss engine, the flywheel of which was used as a main driving pulley for running, through a jack shaft, the plant auxiliaries. These consisted of a boiler-feed pump, a circulating pump, an electric generator for light and power, the air compressor and a rotary blower for circulating the freezing water.

About two years after the plant had been turned over to the owners we were requested to send a man to the plant to report upon some changes that their engineer had proposed. Upon reaching the plant, I found that there had been a change of engineers, the new man being a young fellow who had been an oiler in a large central station employing turbine units. He had previously taken a correspondence course in refrigeration and then sought a job of greater responsibility, finally landing his present position.

He began his argument for the proposed changes by stating that, although the steam consumption per horsepower-hour of this plant was as good as the turbine plant, the vacuum on the machine did not average more than 24 inches, while the turbine plant averaged 28½ inches. He had looked up the theory of the loss due to incomplete expansion and had found that if the steam in the ice plant could be expanded down to 28½ inches, the consumption would be decreased at least two pounds per horsepower-hour. According to his figures this saving in steam would be equivalent to 18 per cent. of the coal used. The owner of the plant was interested when he saw these figures and signified his willingness to take a chance, providing the machine builders would say that it was feasible. The engineer was not sure as to the cheapest way of increasing the vacuum but had thought of getting a larger air pump, a larger circulating pump and a cooling tower so that the barometric condenser could be forced to its limit. There were a number of other suggestions, such as moving the condenser nearer the low-pressure cylinder, etc. After he had said all he could think of, I started in to have my say, which was somewhat as follows:

"There are many who do not understand why a high vacuum is not as good for reciprocating engines as it is for turbines, but most of us have read or been told that with the former it does not pay to run the vacuum any higher than 26 inches, with the barometer at 30 inches.

"The expansion and compression of gases follow the same laws whether the range of pressures be high or low. For example, consider the compression in an ammonia cylinder when carrying 15 pounds back pressure and it is desired to find what the pressure in the cylinder will be at half of the compression stroke. Add the atmospheric pressure to the gage pressure and multiply the 30 by two, because the volume is halved at half stroke. This gives 60 pounds as the absolute pressure in the cylinder at half stroke. When the 15 pounds atmospheric pressure is subtracted from the 60, it will give 45 as the gage pressure at half stroke, that is, when the volume is halved.

"The same law holds true for the expansion of gases. In a compound engine with 15 pounds receiver pressure and cutting off at half stroke in the low-pressure cylinder, when this 30 pounds absolute steam pressure has expanded down to a full cylinder volume, the pressure will be halved. This is because the volume has been doubled and there will be just atmospheric pressure in the cylinder when the exhaust valve opens at the end of the stroke.

"A pound of steam at atmospheric pressure occupies about 26 cubic feet of space and that is about the capacity of the 36x48-inch low-pressure cylinder. This same pound of steam at 15 inches of vacuum occupies 53 cubic feet of space. To hold this steam the low-pressure cylinder would have to be 4 feet in diameter. At 26 inches of vacuum the volume of a pound of steam is approximately 175 cubic feet and the required cylinder diameter would be 7½ feet, and at 28 inches of vacuum the volume would be 340 cubic feet, necessitating a cylinder diameter of 10½ feet. Or, further, a 29-inch vacuum would require a 14½-foot cylinder. To attain the benefit of the extra inch of vacuum between 28 and 29 inches, the area of the cylinder must be doubled."

The engineer replied that he would be satisfied with the 28 inches; but I told him that his low-pressure cylinder was about right for 21 inches of vacuum and to expand to 28 inches would necessitate a low-pressure cylinder of 60 inches in diameter. To compensate for the attending cylinder condensation, the steam would have to be superheated 500 degrees above that corresponding to the throttle pressure. This would mean a temperature of 865 degrees Fahrenheit and it would be hard to find oil and packing to withstand this.

He accused me of not knowing what I was talking about and said that the engines of the new cotton mill in town often ran 28 inches of vacuum. I admitted that anyone could get 28 or more inches of vacuum if he had water enough and offered to wager that if they took diagrams from the mill engine when it was carrying 28 inches of vacuum that the diagrams would show the exhaust valves opening early in the stroke with the pressure in the cylinder corresponding to 28 inches of vacuum when the piston reached the end of the stroke. There would probably be more than 6 pounds absolute pressure in the low-pressure cylinder when the exhaust valve opened and all this heat would be rejected into the condenser.

He admitted that I might be right, but could not see what difference that made as the 28 inches of vacuum in the exhaust pipe would represent a removal of most of the atmospheric pressure, and he claimed that a pound of pressure removed from the front of a piston was just as good as an extra pound behind the piston. I replied that there was a big difference between the actual and theoretical mean effective pressure when an engine is run condensing. As a rule there is 5 pounds less mean effective pressure with 28 inches of vacuum than calculations would indicate.

His next question was, "What did I think of lowering the exhaust pressure by means of a larger air pump?" This is another way of wasting power. To lower the vacuum from 26 to 28 inches would require a condenser temperature 23 degrees lower and the pump would have to take out about 60 cubic feet more vapor for every pound of steam the engine used.

Our friend then got out his notebook and made these few entries: "Turbines show a gain, due to complete expansion to a high vacuum because the temperatures remain the same at each point in the turbine. They have no condensation loss. Reciprocating engines running with complete expansion to a high vacuum do not show as good results, because the loss from the cylinder condensation is high. Look up the question of B.t.u. per horsepower and see how much of the available heat in the steam I am getting. Charge the heat required to run the auxiliaries, to gain by condensing."

An Efficient Boiler Installation

By H. R. Mason

The description of a recent boiler and economizer installation embodying some novel features. The results of economic tests are given, showing that, by the adoption of these improvements, a rating 28 per cent in excess of the guarantee was attained under actual running conditions.

An efficient steam-generating equipment is the first essential to a satisfactory power plant, and this feature depends as much upon the design and arrangement of the boiler-room apparatus as upon the skill of the attendants after the plant is completed. The present article deals with the arrangement of boilers, economizers and stacks of a certain large plant which was recently completed.

The original plant consisted of three Heine boilers of 420 horsepower each, in connection with a single economizer, the boilers arranged so that each could be connected directly to one of three 500-kilowatt units. The load increased rapidly and plans were adopted for an extension of the plant by the addition of 2000-kilowatt Parsons turbines, each served by four 480-horsepower Heine boilers with individual economizers, constituting distinct units which could be operated independently from the boiler-feed pump to the condenser discharge.

The boilers were of the standard Heine type and special attention was given to the baffling, exhaustive tests being made to determine the most advantageous arrangement of baffles. It was found that in boilers of this size with only the customary top and bottom baffles, the gases followed nearly a diagonal path from the edge of the lower baffle to the edge of the top baffle, leaving a very large portion of the heating surface ineffective and resulting in excessive stack temperatures at heavy loads. This, of course, brought about a serious reduction in both efficiency and capacity, and was overcome by putting in an intermediate baffle in the following manner: The lower baffle was extended from the front tube header to a point approximately 4 feet 10 inches from the rear tube header, securing an area of about 25 square feet for the gases to leave the combustion chamber and enter the tubes. Under favorable conditions it was found that the combustion-chamber temperature approached 2000 to 2200 degrees Fahrenheit, and that there was an exceedingly rapid transfer of heat to the first tubes which the gases came in contact with. As the gases, in cooling, contract in volume in proportion to their absolute temperatures, the necessary areas and surfaces for the most effective results were easily calculated and an intermediate baffle of cast-iron plates was inserted on top of the ninth row of tubes, extending from the rear header to a point 3 feet from the front header, as shown in Fig. 1. This left an area of 18 square feet at this point for the passage of the gases, and this area was preserved from that point to the top of the stack, as it was feared that the draft would suffer through friction losses if the area were reduced sufficiently to maintain the same velocity. The top baffle was then extended from the front header to a point 3 feet from the rear header, thus reversing the ordinary arrangement. The spaces between the two drums and between the drums and the side walls was such that the breeching was carried back about 6 feet and the remaining areas of the boiler drums, having no strong circulation of gases about them probably did but little work. This amounted to less than 200 square feet and being in the coolest portion of the path of the gases, it was considered best to sacrifice this small percentage of the heating surface in order to gain the 30 or more per cent. which was lost through the usual form of baffle.

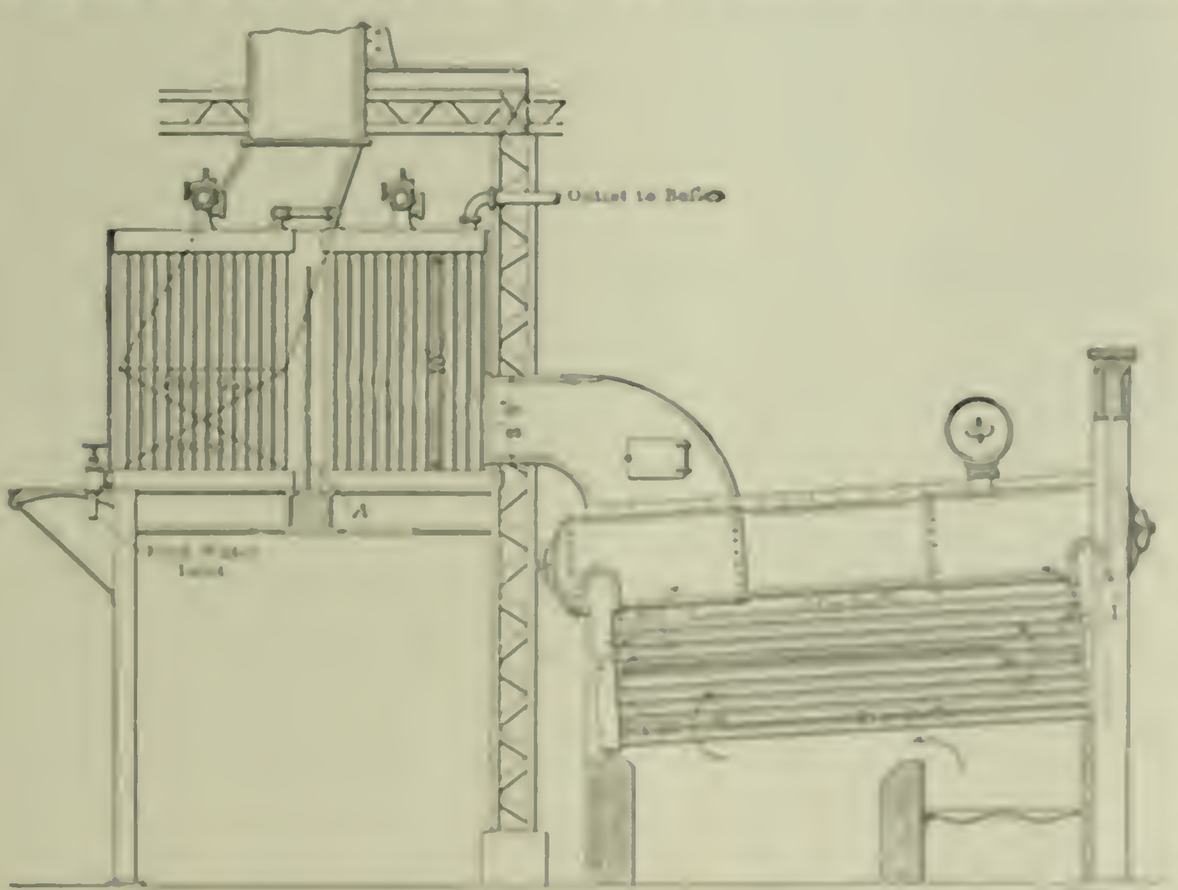


Fig. 1. Section through Boiler and Economizer

The columns supporting the front portion of the boilers extend about 22 feet above the boiler-room floor, and carry 24-inch box girders, from which the boilers are hung by yokes passing under the front end of each drum, as shown in Fig. 2. This was done to get the boiler supports away from the heat of the furnace, and also to accommodate any type of mechanical stoker which might be decided upon. The rear ends of the boilers rest upon rollers. The walls are of reinforced concrete lined with fire brick, instead of brick throughout, as is the usual custom. The rear wall is built solid, but the side walls are in sections about six feet square, separated by barriers of ½-inch sheet asbestos, as it was anticipated that undesirable cracks would form in a solid wall of such size when exposed to the varying temperatures. In two years these walls have shown very little tendency to crack, and having a hard finish, much less air passes through them than through the ordinary form of brick wall.

In the design of the breeching, economizer baffles and the uptake to the stack, special care was observed to avoid, as far as possible, all abrupt turns which would be liable to cause eddies or back drafts. The gases from each boiler are discharged into an economizer of the standard Green type, provided with mechanically operated scrapers. These economizers are supported by cast-iron columns and inclosed with a series of double sheet-iron plates, 1½ inches apart, with asbestos tamped between, as shown in Fig. 3. The gases enter near the bottom of the discharge section of the economizer and are prevented from going straight through to the stack by a cast-iron baffle plate, shown at A, Fig. 1. The boiler-feed water is delivered to the section nearest the stack and passed from the first group of sixteen sections to the second group, through return bends at the top of the economizer, and is finally discharged from the section nearest to the boiler, where the gases have the maximum temperature.

The steel stacks are 78 inches in diameter and extend 150 feet above the economizer; for the first 75 feet the metal is ¼ inch thick and 3/16 inch for the remaining distance.

Before the erection of the first set of boilers it was argued that the draft might prove insufficient, as the path of the gases seemed unduly long and tortuous, and much of it was in a horizontal plane. In practice, however, it was found that there was little more to be desired. The draft gage and pyrometer showed readings averaging substantially as follows:

	Temperature Flue Gases, Degrees Fahrenheit.	Draft, Inches.
Base of stack	300	1.25
Breeching between boiler and economizer	485	0.75
End of intermediate baffle	770	0.50
Combustion chamber (estimated)	1600	0.37
Furnace (estimated)	2100	0.25

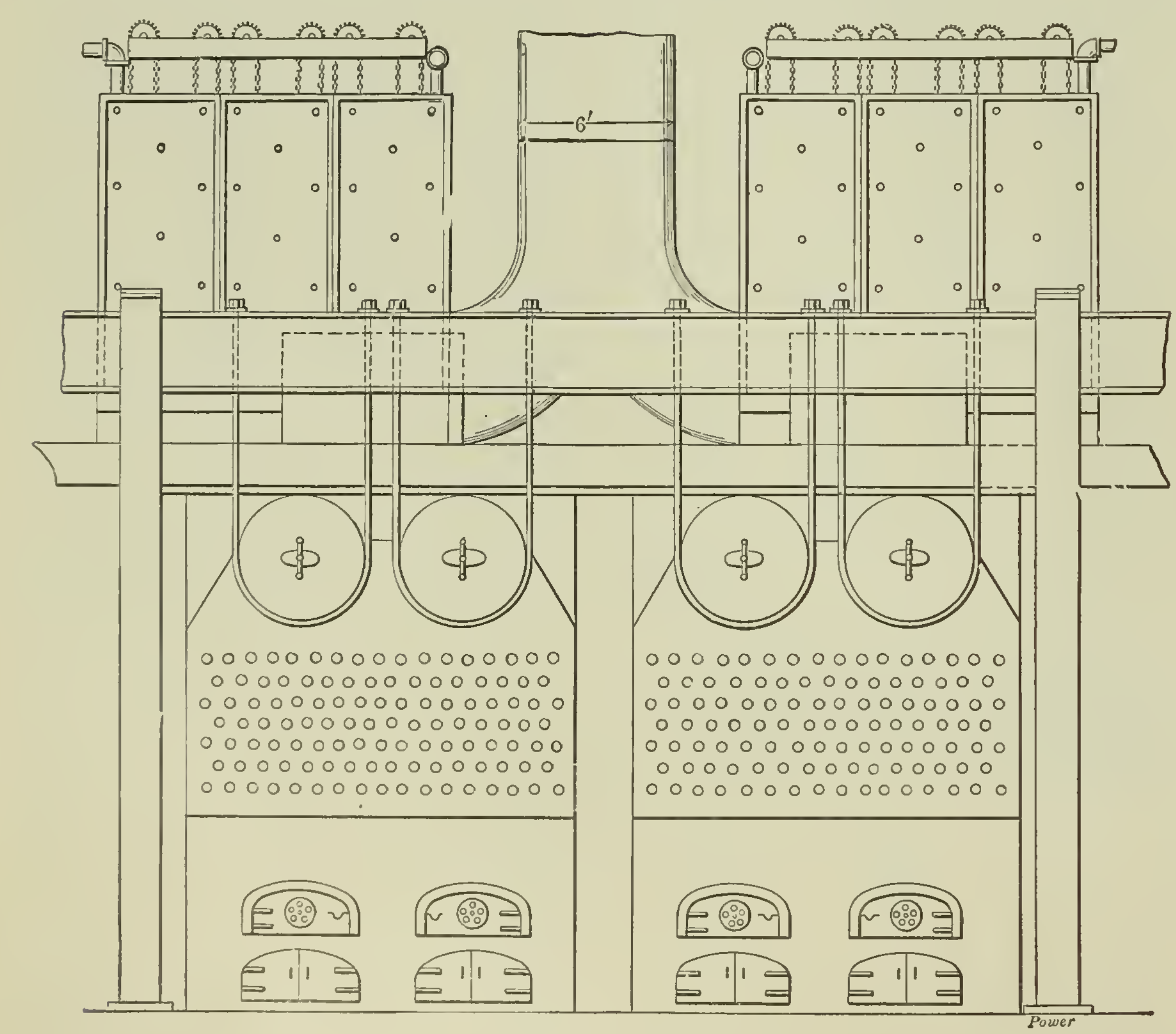


Fig. 2. Front View of Boilers

This draft proved sufficient to consume over 30 pounds of screenings per square foot of grate surface, and as the grate of each boiler is 10x7 feet, this produced ample heat with the low grade of bituminous coal to run the boilers far above their rating. The coal had a heating value of about 10,000 B.t.u., and monthly averages showed an evaporation of approximately 6 pounds of water per pound of screenings burned, or an efficiency of nearly 60 per cent. As 70 per cent. is considered very fair on test performances, this result was quite exceptional. The feed water entering the economizer averaged about 150 degrees Fahrenheit and the economizer delivered it to the boilers at temperatures varying from 240 to 300 degrees.

Following is the report of a test on one of these boilers:

RESULTS OF BOILER TEST.

Breese, Trenton Coal, Fresh Screenings, 1-inch Size.

Grate surface, 71.75 square feet.
Water heating surface, 4,820 square feet.

Total Quantities.

Duration of test, hours	9
Weight of coal as fired, pounds	21,988
Percentage of moisture in coal	6.58
Total weight of dry coal burned, pounds	20,541
Total weight of ash and refuse, pounds	3,546
Pecentage of ash and refuse to coal as fired	16.16
Percentage of combustible in ash. Not determined.	
Total weight of water fed to boiler, pounds	161,360
Quality of steam, per cent	98.8878
Water actually evaporated, pounds	159,569.7
Factor of evaporation:	
Boiler	1.071
Boiler and economizer	1.1928
Equivalent water evaporated from and at 212 degrees Fahrenheit, pounds:	
Boiler	173,930
Boiler and economizer	192,470

Hourly Quantities.

Coal consumed per hour as fired, pounds	2,443.1
Dry coal consumed per hour, pounds	2,282.4
Coal per hour per square foot grate surface, pounds	34.1
Dry coal per hour per square foot grate surface, pounds	31.8
Apparent water evaporated per hour, pounds	17,928.9
Water per hour corrected for quality of steam, pounds	17,729.0
Equivalent evaporation dry steam per hour from and at 212 degrees, pounds:	
Boiler	19,110.0
Boiler and economizer	21,147.2
Equivalent evaporation per hour per square foot heating surface, pounds:	
Boiler	3.961
Boiler and economizer	4.38

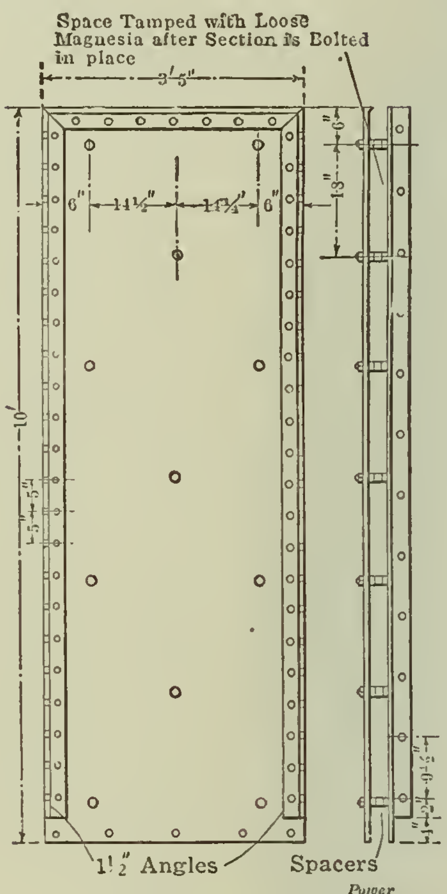


Fig. 3. Economizer Jackets

Average Pressures, Temperatures, Etc.

Steam pressure, gage	160
Temperature of feed water, degrees Fahrenheit:	
Boiler	194
Boiler and economizer	74.2
Temperature of escaping gases:	
Boiler	480
Boiler and economizer	326
Draft over fire, inches of water	0.189
Draft in breeching, inches of water	0.484
Moisture in steam, per cent	1.1122
CO_2 in flue gas, average per cent	11.35
Calorific value of coal in B.t.u	10.168.0

Horsepower.

	Boiler.	Boiler and Economizer.
Horsepower developed	560.2	619.8
Builder's rated horsepower (boiler only)	482.0	
Per cent. of rated horsepower developed	116.2	128.5

Economic Results.

	Boiler.	Boiler and Economizer.
Apparent evaporation per pound of coal as fired		7.34
Equivalent evaporation per pound coa as fired	7.82	8.65
Equivalent evaporation per pound dry coal	8.41	9.22
Efficiency of boiler, per cent	74.2	
Efficiency of boiler and economizer, per cent		80.9

This is one of a large number of tests on these boilers, most of which showed about the same general results. In these tests cold water was used, with the result that the economizer tubes sweated and gathered a coating of soot, which detracted somewhat from the efficiency of the economizer. Tests with a much better grade of coal gave results as high as 950 horsepower per boiler unit for occasional periods, with nearly the same efficiency. The test shown above was taken under conditions which were substantially the same as those under which the boilers were normally operated, and the object was to determine the most satisfactory operating conditions.

The first cost of the plant averaged very close to $10,000 per complete boiler unit, including one boiler, setting, supports, economizer and one-half the cost of one stack and its supports. The addition of the intermediate baffle increased the capacity of the boiler to a great extent, and the further addition of the economizer brought the working capacity of the unit up to nearly 650 horsepower. This brings the total cost per boiler horsepower to something over $15, which cannot be termed excessive in view of the high efficiency secured, as a very small percentage of saving in the annual coal bill of a moderately large plant will justify a large outlay of capital in improved methods of construction, provided the plant is subsequently managed in such manner as to realize this saving.

Expansions in Compound Engine

By F. R. Low

In reply to an inquiry the author tells what is meant by the number of expansions in a compound engine and in a simple way shows how the ratio is calculated.

A volume of steam is taken into the high-pressure cylinder. This volume equals the capacity of the high-pressure cylinder up to the point of cutoff and including clearance. It is eventually expanded to the full volume of the low-pressure cylinder, including its clearance. The final volume divided by the initial volume equals the "ratio of expansion," or the number of times the steam is expanded.

It is not necessary to work with actual volumes. Suppose in the accompanying diagram the stroke or displacement of the high-pressure cylinder represents 1; then the clearance volume will be directly represented by the clearance expressed in hundredths of the displacement, the volume displaced up to cutoff by the fraction of the stroke completed at that point, and the total volume up to cutoff by the sum of the two. If, for instance, the engine cuts off at quarter stroke and the clearance is 5 per cent., the volume inclosed behind the high-pressure piston will be

$$0.25 + 0.05 = 0.3$$

of the displacement of the high-pressure piston, or since that displacement is taken as unity, will be represented simply by 0.3.

The areas of the cylinders are to each other as the squares of their diameters. Suppose the low-pressure cylinder has a diameter twice that of the high; its area will be four times as great and with the same stroke (which is usually the case) its displacement will be four times as great, and the same percentage of clearance would give four times as much volume, so that, supposing the clearance of the low-pressure cylinder to be 5 per cent. also, the final volume would be

$$4 + (4 \times 0.05) = 4.2$$

Then the number of expansions or the "ratio of expansion" would be

$$4.2 \div 0.3 = 14$$

This can be boiled down to the simple rule:

Divide 1 plus the clearance of the low-pressure cylinder by the fraction of the stroke completed at cutoff plus the clearance of the high pressure cylinder, and multiply the quotient by the ratio of the cylinders, i.e., by the square of the quotient of the diameter of the low divided by the diameter of the high.

$$R = \left(\frac{D}{d}\right)^2 \times \frac{1 + C}{f + c}$$

where

R = Ratio of expansion;
d = Diameter of the high-pressure cylinder;
D = Diameter of low-pressure cylinder;
c = Clearance of the high-pressure cylinder;
C = Clearance of the low-pressure cylinder;
f = Fraction of stroke completed at cutoff.

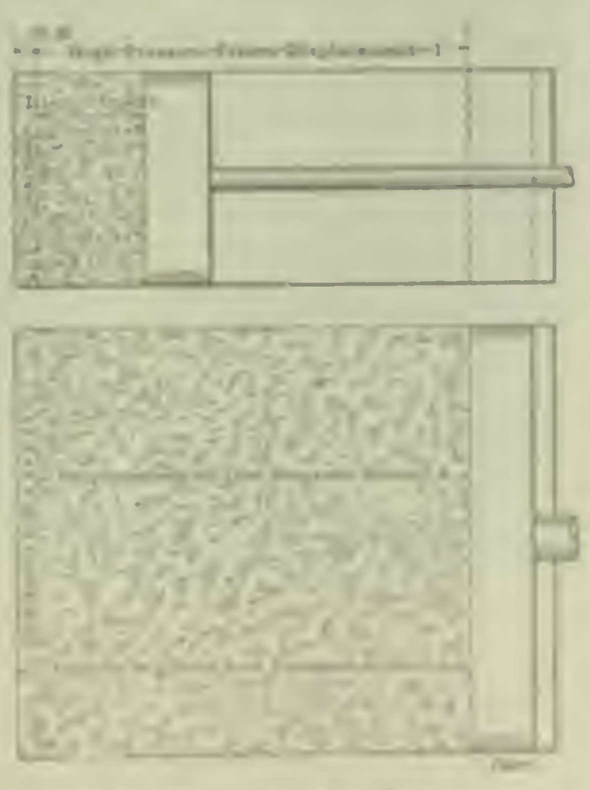


DIAGRAM OF HIGH- AND LOW-PRESSURE CYLINDERS

Substituting the figures of the previous example where each clearance was 0.05, $\frac{D}{d} = 2$ and $f = 0.25$,

$$R = (2)^2 \times \frac{1 + 0.05}{0.25 + 0.05} = 14$$

To be accurate, all of the steam included in the initial volume does not appear in the final volume, for a part of it is retained in the high-pressure cylinder when the exhaust valve closes. The real case is that a certain quantity of steam is expanded in the high-pressure cylinder and then a portion of this steam expanded in the low. Where extreme accuracy is desired or where a high degree of compression is used it is well to consider the cylinders separately, deducting from initial volume in the low-pressure exhaust, which will depend upon the receiver pressure as well as the point of closure of the exhaust valve. When there is no free expansion or cylinder drop, i.e., when the high-pressure diameter ends in a point, there is no escape of steam into the receiver except as the piston pushes it out. The proportion of the steam passed on to the low-pressure cylinder in this case would be the proportion of the stroke completed at exhaust closure. If, for instance, the exhaust valve closes when the stroke is four-fifths completed, then the volume displaced will be four-fifths of the displacement of the high-pressure piston, and since the entire displacement is taken as unity, will be correctly represented by four-fifths or 0.8. Since the volume of the low-pressure cylinder is proportional to $\left(\frac{D}{d}\right)^2 \times (1 + C)$, the number of expansions in the low-pressure cylinder is, calling the portion of the return high-pressure stroke completed at exhaust closure e,

$$\frac{\left(\frac{D}{d}\right)^2 \times (1 + C)}{e}$$

The number of expansions in the high-pressure cylinder is

$$\frac{e + c}{f + c}$$

and the total number of expansions is the product of the two, or

$$\frac{(e + c) \times \left(\frac{D}{d}\right)^2 \times (1 + C)}{e\,(f + c)}$$

Substituting the figures of the above assumed case, and calling e = 0.8, this would give

$$\frac{(0.8 + 0.05) \times 4 \times 1.05}{0.8 \times (0.25 + 0.05)} = 14.9$$

a considerable difference, for a very ordinary ratio of compression.

Confessions of an Engineer

By R. O. Warren

The chief gives the firemen their own way and fails to realize how much coal is being wasted. The manager makes some suggestions which result in a large saving.

Over a week passed before Manager Wood again came into the engine room, although I had seen him several times out in the boiler room, not that he interfered with the firemen, but he seemed to be noting how the men did their work.

If I had had enough sense, I would have known that Wood was getting interested in the combustion conditions of the plant, but for eight months I had seen that the firemen kept up steam and that seemed, to me, to signify that my fireroom force was well organized.

I had read about and discussed boiler-room conditions, time and time again, and had pointed out the mismanagement of other steam plants, but somehow or other it never seemed necessary for me to look into the working condition of my own.

The local association members had been discussing the combustion of coal for years, and had taken up the subject of CO_2, showing how the economy of a steam plant could be increased if a high CO_2 could be maintained. I had been greatly interested in the subject, but as soon as I found out that an instrument cost up in the hundreds of dollars, I came to the conclusion that the matter was not of enough importance for me to bother with, as the chances were, I assumed, that the firm would turn it down if I should ask them to purchase a CO_2 recorder costing so much money.

Now, I knew that air leaking into a furnace through a boiler setting reduced the furnace efficiency to a considerable extent, and I had, therefore, sealed all cracks, so that the boiler setting was in good shape.

For this reason I did not bother much about Wood looking around, but I did make up my mind that if he interfered with the men there would be an understanding as to who was chief engineer.

Wood, however, was a sensible man, and gave me no opportunity of demonstrating which of us was "boss." If I had known him better, and cut out some of my own self-importance, I would have been better off in many ways.

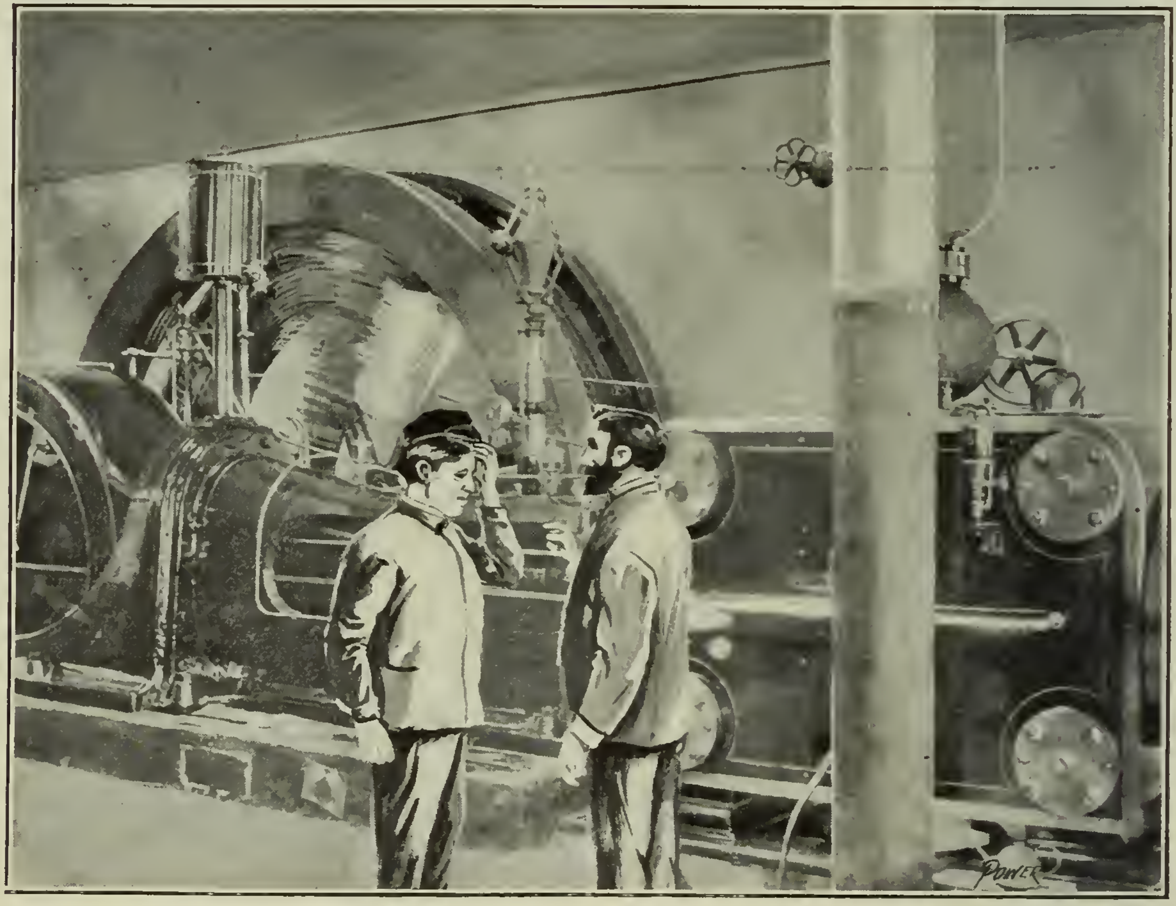
The second visit of Wood was made one forenoon while everything was working to perfection. The firemen had the boiler pressure at the blowing-off point and were sitting down, contented that there was sufficient steam and a little more.

"Good morning, Warren," said he. "How are things going?"

"Fine as a fiddle," I answered, noting with satisfaction that the boiler pressure was up above the normal working point, and that the engine was cutting off shorter than usual.

"Got some pretty good firemen?" was his next question.

"Can't be beat," I answered. "They are the best boys in the town, willing to work and will do just what they are told. The only trouble is that they will take advantage of me if I am not strict. They are like most people for that matter. If you give them an inch, they will take a foot. I don't have much to do with them, because they are apt to get familiar, which won't do." I said this with considerable pride, as I felt that such a stand added to the dignity of my position.



The Manager Had Me Guessing

Wood said nothing, but coughed slightly. After a pause he said, "Good firemen are scarce, and men who would make good firemen are not properly trained. The losses a fireman causes in a steam plant are next to the furnace losses, which are the largest. In my opinion a good fireman has greater responsibility, as far as fuel is concerned, than the engineer. The engineer's business is to see that instructions are carried out, and if he fails to do so and the fireman shirks his duties, the plant is in a bad way, from an economical standpoint at least."

I acknowledged that he was right, supposing that Wood was speaking on generalities.

"You said a little while ago that the firemen would take a foot if you gave them an inch. I should judge they had taken something like a yard this morning."

"How so?" said I, and I was never more surprised in my life.

"Well," said Wood, "they have allowed the safety valves on the boilers to blow for over ten minutes since I've been in here, and I have heard them blowing off several times before this morning. They surely have different instructions than that."

"Of course," I replied. But to tell the truth I had never told the firemen anything about blowing safety valves. I assumed that they would look after the matter without instructions from me.

I made up my mind I would give them a "jacking up" as soon as Wood went away. I never did, however, for, after our little séance was over, I came to the conclusion that no one was to blame but myself.

Continuing, Wood said: "The blowing of a safety valve means that coal has been burned in heating water and changing it into steam that will never do any work in the engine cylinder. So far as the company is concerned, the coal might just as well be thrown into the streets. You can see the point, can't you?"

Yes, I could see the point, and I felt like kicking myself when I thought that it was necessary for the new manager to call my attention to the fact that I was allowing my firemen to waste coal by letting the safety valves blow off for long periods. I tried to justify myself by saying, "The firemen should know better than to get up such a head of steam."

"You can't blame the firemen for getting through the day as easily as they can. If they were getting three or four dollars a day it would be a different proposition. It is up to the chief engineer to see that only such methods are practised as produce economy."

"A man don't like to keep jawing his men all the time," I grumbled, trying to justify my shortcomings.

"It isn't necessary," replied Wood. "A chief engineer should be obliged to issue an order but once and the men should be made to know that when an order is issued, there is but one way out of it, and that is to obey it."

"I guess you would have a good time getting the men in most boiler rooms obeying every order," I answered, for I was becoming nettled by the way Wood was getting at me.

"There would be no trouble at all. The first disobedience of orders might be overlooked, but the man should be warned. The second occurrence would probably end in the discharge of the man unless a good excuse was forthcoming. If an engineer cannot enforce his orders—if he does not know how to handle men, then he is most likely to be a failure. There must be someone about the steam plant who is in charge."

As Wood said this he looked through me, so it seemed, and somehow I felt that he meant me, and that I was getting just what I deserved.

"I don't have that kind of trouble with my men," I protested. "We get along all right."

"No, I've noticed that there is very little friction, but perhaps you do not exert your authority. Most men will get on with their chief so long as they have their own way—so long as he is an 'easy mark.'"

"I'm no easy mark," I remonstrated.

"I hope not," replied Wood, and after a pause said, "The point is just this. You are chief engineer of this plant. I am manager. It is up to me to get economy out of the mill, and it is up to you to get the steam plant running on as economical a basis as possible, but the firemen won't do it. They won't save coal unless they are shown how, and that is where you come in."

"The men don't throw away coal. I have watched the coal pile for that very thing," I rejoined, and my spirits began to rise.

"There is more than one way of throwing away coal," replied Wood. "I have seen it done more than once since I came here."

"I'd like to know where," I challenged, although I was beginning to see that Wood had me cornered, but just at what point I did not know.

"Well, for instance," replied the manager, "just as I was coming in through the boiler room, one of the men had a fire door open, but before throwing in a charge of fresh fuel, he stopped to fill a pipe, light it and crack a joke with one of the other men. All of this time cold air was being drawn into the furnace over the fire, and coal was thrown away in heating that cold air. There can be no doubt about that, can there?"

"N-o-o," I said, rather faintly, for he had me "going," as the saying is. There was nothing else to say. I knew he was right. I knew that a loss was occasioned every time a furnace door was opened, but here again I had failed to put my knowledge into practical use. I had just the thing that was lacking, but did not use it. Why? Because I did not think that such a small matter made much difference one way or another. I had not taken the trouble to figure out that a little loss here and a little loss somewhere else, added together, made a big item in the total loss account. Here again it was a case of dozing in the engine room while the firemen allowed wastes to occur that I should have prevented. And the worst of it was, the new manager had noticed the loose way in which the boiler room was being managed.

"That was only one instance," I managed to say. "You could probably come into the boiler room a hundred times and never see a man do such a thing again."

I went a little further as my courage returned and was willing to bet that he could stay in the boiler room all day unnoticed and would not see a second like occurrence. But I knew he would, for if a fireman would do any particular thing once, he would do the same again.

"Let it go at that," said Wood. "I noticed another practice that seems to be followed regularly. I refer to the men firing heavy and then allowing the damper regulator to take care of the steam pressure."

"What's wrong with that?" I asked, although I knew well enough. Here was another case of knowing and not seeing that the proper thing was done.

"You wouldn't think of building a furnace of the latest design and then stopping up the tubes of the boiler in order to prevent heat going up the stack, would you?"

"Of course not," I answered.

"Then, why should you build a furnace under a boiler and then allow the fireman to stop up the smoke uptake?"

"I don't allow any such thing. The men don't do it either," I replied, rather nettled.

"It amounts to practically the same thing. You allow the firemen to fire heavy, and in any manner they choose, and then when the pressure rises the damper closes, shutting off the draft in the uptake and deadening the fires in the furnace. The result is that the fires, the furnace and the boiler are not allowed to work efficiently and good coal is thrown away, because the furnace is not worked to its greatest capacity."

"That's splitting hair," I retorted, although I knew he was right.

"Nothing of the sort," replied Wood. "Let's get down to coal dust and see if the thing isn't about as I say it is. Now the rate of combustion in a boiler furnace depends upon the ratio of heating surface to grate surface, the draft and the condition of the furnace and the character of the coal."

"Of course, everybody knows that," I replied.

"Well, now," said he, "what is the lowest rate of fuel consumption per square foot of grate surface that you know of, and what kind of coal would you use?"

"About 8 pounds, I guess, and poor coal and boiler setting," I added, as vague recollections of such figures came before my mental vision.

"And what is the best?"

"Between 35 and 45 pounds," I answered, "but it would have to be good coal and the best of furnace conditions," I added.

"I guess that would be about right," replied Wood. "That would mean about 3.5 pounds to 10 pounds of coal per horsepower per hour. Quite a difference. Now, boilers such as we have here should burn between 12 and 15 pounds of coal per square foot of grate surface per hour. If the amount of coal is less, the furnace is not doing the proper amount of work. If the rate of fuel consumption is increased, the efficiency of the furnace is increased."

There was no getting around that and I admitted that he was correct.

"If that is so, then better conditions can be obtained if a high rate of combustion is maintained, but it can't be done with the damper closed a portion of the time. And if the damper is frequently closed, it shows that more boilers are being used than is necessary."

"I don't believe that condition exists here," I protested, but having had my attention directed to the matter I was aware that the dampers were closed a whole lot more than I had thought.

"I am not so sure about that," was the rejoinder. "My observations of the way the men work and the condition of the fires and working of the damper lead me to think that a boiler could be cut out just as well as not. Of course, I am not running the steam end—only have an interest in it as a general—but if I were you, I would try getting along with one less boiler."

The tone was not threatening at all, but it had a ring that caused me to act upon the suggestion.

The result was a surprise to me. When the firemen were told to get out one boiler, as they were at the end of the day's run, considerable grumbling was indulged in, which showed me that the manager was correct when he said that men could get on with their chief so long as they had their own way.

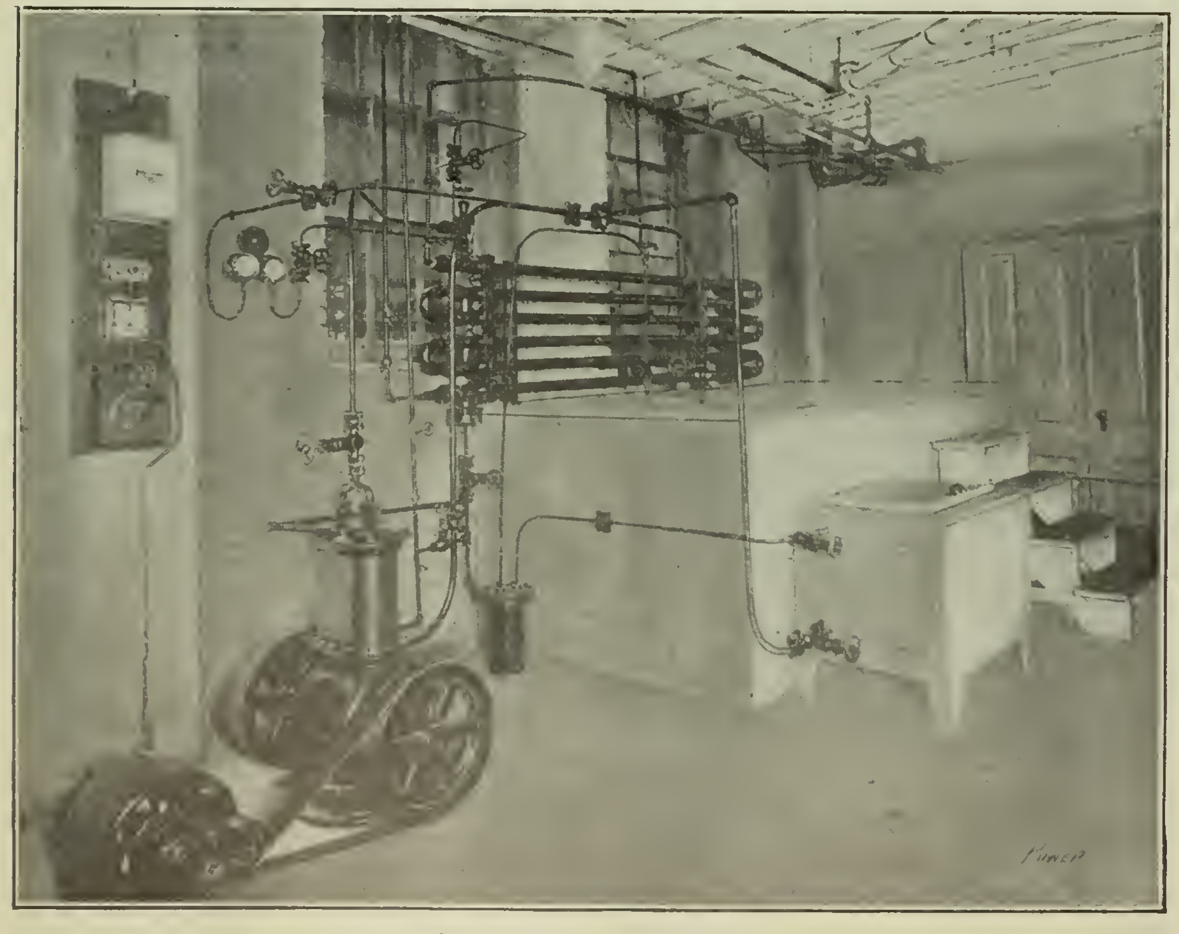
But the boiler was cut out, and the plant was run with one less boiler than it had been for the remainder of my stay. The difference was that the men had to fire oftener; the damper seldom closed and the coal consumption was greatly reduced; just how much, I do not recollect at this late day.

Low Pressure Refrigerating System

By R. C. Turner

The illustration shows an interesting little refrigerating system which is installed at the Commerce Hall building in Atlanta. The machine is of the single-acting type, of 1 ton capacity, and is driven by a 2-horsepower motor. The refrigerant used is Picteau fluid, and only a very small charge (22 pounds) is required for the system.

It will produce a ton of ice upon the cost of 12 kilowatt-hours and 60 minutes labor charge, the machine being in charge of the elevator operator. The cost of power being 36 cents and that of labor 25 cents, shows that a ton of ice is produced for 56 cents, not including any depreciation charges, which at the most would be only a cent or two.



Refrigerating Outfit

The method of operation is as follows: First, the expansion valves are closed tightly, then the motor is started and the freezing coils are pumped down to 2 inches of vacuum; next, the expansion valves are cracked slightly and the system is ready. The best results are obtained with a condenser pressure of 60 pounds, a suction equal to 2 inches of vacuum, and the machine running at about 65 revolutions per minute.

The machine, having an inclosed crank case, requires no attention; one gallon of oil put into the crank case being enough for a six months' run. The best oil for the purpose is a fine grade of transformer oil, on account of its freedom from moisture.

Exhaust Steam in Low Pressure Turbines

By George F. Fenno

There are enough good things that can be said about exhaust-steam turbines, without giving false impressions; and engineers should realize just how much power an exhaust-steam turbine can get out of the exhaust from reciprocating engines. The statement is usually made that, theoretically, there is very nearly as much power to be gained from the expansion of steam from atmospheric pressure to a 28-inch vacuum, referred to a 30-inch barometer, as is possible from steam at 150 pounds gage expanding down to atmosphere. This is very nearly true; but in a recently issued catalog of a turbine builder the statement is made that if a pound of dry saturated steam is expanded from 150 pounds gage to atmospheric pressure, 176 B.t.u. are available for conversion into work, when the expansion is adiabatic; that is, without receiving heat from or imparting heat to any outside body. It is then stated that a pound of dry saturated steam expanding from atmospheric pressure to a 28-inch vacuum renders 169 B.t.u. available for turning into work. A comparison of these figures shows that the expansion of steam in the lower range renders available for useful work only 7 B.t.u. less than that given up by the expansion of steam in the upper range. While these statements are true, the comparison is not fair, for if starting with a pound of dry saturated steam at 150 pounds, this same pound of steam is not saturated after expanding down to atmosphere. Therefore, the statement of the turbine builder assumes that the steam at atmospheric pressure has a much higher heat content than is usually the case. For instance, using the Marks and Davis entropy diagram, it will be found that when the original pound of dry and saturated steam expands from 150 pounds gage to atmospheric pressure it does give up about 176 B.t.u. which a perfect engine could convert into work, but that at the end of this expansion which, it must be remembered, is done at the expense of the internal energy of the steam, the steam has a quality of approximately 85.7 per cent. This is on theoretical grounds alone. In actual practice the quality of the steam will not be as high as this, due to cylinder condensation and radiation. However, to give the turbine the benefit of all doubt, assume that the quality is as high as 85.7 per cent. Now, in order to make a fair comparison, it must be remembered that the exhaust turbine must take the steam at this point and expand it down to the vacuum. Of course, in practice the turbine does not receive wet steam, as separators are inserted in the line; but this does not alter the argument, for this means that for every 100 pounds of dry steam used by the reciprocating engine, the exhaust-steam turbine receives only 85.7 pounds of dry steam at atmospheric pressure.

Starting at this point, with the steam at atmospheric pressure and with a quality of 85.7 per cent., and expanding it down to a 28-inch vacuum, referred to a 30-inch barometer, the heat content will drop from 1018 B.t.u. to about 869.7 B.t.u. That is, in the lower range of expansion there are really only 148.3 B.t.u. available for converting into useful work during adiabatic expansion, instead of 169 B.t.u. as claimed in the pamphlet referred to. So that, whereas this pamphlet claims that 96 per cent. as much energy is available in the lower range of expansion as in the upper; in fact, when correctly figured out, this proportion is only 84.3 per cent.

However, this 84 per cent. is well worth conserving, and turbine builders should be satisfied with it. Nevertheless, manufacturers should be careful about the statements they make in their literature, especially as engineers nowadays freely consult the catalogs of manufacturing concerns, realizing that they often contain the latest information in regard to the advance of engineering science.

The Straight Flow Steam Engine

By Rulof Klein

This engine, designed by Professor Stumpf, discharges its steam through large slots at the center of the cylinder. It compares favorably in economy with compound or triple-expansion engines and is much simpler and cheaper to build. The engine has met with great favor in Germany.

In a paper read before the Berlin District meeting of the Verein Deutscher Ingenieure, Prof. J. Stumpf, of the Charlottenburg Engineering College, Germany, inventor of the straight-flow steam engine, of which the principle of operation has been described in a previous issue of this paper, has described its thermal principles and published the vital details of construction and some operating performances, which should be of great interest to all readers familiar with steam-engine operation.

General Principles

In treating the thermal principles, he compares his one-cylinder creation throughout with the triple- and even the quadruple-expansion engine, because its ratio of steam expansion is about equal to that in these types, running from 1 to 15 to 1 to 30 or even higher, according to the load and initial steam pressure. See Fig. 1.

That these high expansions can be obtained economically in a single cylinder is due to the straight flow of the steam through the cylinder similar to the expansion and exhaust flow of the double-acting two-stroke-cycle gas engine of which the elongated piston acts as an exhaust valve, opening slots in the middle of the cylinder shell toward the end of the expansion stroke and closing them at the beginning of the compression stroke. As Fig. 2 shows, the live steam, which preferably is highly superheated, enters the engine through the cylinder head, which it heats and is admitted into the cylinder through the double-seated poppet valve and after expansion is exhausted through the large slots in the middle of the cylinder shell which, as described before, are opened by the piston acting as a large valve. The advantages of this arrangement above that of the ordinary steam engine can be classified as thermal, constructive and operative.

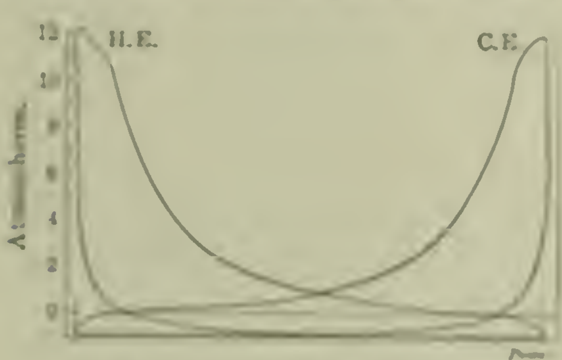


Fig. 1. Sample Diagram

Thermal Features

The main thermal advantage is the fact that the reëvaporation of the steam during the latter part of the expansion stroke in the ordinary steam engine does not occur here. The loss of heat necessary for this process is prevented in this engine as follows:

The steam entering the cylinder is heated by the compression charge, which is of extremely high temperature. During the expansion, condensation occurs to such an extent that at the end of the stroke the steam contains a great deal of moisture, with the exception, however, of the portion nearest to the steam-heated cylinder head which is kept in superheated condition by radiation from that source. The steam following nearest the piston is in contact with the coolest surfaces and therefore contains the highest percentage of moisture, the more so as here the cylinder wall is of still lower temperature and absorbs some of its heat, to return it later during the compression.

During the period of exhaust the straight-flow engine expels the coldest steam, which contains the largest amount of moisture, retaining the driest portion for compression, in contrast with the ordinary engine in which the hottest exhaust passes out carrying along the heat of the hot surfaces it strikes when leaving the cylinder.

Compound-, triple- and even quadruple-expansion engines have been built to reduce the disadvantage of great temperature differences of this nature, and equipped with all modern refinements, steam jacketed and superheated, these engines have not been able to establish any record of economy of steam consumption which cannot now be approached by the simple single-cylinder straight-flow steam engine.

A comparison of the combined diagram of the triple-expansion engine, Fig. 3, with the diagram of the straight-flow engine indicated by dotted lines in the same figure brings out the advantage at once.

Although the ratio of expansion is almost the same, the combined diagram is at a disadvantage at points A and B, the points of release of the high- and intermediate-pressure cylinders. At those points not only a portion of the indicator-card area is lost, but also the corresponding amount of heat on account of the sudden partial expansion. It has been tried to reheat the steam by jacketing but only with its application to the low-pressure cylinder, material advantage has been gained, as the steam entering that cylinder has gradually become so moist and cool that on account of the great temperature differences between itself and the jacket, it is able to absorb heat effectively and regain some lost energy. However, it is all too evident that most of this extra heat is exhausted directly to the condenser. Imagine that during almost the entire revolution of the engine the jacket of the low-pressure cylinder transmits heat to the coolest steam of condenser pressure to have it driven out through the wide-open exhaust valves. In the straight-flow steam engine the extra heat is only absorbed by the steam near the cylinder head, and, as pointed out before, is trapped, as it were, by the returning piston.

Besides the above features, Fig. 3 is also a comparison between the indicator diagrams of the two types of engines for the same brake horsepower. On account of its high mechanical efficiency of 92½ per cent., the straight-flow engine does not need as great a cylinder diameter for the same amount of power as the triple-expansion engine in its low-pressure cylinder. The diameters shown here are respectively 33 inches and 35.4 inches. Professor Stumpf claims that under equal conditions, the engine cost, leaving the

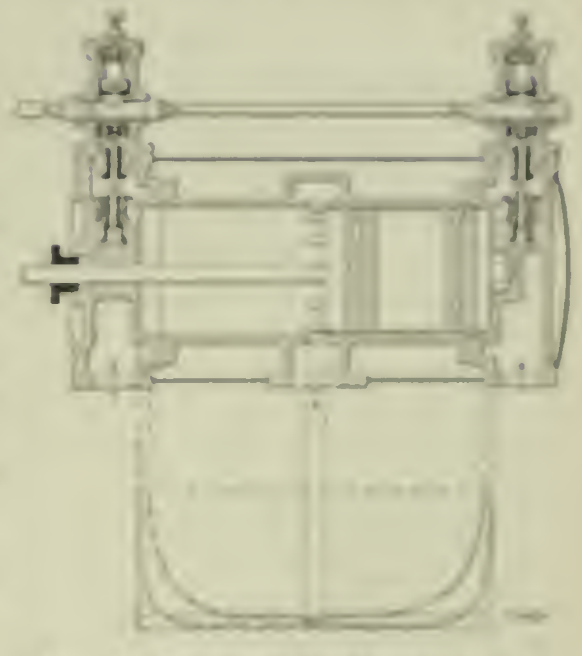


Fig. 2. Cylinder Arrangement of Straight-flow Engine

same power as a compound engine, although its efficient area is only four-fifths of the area of the low-pressure piston of the latter.

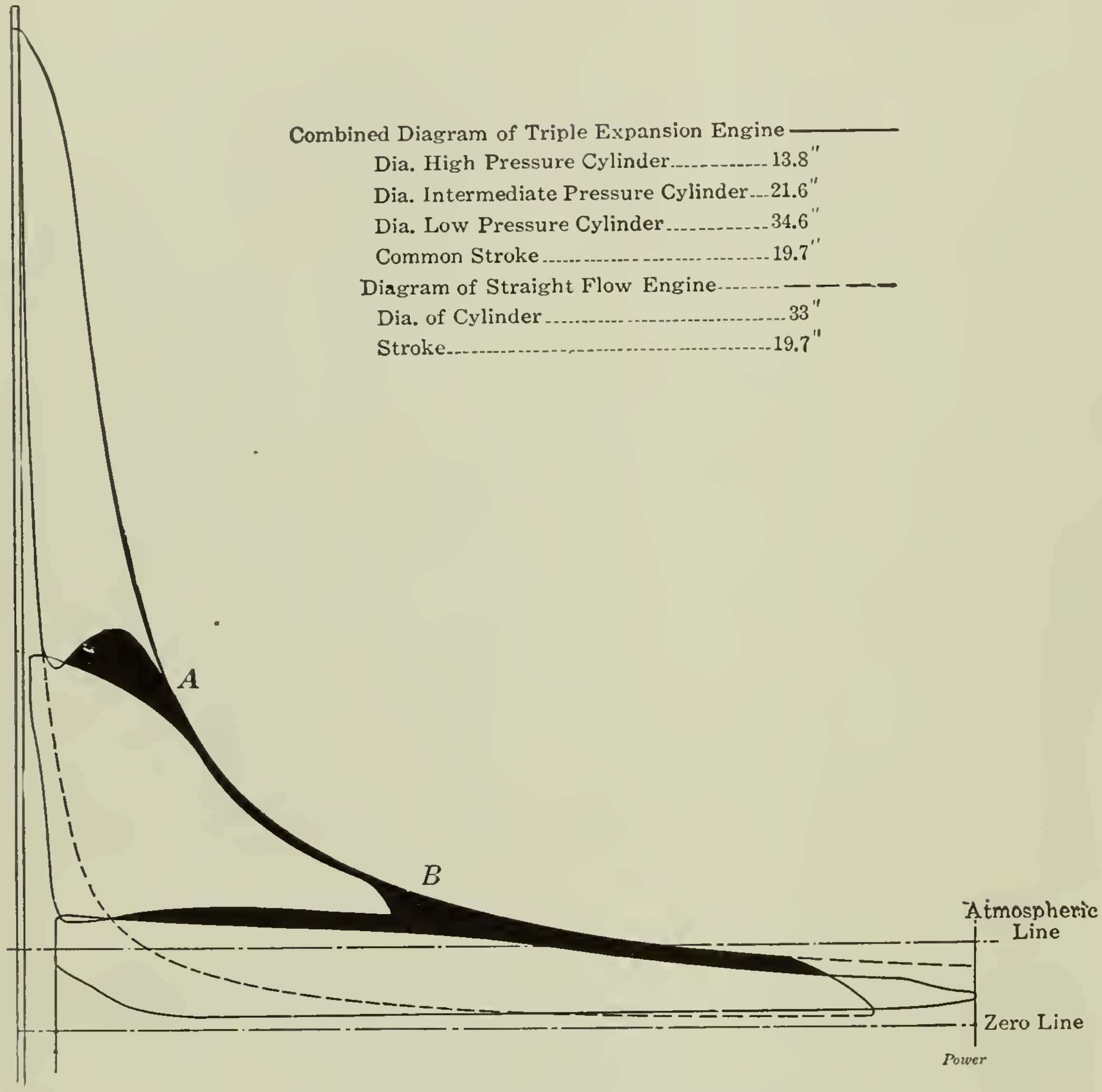


Fig. 3. A Comparison of Diagrams

The compression stroke for the straight-flow engine has also its advantages above that of an ordinary triple-expansion engine as the steam comes in contact with hotter surfaces the more it is compressed, while in the ordinary engine the surfaces of the compression chamber are immediately before swept by the cool exhaust steam. The compression in the new engine, which is carried higher than that in an ordinary engine, equals about the combined compression of the triple-expansion engine with which this engine should be compared. That the temperature of the steam at the end of the compression stroke is well above that of the inlet steam and greatly superheated, is shown by the following figures. Dry saturated steam at 28½ inches vacuum, compressed adiabatically to 177 pounds absolute, or 162 pounds gage pressure, will have a temperature of 1730 degrees Fahrenheit. The temperature of steam at 177 pounds gage pressure and 250 degrees superheat is only 628 degrees Fahrenheit.

High compression from high vacua to steam-inlet pressures seems more or less a necessary evil of this type of engine as the time of closing of the exhaust port is fixed at such a fraction of the stroke as the length of the exhaust slots is to the entire stroke. At lower vacua or atmospheric exhaust, modifications have been made in the described simple construction, in order to prevent the compression from running above the admission line.

To meet these requirements three distinct modifications have been made. For the stationary engine with atmospheric exhaust the clearance has been artificially enlarged by means of an extra compression chamber in each of the cylinder heads outside of the actual steam chest. With a valve in the head, this addition of the clearance can be closed off. For noncondensing operations a clearance of 16 per cent. has been found necessary, quite a good deal larger than the 1½ per cent. of clearance necessary with a vacuum of 28½ inches, or the 3 per cent. of our Corliss engines.

For locomotive engines running likewise noncondensing, the clearance is enlarged artificially to 17½ per cent. by concave construction of the piston ends. See Fig. 4. This design, in principle the same as the previous, has proved very efficient in tests made by the Prussian State Railway. Three locomotives were built especially to compare the merits of the straight-flow, the piston-valve and the Lentz valve engines. The comparison of coal consumption for these different types was respectively in the ratios 1, 1.19 and 1.285, giving the straight-flow engine an advantage of 19 per cent. over the piston-valve engine and of 28½ per cent. above the engine equipped with Lentz valves.

The poor showing of the Lentz valves was partly due to the design of the cylinder, of which both inlet and exhaust valves were located in one long steam port. This feature is in direct opposition to the straight-flow principle, as the steam passage is effectively cooled by the exhaust just before the admission of the live steam.

The latest design of noncondensing straight-flow steam engine, which bears witness of the resourcefulness of the inventor, is shown in Fig. 5. A piston valve is placed inside the piston directly below the rod. It is operated by a little rocker arm, which is attached to the crosshead end of the connecting rod, and rocks about the crosshead pin as center. The valve alternately opens one side of the piston or the other to the respective cylinder ends, procuring passage for the ex-

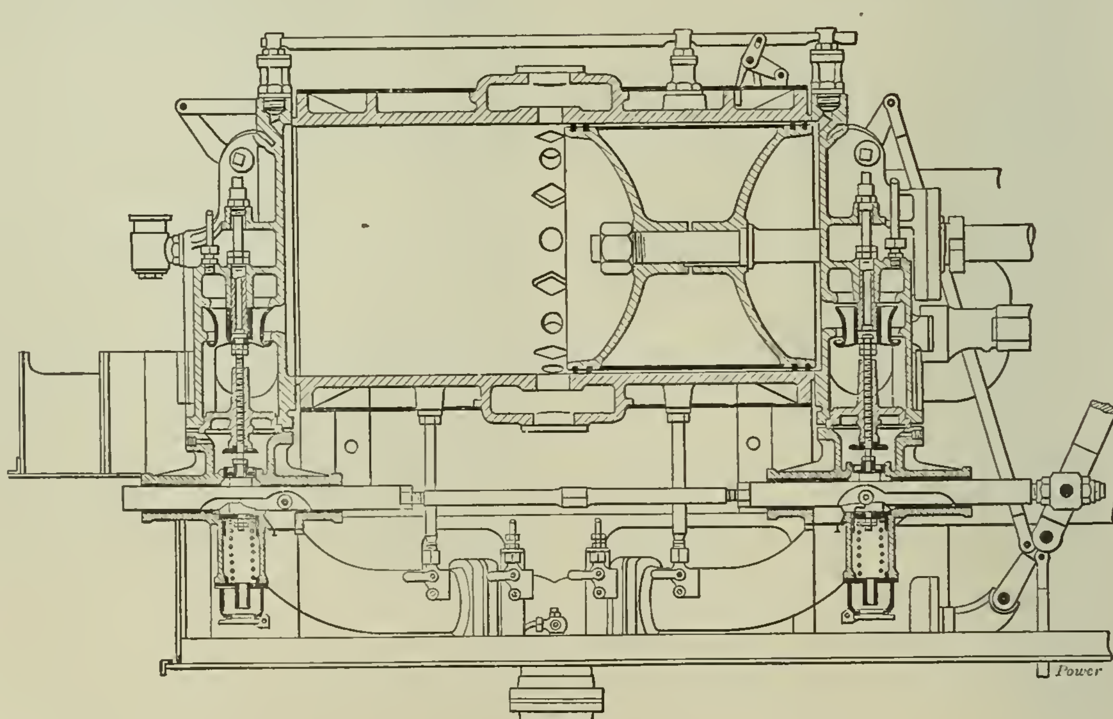


Fig. 4. Locomotive Cylinder, Showing Piston of Concave Construction

haust steam from these ends through its seat and the holes in the side of the piston to the exhaust slots. These valves close a trifle after the exhaust slots are closed by the second set of piston rings passing them. It is clear that the pressure inside the piston is kept atmospheric throughout the stroke.

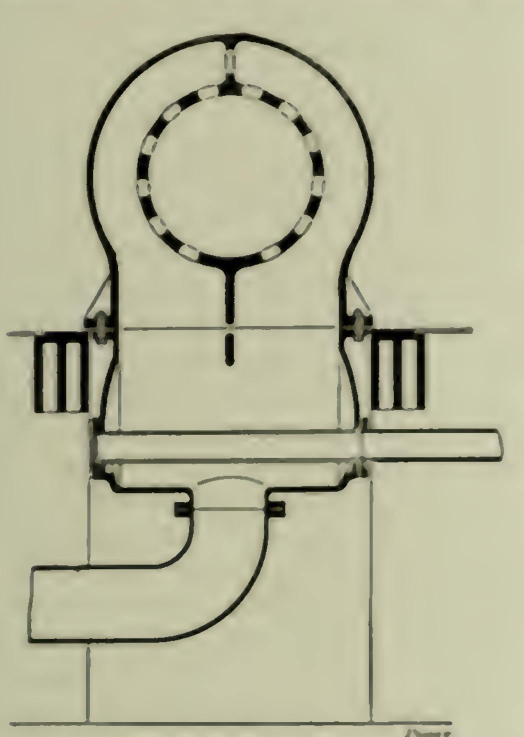


Fig. 5. Latest Design of Noncondensing Straight-flow Engine

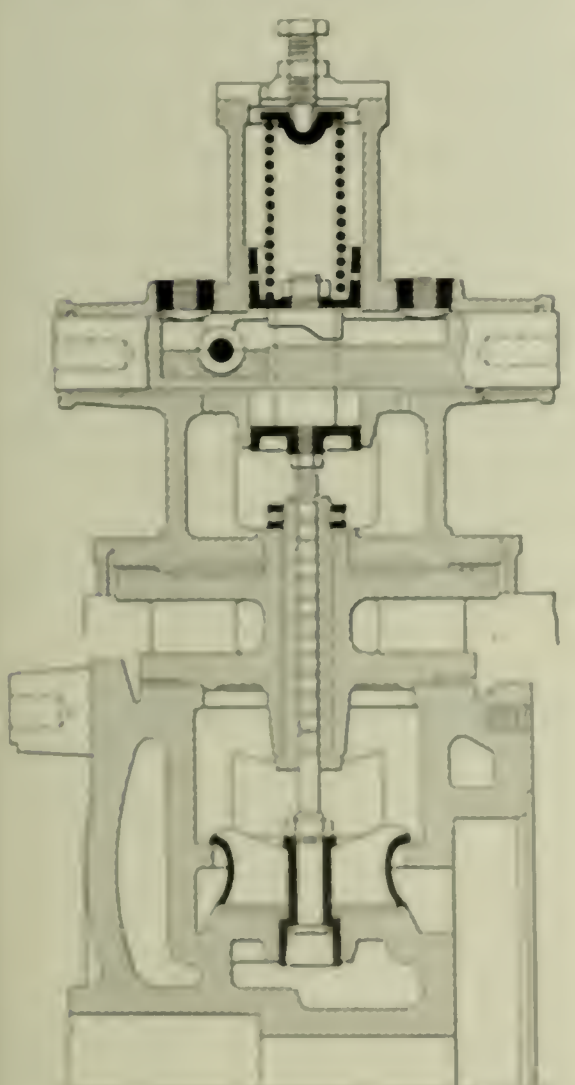


Fig. 6. Inlet Valve and Gear

We have seen that during the thermal cycle of ordinary engines hot steam strikes cooled surfaces and cold steam strikes hot surfaces to the detriment of their efficiency, while this is almost entirely omitted in the new engine and even that portion of the steam which absorbs heat from the cylinder heads during the latter part of the expansion stroke is trapped for use during the compression.

As Professor Stumpf says, in the ordinary engine a thermal washing takes place. Surfaces are heated and cooled constantly, while in his engine both inlet ends are hot and stay hot, while the common exhaust end in the middle of the cylinder is cool and stays cool.

Yet, with all the thermal advantages of his engine, the inventor calls for still higher superheat than is already used in European power houses. He claims that his engine is in better condition to utilize it than any other, on account of its large ratio of expansion. This leaves the steam very moist at the end of the stroke, even if the highest degree of present superheating is applied.

Constructive Features

As to the constructive advantages of this engine, we detect immediately the absence of exhaust gear and valve; the only visible moving valve part is the rod, shown on top of the cylinder, operating the valves by means of roller and cam similar to the valve gear of the blowing tubs of the Southwark Foundry and Machine Company, of Philadelphia.

As is shown in Fig. 6, the slot containing the rollers is at the same time an oil reservoir which never passes the end of its guide so that oil cannot be spilled nor dust enter. The valve stem is packed by means of a labyrinth packing. The piston, elongated to the length of the stroke minus that of the exhaust port, offers a large bearing surface to the cylinder wall, which is coolest at the point where the piston speed is highest. Therefore, favorable friction conditions exist.

On account of the high compression, a great piston speed is possible in spite of the heavy reciprocating parts, preferably 800 to 900 feet per minute. The diagram, Fig. 7, which corresponds to this speed condition shows that the resultant pressure on the crank pin is approximately constant over the entire stroke, most of the high initial steam pressure being absorbed by the inertia of the reciprocating parts to be imparted later to the crank pin, when the steam pressure has decreased. No knock does occur, however, for the compression line passes the inertia line before the end of the stroke, as shown in the lower part of the diagram. As a matter of fact, this engine has attracted attention in operation on account of its smooth running.

No wonder that with this high speed and heavy reciprocating parts a heavy counterweight opposite the crank pin is

Fig. 7. Diagram of Resultant Piston Pressure for Engine Running Condensing

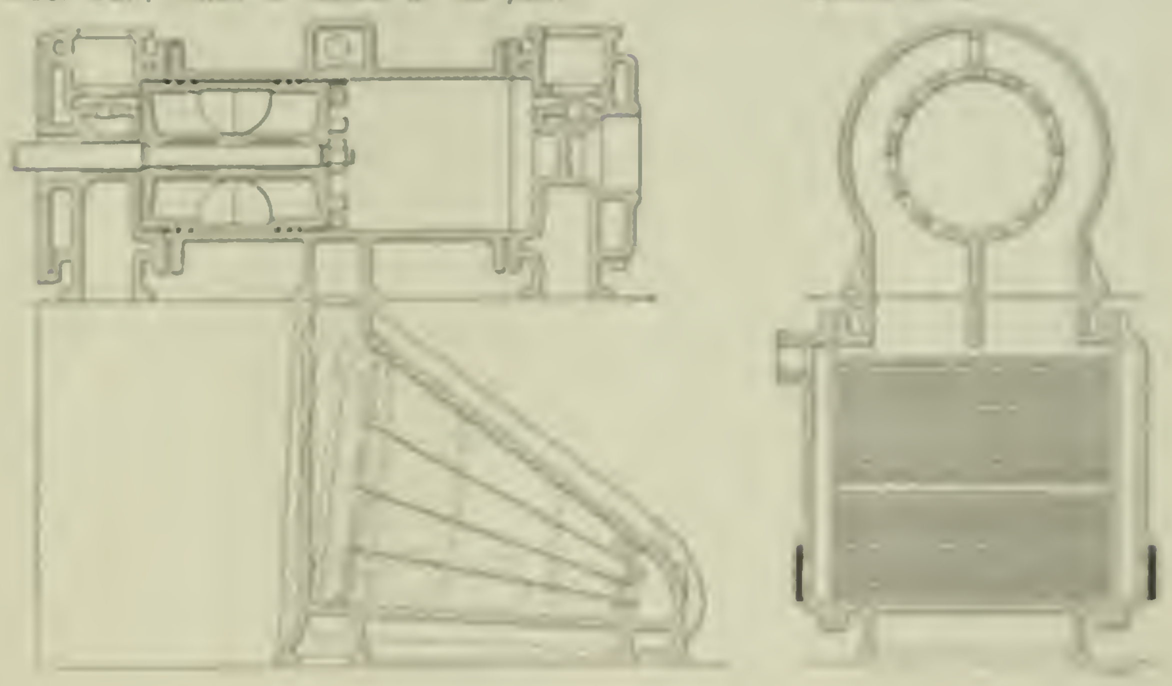


Fig. 8. Straight-flow Engine with Surface Condenser

necessary, and also a very solid foundation, for the inertia, which tends to cause vibration, is many times greater with this engine than with an ordinary steam engine of the same power, especially with cross-compound or triple-expansion engines where the different sets of reciprocating parts balance each other more or less.

FIG. 9. DIAGRAM FROM QUADRUPLE-EXPANSION ENGINE

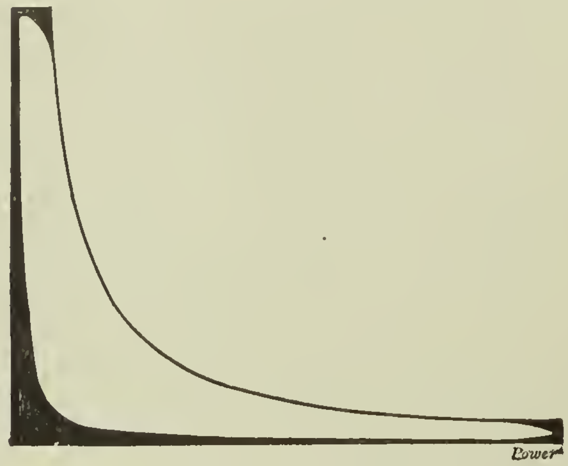


FIG. 10. DIAGRAM FROM STRAIGHT-FLOW ENGINE

On account of the absence of valves below the cylinder of this engine, room is left for immediate connection to the condenser. A surface condenser attached is shown in Fig. 8. The design of the condenser proper is interesting. It offers a large tube area to the inrushing exhaust steam, and is provided with simple trays, which convey the condensate to the outlet, preventing the detrimental flooding of the tubes.

TABLE 1. TEST ON THE STRAIGHT FLOW ENGINE OF THE ELSASSISCHEN MASCHINEN FABRIK.

STEAM ENGINE.	
Average gage pressure at throttle, lb. per sq.in.	179
Average gage pressure at inlet of cylinder, lb. per sq.in.	169
Average steam temperature at throttle, deg. F	628
Average steam temperature at inlet, deg. F	581
Vacuum in cylinder, in. of mercury, abs.	4.35
Vacuum at oil separator, in. of mercury, abs	3.63
Vacuum in condenser, in. of mercury, abs	2.25
Revolutions per minute	121
Indicated horsepower	503.1
Brake horsepower	465.7
Mechanical efficiency, per cent	92.5
Steam consumption, lb. per I.H.P.-hr.	10.1
Temperature of cooling water entering condenser, deg. F	54
Temperature of cooling water and condensate leaving condenser, deg. F	88
Pounds of cooling water per pound of steam	30
GENERATOR.	
Amperes	1277
Volts	250
Kilowatts generated	319.4
Efficiency, per cent	93
Net kilowatts	307
Steam consumption, lb. per kw.-hr.	16.5

Where an invention has so many advantages as just described, it is hardly possible that not a few drawbacks are attached to it. To the great inertia forces of the reciprocating parts and the large clearance necessary for the noncondensing engines of this type, may be added its enormous maximum piston pressure per horsepower, which necessitates the design of extremely heavy parts.

It is to be compared with the low-pressure part of a triple-expansion engine able to stand the live-steam pressure, necessitating a heavy construction throughout and to develop the energy of all three cylinders combined requiring enormous bearings. To add to this feature the piston and correspondingly the cylinder are abnormally long, which is a feature of all center-exhaust engines.

The cost per unit of power of this engine, calling for a lean diagram for the most economical operation, will therefore be somewhat higher than that of the ordinary single-cylinder engine, although the absence of exhaust-valve gears rectifies this feature to a certain degree. Compared with a compound- or triple-expansion engine, however, with which it so successfully competes in economy, this engine is a good deal cheaper, the reason why it has met with great success in Europe, where its manufacture is taken up by almost all leading engine builders. To date, over half a million horsepower are built or in course of manufacture.

OPERATIVE FEATURES

After the completion of a couple of small experimental engines in 1908, the first 500-horsepower engine was tested in February, 1909. A log of this test is given in Table 1. It shows that with a gage pressure of 179 pounds, 628 degrees steam temperature and a vacuum of 26.4 inches at an oil separator, which unfortunately throttled the connection to the high vacuum in the condenser, the engine consumed 10.1 pounds of steam per indicated horsepower-hour and 16.5 pounds per net kilowatt-hour, including power for the operation of the condenser. That these records have been lowered to 8.5 and 14.4 respectively by a 300-horsepower engine, is shown in Table 2, where the performance of such a small single-cylinder engine is compared with the hitherto most economical triple-expansion engines. In this table are also shown performances of still smaller engines.

Besides the merit of high economy, the straight-flow engine has also a flat efficiency curve, which means that at fractional load or overload it consumes only little more steam per unit of power than at normal load.

The 33 moving parts compared with the 228 on the other engines show its simple construction, which is reason of its low oil consumption and of its being called the "engine with nothing to it." This feature is especially important with marine engines, where vibrations have to be reduced to a minimum..

Professor Stumpf admits that for smaller capacities, when three or more cylinders are not necessary, his engine stands behind the ordinary type, but claims its superiority with capacities where the application of a great many cylinders is justified, giving for comparison the diagrams of a quadruple-expansion and the new engine, Figs. 9 and 10.

In these diagrams the shaded parts represent losses which are 45 to 40 per cent. in Fig. 9 and only 20 per cent. in Fig. 10. This proves also that the cylinder diameter of the four-unit straight-flow engine can be made smaller than that of the low-pressure cylinder of a quadruple-expansion engine of the same power.

TABLE 2. COMPARISON OF OPERATING PERFORMANCES OF TRIPLE-EXPANSION STEAM ENGINES AND STRAIGHT-FLOW STEAM ENGINES.

Manufacturers.	Indicated Horsepower.	Diameter of Cylinders in Inches. High.	Intermediate.	Low.	Stroke in Inhces.	Rev. per Min.	Number of Moving Parts.	Steam. Pressure.	Temperature.	Steam Consumption per I.H.P. per Hour.	Kw. per Hour.
	BEST PERFORMANCE OF STATIONARY TRIPLE EXPANSION ENGINES.										
Sulzer, Switzerland	6000	40	60	2x73	67	83	228	170	572	8.5	13.7
Gorlitz, Germany	6000	40	60	2x73	67	83		170	572	8.5	13.7
Nurnberg, Germany	6000	41	60	2x73	67	83		170	572	8.5	13.7
	STRAIGHT FLOW STEAM ENGINES.										
Sulzer, Switzerland	300		23.5		31.5	155	33	130	617	8.5	13.7
Same engine	300		23.5		31.5	155	33	130	0	10.6	
Gebr. Stock, Holland	80		12.6		19.8	200		149	662	9.7	
Burmeister, Denmark			17.8		23.5	180		138	662	9.5	

After being given the speed of a Corliss engine, diameter of shaft, diameter of governor pulley and desired speed of engine, an applicant for a first-class engineer's license said he would raise the steam pressure to increase the speed of the engine.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Catechism of Electricity

The Self-starting Single-phase Induction Motor

1134. *Why are single-phase motors built with commutators and brushes as described in the last lesson?*

In order to make them start automatically and with a strong torque when the connections with the supply circuit are closed. An ordinary single-phase induction motor will not start when current is passed through the stator winding.

1135. *Why is the ordinary induction motor unable to start itself?*

Because the magnetic field set up by the winding is stationary and merely induces currents in the rotor conductors exactly as the primary winding of a transformer induces current in the secondary winding. The currents in the rotor conductors do not react on the field in such a way as to cause the rotor to turn, and it must, therefore, be started up by some external means. The commutator motors start automatically, and with a fairly good power factor.

1136. *Is it necessary to use a commutator to make a single-phase motor start automatically?*

No. A single-phase motor can be made to start without using a commutator, and many self-starting motors are built without the commutator arrangement.

1137. *What means is used to make the motor start itself?*

An auxiliary stator winding which produces a magnetic field that is out of phase with the field produced by the main winding. The result is a sort of two-phase rotating field somewhat like that produced in a two-phase motor, but not so uniform or regular in its variations. This rotating field serves well enough to start the rotor, however, if there is no load or a very small load on it while starting. Fig. 371 shows a motor of this kind.

1138. *Describe the construction of this motor.*

The stator is of the same general con-

Fig. 371. Self-starting Single-phase Induction Motor

struction as that of the ordinary single-phase induction motor, but the stator winding is divided into two parts, a main winding and a starting winding, and these are arranged in the slots exactly like the windings of a two-phase motor. The two windings are not alike, however. The main winding is of much larger wire than the starting winding. The rotor is of the simple squirrel-cage type. The construction of the stator and rotor cores is mechanically the same that is used in all induction motors.

1139. *Why are the two stator windings made different as to the size of wire?*

In order to obtain the "split-phase" effect. The starting winding, being of smaller wire, has a much higher resistance than the main winding, but, as the number of turns in the two is the same their reactances are equal. Consequently, the ratio of reactance to resistance is different in the two windings and this causes the currents in them to be out of phase with each other. The magnetic fields produced by the two windings are therefore out of phase and combine to form a resultant rotating magnetic field somewhat like that of a two-phase motor. This rotating field pulls the rotor around with it.

1141. *Is not the starting winding liable to overheat?*

It would if left in circuit continuously, but the rotor contains a centrifugal governor which operates a switch to cut out the starting winding when the speed is almost up to the regular running speed. Then the machine operates as a simple single-phase induction motor.

1142. *What are the advantages of single-phase motors?*

A single-phase motor requires only a single transformer and two lead wires; it can be supplied from any alternating current—single-phase, two-phase or three-phase—and the starting apparatus is of maximum simplicity. The self-starting type has the additional advantage that it can be thrown on and off the circuit from a distance by means of a simple knife switch and if the supply of current should be accidentally cut off, the motor automatically returns to its starting condition and therefore will not be damaged if the current is cut off and restored when no one is around.

Fig. 372. Single-phase Motors on Two-phase Line

Fig. 373. Single-phase Motors on Three-phase Line

1143. *How are single-phase motors connected to two-phase circuits?*

If the circuit is of the proper voltage for the motor, it is connected directly to either of the two "legs" or phases of the circuit, but if the circuit is a high-voltage primary line, a transformer must be used between the line and the motor; in that case the transformer may be connected to either leg of the supply circuit. Fig. 372 is a diagram showing these methods. The motor *A* is connected directly to a 110-volt lighting circuit which is supplied through a transformer from one leg of a two-phase primary circuit. The motor *B* is supplied through a transformer from the other leg of the same primary line, and the motor *C* is connected to one leg of a secondary 220-volt circuit which delivers current also to a two-phase motor *D*.

1144. *How are single-phase motors connected to a three-phase circuit?*

Each motor is connected to two wires of the circuit, either directly or through a single transformer. Fig. 373 shows connections in which each motor is connected in the same way, relatively, as the motor bearing the same letter in Fig. 372.

1145. *Are there any disadvantages in the operation of single-phase motors on two-phase and three-phase circuits?*

Yes. Both two-phase and three-phase circuits should be balanced as to the division of load between the different phases, and a single-phase motor operated on one phase or leg will unbalance the system. It is important, therefore, to have the same total motor load connected to both legs of a two-phase or all three legs of a three-phase system, and it is almost impossible to get such a division of load with a large number of single-phase motors on either of the systems, especially a three-phase system.

A New Method of Setting Brushes Accurately

By C. A. Boddie

A great deal of the sparking and commutator trouble in direct-current machinery is due to incorrect brush setting. In most industrial plants the voltmeter method of finding the neutral is either unknown or inconvenient.

Those in charge of direct-current machinery usually determine the best brush position by shifting the yoke back and forth until a position of minimum sparking is found. If the brushes are in good condition, they may be shifted through a considerable range before sparking develops. The usual intention is to fix the brushes in a mean position between the forward and backward limits set by sparking. This method is too rough. As long as the brushes are in good condition the machine may run sparklessly even though they are not on the neutral lines; but invisible sparking due to local currents at the brush faces will in time injure the contact surface and visible sparking will result. An examination of the motors of numerous industrial plants shows that the majority of motors are running with their bruhes not set at the neutral lines.

The writer has devised and used successfully a method of setting brushes which does not require expensive instruments or special apparatus. All that is required is a short piece of No. 12 insulated copper wire from which the insulation has been removed for a couple of inches from one end; this end is

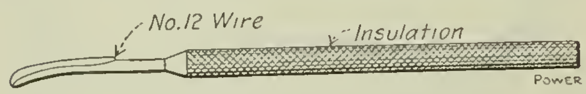


Fig. 1. Testing Wire

flattened and tapered to a point, as shown in Fig. 1. It will be found convenient to bend the end backward as indicated. When the machine is running and carrying its regular load, the wire should be brought into contact with the commutator and carefully moved toward the brush until it touches it. Usually the toe of the brush is the edge which sparks, and this edge should be tested first. If the brush spits and glows when touched with the wire, the brushes are not on the neutral line corresponding to the load on the machine.

Both the toe and the heel of the brush should be tested and the yoke shifted until the glowing stops. The brushes on each arm of the machine should be tested. If some spark while others do not, this is an indication that the spacing is not right. If a position cannot be found where the glowing stops, it shows there is something

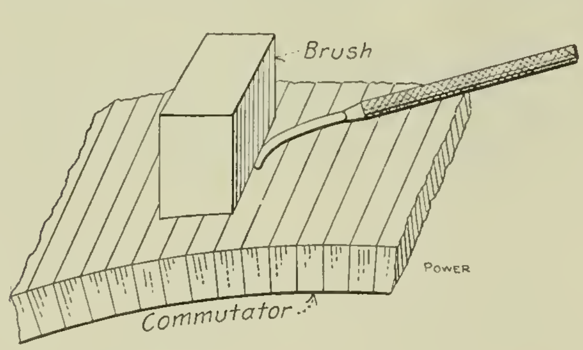


Fig. 2. Method of Testing

wrong in the adjustment or in the design of the machine. Small 500-volt machines and machines having high commutator speed will always spark more or less under this test, but the sparking is very slight if the machine is in good condition, even when carrying full load.

This test is based on the fact that a copper wire simultaneously in contact with the commutator and brush provides a low-resistance path between the two. The carrying capacity at the point of contact on the brush is low, so that if the potential is greater than it should be, enough current flows to heat this point to incandescence.

LETTERS

Mr. Greer's Rotary Converter Trouble

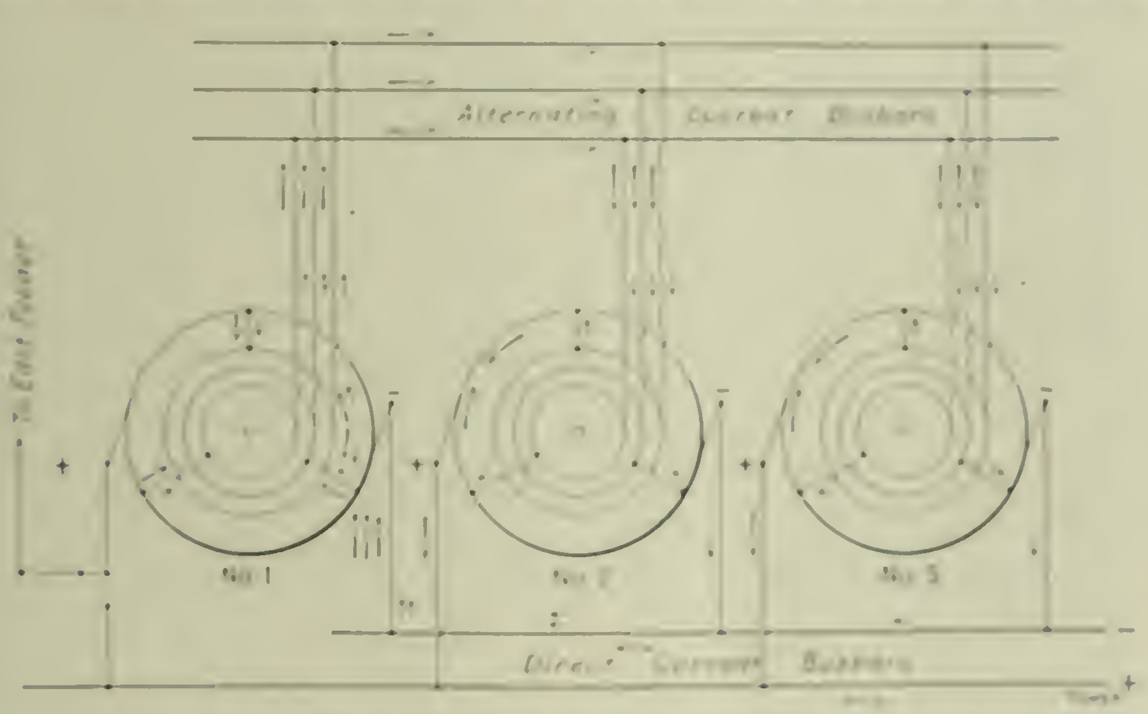
Mr. Greer's description, in the November 15 issue, of the peculiar behavior of his rotary converters interested me very much. For several years I have been operating rotary converters in parallel on both the alternating-current and direct-current sides without intervening transformers on the alternating-current side, and have had abundant opportunity to observe the conditions which arise from this method of operation.

When rotary converters are connected together on both the alternating-current and direct-current sides, a complete local circuit is formed by two converters and the alternating-current and direct-current busbars and a difference in the conditions of operation in the two machines—a slight difference in the relative positions of the direct-current brushes of the two machines, for example—will cause large cross currents to flow in this local circuit and produce many other peculiar conditions, one of which Mr. Greer described.

When two converters are running in parallel under the conditions stated, if one direct-current terminal of one machine is disconnected from the busbar, current will flow in the other lead, provided the direct-current voltages of the two machines are not exactly equal. The direction the current will take through this lead depends on whether the direct-current voltage of that machine is higher or lower than that of the other machine. With the machines I am operating, if the positive and equalizer switches are opened on machine No. 1 (the equalizer is on the positive side), and the field strengthened until a leading current of 94 per cent. power factor is obtained, equal currents will flow in the negative leads of both Nos. 1 and 2. Weakening the field of No. 1 will decrease the current in its negative lead until at 100 per cent. power factor the current is zero and further weakening of the field causes current to flow in the opposite direction—that is, in a positive direction in the negative lead—and at 94 per cent. leading power factor the current reaches the same value as before, but the machine is running inverted.

Mr. Greer's diagram of circuits does not show the direct-current ammeter connections, but the proper connections for them would be in the negative leads and I have assumed that they are so connected. He says that when an attempt was made to run the large machine, No. 1, in parallel with the smaller machines, No. 1 took all the load, indicating that at the busbar connections No. 1's voltage was slightly higher than that of the smaller machines, and this condition would cause all the current from the rail to pass through No. 1's negative lead and armature, and that coming from the west end passing through the alternating-current leads and busbars to the smaller machines. If Mr. Greer had inserted ammeters in the positive leads of Nos. 2 and 3, he would have found that current was flowing in them to the west feeder and when the direct-current sides of 2 and 3 were disconnected from the busbars that current was interrupted, which accounts for No. 1 dropping the west load and the potential falling to that of the distant west-end substation. The reason the ammeter needles on Nos. 2 and 3 went against the stops was because an equalizing cross current was flowing in the local circuit mentioned above, between the two smaller machines and No. 1.

In the accompanying diagram the paths and directions of the currents from the smaller machine to the feeder and rail through the armature of No. 1 and the alternating-current busbars are shown by the long arrows. The triple arrows on the negative lead of No. 1 converter mean that not only its own negative current but the negative currents of Nos. 2 and 3 are passing through it. The short arrows indicate the path of the cross current in the local circuit.



Mr. Harvey's Diagram of Circuits

The resultant current due to the combined direct and alternating currents flowing through the alternating-current busbars was probably alternating in character, though the wave form was doubtless very much distorted. The manner in which the current distributed itself among the collector rings and alternating-current leads varied with each position of the armature. For example, when one wire was carrying the greater part of the direct current the other two wires would probably be supplying the greater part of the alternating current. A study of conditions similar to the above, by means of an oscillograph, would be very interesting and instructive.

S. H. Harvey.

Hamilton, O.

In the issue of December 20 are three answers to my inquiry concerning the peculiar trouble with rotary converters which was described November 15. Of the three, that of Mr. Farwell is without doubt the correct solution. A more clear and concise explanation would be difficult to find. Mr. McKenney was correct in his statement that the trouble was due to operating the converters from a common set of alternating-current busbars, but the remainder of his explanation is wrong. By reading the description of the behavior of the machines one will see that it was not simply an exchange of current between No. 1 and the others, but that No. 1 actually was carrying the load on both feeders, although the feeders were actually separated at the switchboard because, as Mr. Farwell points out, the machines were tied together through the armatures and the alternating-current leads until separated by Nos. 2 and 3 being taken off the direct-current busbars.

Mr. Filkins is wrong in his explanation; the east and west end trolley wires were separated by a section insulator. I stated in the article that there was no link between the east and west end, and this was proved by the fact that the voltage of the direct-current busbars was that of the distant west-end substation (less the line drop) when Nos. 2 and 3 were taken off the direct-current busbars. If it had been as explained by Mr. Filkins the voltage of the direct-current busbars would have been practically that of converter No. 1, since the drop in the feeders to the first trolley tap and that of the trolley wires between the first taps would have been slight.

C. L. Greer.

Handley, Tex.

The Light That Failed

In a certain power plant, which was so small as to require only one attendant, a disagreement arose between the employer and the operator, which so angered the latter that he quit on one day's notice. It was impossible to get an experienced man to take the position in time to keep up the service, so an unskilled laborer was put on the job. The retiring operator refused to give this man any instructions, and it was more by luck than anything else that he kept the plant going for three days. At the end of that time an operator was secured who found no difficulty in understanding the plant, for it was a simple water-power installation of two units.

It was winter and the load was so light that it was unnecessary to run both generators together until one evening in early January, when some slight trouble with the machine in operation caused the attendant to decide to parallel the generators and take the first one off the line. His tracing of the connections had shown him that the synchronizing lamps should be dark when the two machines were in synchronism, and so, after getting No. 2 up to speed, he switched on the lamp ready to throw the main switch when the lamp darkened. He was surprised to find that the lamp did not glow at all and after rejecting the supposition that the machines had happened to come into step and stay there, he investigated the lamp and found that it was in good order.

Evidently there was some trouble in the connections of the lamp circuit and as it was therefore impossible to synchronize the generators, he kept the load on the first one until time for shutting down. A very careful search of the lamp connections was made, with the result that nothing could be found the matter with them. As a last resort the synchronizing lamp switch was taken apart and the source of the difficulty was revealed. A brass strip, intended to carry the current to the lamp, had been filed very thin in one place, and when the metal had contracted in the intense cold of the winter, had pulled apart there.

The fresh appearance of the filed place made it evident that it was the work of the preceding operator. He doubtless expected that the strip would be fused by the current to the lamp when at its maximum, that is, when the two generators were as far as possible out of step. If, when the light went out, the new operator threw the main switch, it would bring the two machines into dead short-circuit with each other, resulting possibly in the destruction of both generators. But for the unforeseen cold snap, this ingenious bit of spite work would probably have succeeded.

Howard D. Rice.

Hood, Cal.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Some Simple Handy Tools

By James E. Noble

A friend has several tools which cost only a few cents for material; the work of shaping them he did himself.

Fig. 1 is a tapered wedge made of steel, which is useful for separating flanges, prying off cylinder heads, scraping off old packing from flanges, etc.

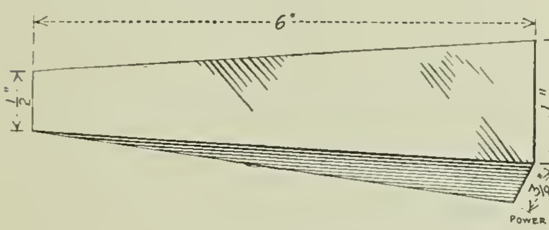


Fig. 1. Steel Wedge

Fig. 2 is a cleaner for gasolene and oil pipes. A piece of steel rope 8 feet long and ¼ inch in diameter is bound tightly near one end with fine wire, leaving about 2 inches of the wire ends to be spread out and act as a brush. A wooden or other handle with a thumb set screw is slipped over the rope and can be set at any point along the length of rope. In using this device, the spread end of the rope is inserted in the gasolene or other pipe and

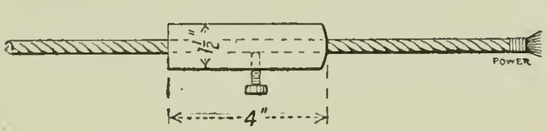
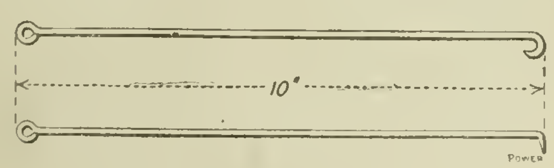


Fig. 2. Oil-pipe Cleaner

the handle is set an inch or so from the end of the pipe and the rope end forced into it; then the handle is moved another inch or two away and the rope forced farther in, and so on. A small pipe is easily cleared of any ordinary obstruction.

Fig. 3 shows a piece of stout wire with a hook formed at one end. It is handy for lifting out springs, picking up anything which may fall in a place difficult to reach with the hand, and so on.

Fig. 4 shows a steel wire with a straight bend at one end, and that end sharpened



Figs. 3 and 4. Packing Hooks

to a point; it can be used to pull out fine packing from packing boxes, etc.

Fig. 5 is a special bit, squared at one end so that it can be used in an ordinary brace or breast drill. The other end is widened out and sharpened as shown; it is especially useful for grinding in small valves and valve seats on gas engines, and for other kinds of work requiring a wide screwdriver blade and extra power.

Fig. 6 is a bolt-hole marker. It consists of a piece of round lead rod with an ordinary iron-pipe cap on one end. In cutting out paper washers as gaskets for gas-engine cylinder heads, some engineers use a hammer to mark the bolt holes, and this sometimes breaks away

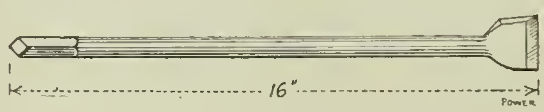


Fig. 5. Screwdriver Bit

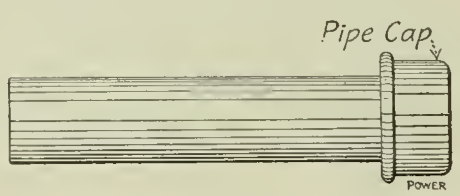


Fig. 6. Bolt-hole Cutter

the sharp edge of the iron around the holes. With this tool you simply lay the paper on the flange, place the lead end over the hole and strike the iron cap with a hammer; the bolt hole will be cut in the paper washer neat and clean. With bolt holes larger than the lead end, it can be used at the opposite side of the flange to mark the holes on the paper far better than an ordinary lead pencil, as the edges are square or sharp at *A* and reach right against the bolt hole.

According to reports received by the United States Geological Survey, the production of coal in the United States during 1910 was between 475,000,000 and 485,000,000 short tons, a considerable increase from the output of 459,715,704 short tons in 1909 and approximately equal to the maximum previous record of 480,363,424 tons, produced in 1907.

Of the total production in 1910 the anthracite mines of Pennsylvania contributed nearly 83,000,000 short tons and the bituminous mines between 390,000,000 and 400,000,000 tons.

Pertinent Features Relating to Gas Power*

By Edwin D. Dreyfus

During the fifteen years of commercial use of the gas engine in this country, abundant experience has been furnished from which may be deduced two features of importance:

1. The distinct fields of usefulness of gas engines may be determined definitely under any conditions, and, in general, are very well defined. Contrary to the frequent implication that gas is a direct competitor of steam power or other source of energy supply, there are unmistakable regions where a gas plant is unqualifiedly superior; and, on the other hand, there are places where it would be a positive economic disadvantage. Evidently there exists a line of division or equality but occasionally encountered, where the decision rests upon probable changes in industrial or operating conditions.

2. Gas-power machinery is less responsive to the ingenious fancy of the designer than the other well known types of station equipment, because the requisite characteristics of satisfactory operation and continuity of service may be satisfied only by a simple and effective design, from which but small deviation is feasible.

The disregard of these factors more than any other cause has been harmful to the gas-engine art. Notwithstanding this, the industry has materially prospered, and, owing to the inherent high efficiency in the conversion of latent thermal energy into useful mechanical power, it will increasingly continue to hold the attention of the engineering profession and commercial world as well.

The available fuels for engine operation are enumerated below and their approximate composition and calorific values are given in Fig. 1.

1. *Natural Gas,* existing principally in western Pennsylvania, western New York, West Virginia, Ohio, Kentucky, Kansas and Louisiana districts. It is a gas of ideal quality, possessing high heat value, being free from suspended impurities and containing only a small percentage of highly inflammable constituents (hydrogen chiefly).

2. *By-product Gas,* obtained mainly from blast furnaces and coke ovens; also from oil refineries as distillate. These gases are, in their crude form, accom-

*Extracts from a paper read before the Pittsburg Railway Club.

panied by objectionable impurities—entrained ore dust in the first two and oily vapors, lampblack and sulphurous compounds in the distillate gas—which must be removed to a reasonable degree by cleaning and scrubbing apparatus before delivery to the engine.

3. *Artificial Gas.* As several different fuels and processes are employed in the manufacture of combustible gases, there are several kinds available, such as:

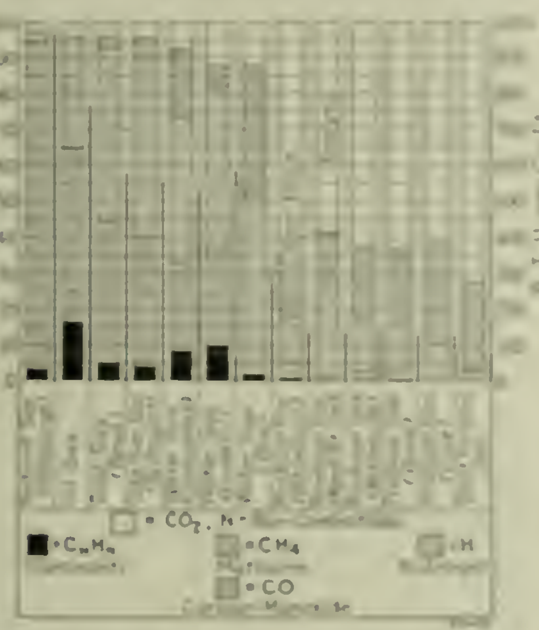


FIG. 1. COMPOSITION AND HEAT VALUE OF FUEL GASES

a. Illuminating Gas, produced from coal in benches or retorts by destructive distillation. This is available in practically all large cities; it is of high heat value and is a fairly clean gas. It contains a high percentage of hydrogen which compels the use of comparatively low compression pressures to prevent preignition. The enrichment essential for illuminating purposes and the added expense of distribution make the cost of this gas to the consumer ordinarily so high that its use for power purposes is restricted to very special cases.

b. City Gas, either made from the partial oxidation of coal and carburetted, or from crude oil, possesses the same limitations as illuminating gas so far as the gas engine is concerned. Blue-water gas of somewhat lower heat value and cost, is also less satisfactory and economical than the familiar producer gas.

4. *Producer Gas. A.* The gases made from anthracite and bituminous coals present the logical solution for the use of the gas engine in the absence of by-product or natural gas at low prices.

B. Oil gas producers for power purposes have not yet attained a sufficient degree of development to warrant extended use, but where crude oil is the predominating fuel supply, some installations have been made with fair success.

THERMAL EFFICIENCIES

The foremost characteristic of the gas engine lies in its uniformly high thermal efficiency in all sizes. This virtue is not found in either reciprocating steam engines or steam turbines; therefore, the greatest utility of the gas engine, barring by-product or natural gas supply, will occur in the smaller operations.

As an illustration, Fig. 2 shows conservative heat requirements in B.t.u. per kilowatt-hour of output for turbines ranging from 500 to 10,000 kilowatts inclusive, and a typical gas-engine curve which applies to all sizes. The latter is based on the total heat of the gas and a gas quality containing a high hydrogen content (lowering the effective value, say 8 per cent.), preferably to place the two types of units on the same plane. It is evident that as the larger capacities are approached, the disparity between gas and steam units steadily vanishes, either plant at best consuming approximately two pounds of coal per kilowatt-hour. Conversely, with a decrease in size of the plant, there is a wider gap between the two types of equipment. Thus the gas plant will continue to develop a kilowatt-hour on two pounds of coal, while the steam station may use eight to twelve pounds.

OPERATING ECONOMY

The impression that gas power invariably implies a lower cost of operation is being dispelled through the critical analysis of the elements of power cost. Fuel is manifestly only a fraction of the entire expense. Customarily a division is made between fixed charges, embodying interest, depreciation, taxes and insurance, and the purely operative expense, which includes fuel, labor, oil, waste, water, supplies and repairs. Fig. 3 illustrates the importance of the cost constituents. It is based on plants consisting of two units and burning coal which costs $3 delivered.

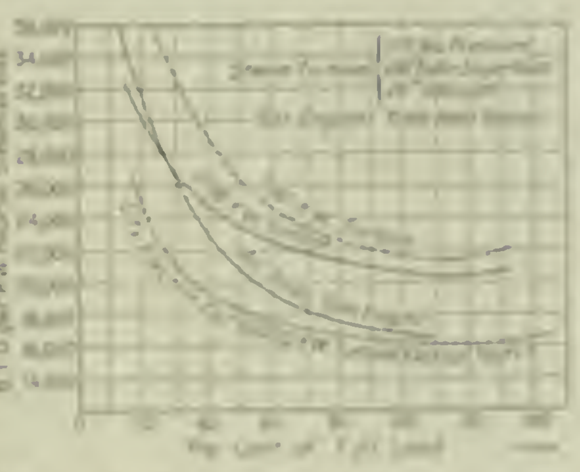


FIG. 2. HEAT ECONOMY OF TURBINES AND GAS ENGINES

The composite cost of a gas-power plant exceeds that of a high-grade steam plant by approximately 30 per cent. Such difference is quite normal in view of the character of working in the two plants. The gas engines must withstand combustion pressures reaching 450 pounds per square inch and corresponding temperatures up to 3000 degrees Fahrenheit, whereas a turbine deals with pressures of 150 to 200 pounds per square inch and temperatures in the neighborhood of 500 degrees Fahrenheit. Moreover, turbines are operated at relatively high speeds and very efficient use can therefore be made of the material employed.

Labor in small gas and steam plants will not differ greatly, but the simple turbine, with its minimum of parts, places a severe handicap on the gas engine when high powers are contemplated, constituting another reason for the barrier against the use of large gas engines for central stations burning coal as fuel. Having the size and cost of the plant, together with the schedule of operating labor and supplies arranged, the decision hinges upon the probable load factor and also upon the price of fuel, where it may be subject to variation. It is an obvious fact that low load factors work against the use of expensive installations, notwithstanding their superior efficiency.

Fortunately for the gas plant, the embarrassment of low-load factor conditions may be partially overcome by the use of a simple low-pressure turbine in conjunction with a heat storage system supplied by the waste heat of the engine and operated to carry the peak of the load.

Available statistics indicate that the cost of repairs in well designed gas-power plants of moderate size should be about on a parity with those of high-grade steam-turbine stations. That this assertion is reasonable is evident from the fact that the greater cost of cleaning and readjustment of boiler and condenser tubes above the negligible upkeep of the producer largely offsets the increased cost of "conditioning" the gas engine above that of the turbine. Hence fixed charges were arbitrarily assumed equal in plotting Fig. 3.

The real difference in obsolescence between the two types of plant is more or less intangible at present, and, therefore, in order to avoid complications, no distinction has been made.

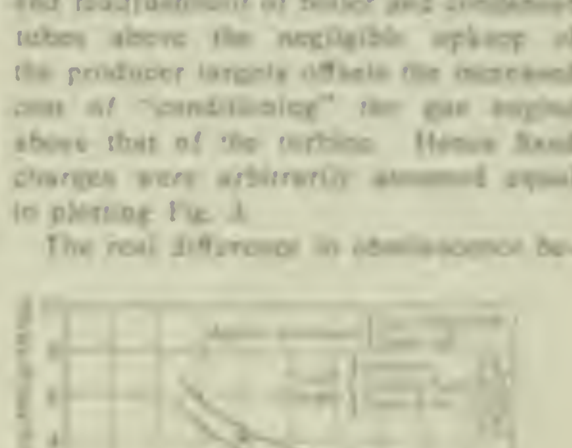


FIG. 3. COMPARATIVE OPERATING ECONOMY

Table 1 is given as an example of the

operating efficiency of a 550-brake horsepower producer-gas plant, including all items of expense:

TABLE 1.

Data on 550 Brake Horsepower Gas Plant. Monthly Record of Operating Costs, December 1909. Unit Load Factor 89.3 per Cent.; Station Load Factor, 67 Per Cent.

Items.	Cents per Kilowatt-hour. Producer Room.	Engine Room.
Fuel	0.202	
Operating labor	0.120	0.036
Repairs { Labor	0.008	0.050
Repairs { Material	0.000	0.002
Water	0.030	0.024
Oil and waste	.....	0.010
Auxiliary power	0.050	.....
Fixed expense at 15% on investment	0.127	0.254
Total	0.537	0.376
	0.913	

Auxiliary Heating

Power generation has mainly been reckoned with as applying to central distribution, but in the machine shop, factory and related industries, the power house is subjected to the extra demand of heat supply, especially above latitude 37 degrees. The heating requirement is often improperly allowed to discount the intrinsic value of the gas plant for the reason that the waste-heat energy is not concentrated in the same convenient vehicle for transmission to the point of consumption as is the case with the noncondensing engine or turbine.

More recently gas-engine exhaust heaters have been devised which render available in the form of steam 70 per cent. of the heat of the exhaust. While this quantity represents only two pounds of steam per brake horsepower developed, it will evidently prove sufficient where the ratio of power to steam demand is low. Where the ratio of the pounds of heating steam required per brake horsepower is known, a choice of prime mover may be made as indicated by Table 2.

TABLE 2. POUNDS OF STEAM PER BRAKE HORSE-POWER.

Simple automatic engine	40
Small steam turbine	30
Single cylinder corliss engine	28
Corliss non-condensing compound engine	22
Automatic bleeder turbine	20
Complete expansion turbine (bleeding 25% from receiver)	6
Gas engine (waste jacket and exhaust heat used in hot water system)	5
Gas engine only, exhaust applied to steaming	2

A late report from railroad circles is that the engines on the Pennsylvania lines east and west are to be equipped with automatic underfeed stokers. Orders have been issued to the master mechanics of all the shops to install the stokers as soon as possible. The reason given is that the company wants to live up to the law requiring the abatement of the smoke nuisance. No confirmation of this report has been heard. It is said that 6000 engines will be so equipped.—*Exchange.*

Some Ignition Pointers

By Paul C. Percy

The sudden stopping of a gas engine which has been running normally is almost always due to a breakdown somewhere in the ignition system. With a jump-spark system this may be a broken connection in either the primary or the high-tension circuit; "frozen" contact points on the vibrator of the spark coil, or a short-circuit in some part—any part—of the system. It could also be due to a slipping or broken timer or to slipping of the belt or pulley of the generator if one is used, but these are not so likely to happen as the first three defects.

If the make-and-break system is used there is no vibrator to "freeze," of course, but the other troubles mentioned can occur. The failure to "fire" can also be caused by the contact points of the igniter having been burned out; this will either prevent them from closing the circuit at all or make the electrical resistance at the contact points so high that the current will be too weak to produce a good spark when the contacts are separated.

If the igniter is of the electromagnet type, failure to "fire" may be caused by trouble at the timer, such as burned con-

A Good Diagram

tacts, loose connections, or a weak spring. It may also be that the rocking contact of the igniter is jammed so that the magnet cannot move it.

Trouble in the ignition system will also prevent an engine from starting up, of course, but failure to start can also be due to many other causes, whereas a sudden stop is rarely caused by anything else.

Too much current in the primary circuit of a jump-spark system is as bad as too little. It overheats the coil and eats away the contacts of the timer and the vibrator very rapidly and very unevenly. This uneven burning of the points is what causes them to stick together or "freeze." The surfaces are so rough and irregular that they finally touch each other only at a small high spot on each piece of platinum, and the heavy arc produced between the sharp points fuses them together.

To guard against "freezing," as well as other contact troubles, the platinum points of all timer, vibrator and igniter contacts should be cleaned and trued up once a week. This can be done in a very few moments with a sharp, medium-cut file, a very fine file and a piece of emery cloth, using these in the order named. In finishing with the emery cloth it should be backed up by a thin strip of steel, such as a machinist's rule, to avoid rounding the edges. The faces of the platinum points should be left dead flat and true with each other.

If the timing of the igniter be retarded beyond the dead-center position of the crank, the cylinder will almost certainly overheat because the combustion of the mixture is greatly prolonged; also, the power of the engine will be reduced. If the timing be advanced too far, the engine will usually knock, but this cannot be considered a reliable guide because some engines do not begin to knock until the timing has been advanced so far as to be really dangerous.

It is advisable to put stops on the timer mechanism which will prevent retarding the timing beyond the dead-center position and advancing it too far. It is necessary to take diagrams, with the best mixture that will ever be used, to find the point to which the timing should be advanced at full load; the point of maximum advance should be that which gives the nearest approach to a well rounded diagram, such as the one here shown. Sharp corners at the peak and the ignition point on the diagram are not desirable, but with a rich mixture containing much hydrogen it is not easy to avoid them; that can best be done by adding more air to the mixture and advancing the ignition point a little more.

A New Aeroplane Engine

The *Yorkshire Observer,* in an account of a lecture delivered before the Leeds University Engineering Society, by R. J. Isaacson, gives his claims as inventor of an improved aëroplane engine, as follows:

He stated that his new engine was based on the same general principles as the Gnome, but embodied many of his own devices, notably one which enabled the engine to be started slowly and run at almost any speed up to its maximum that the aviator wished. This was a vast improvement, because with all machines in use at present it was only possible to work at one speed, and that the highest. Therefore, when an aviator, having attained a considerable hight, wished to descend, he must shut his engine off altogether. But if the propeller once stopped revolving it was impossible to restart the engine without help, and therein lay the reason for the awe-inspiring volplanes, by which aviators descended from great hights. It was necessary to descend at a great speed, so that the force of the air against the propeller might keep it in motion in order that when the aviator neared the ground he might restart his engine, and thus control his movements. Mr. Isaacson claimed that the use of his engine would obviate all necessity for volplaning.—*Daily Consular and Trade Reports.*

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Water Control Valve on Heater

Much worry and trouble are caused by the automatic valve which regulates the flow of feed water into an open heater. I know of no valve of which so much is expected. It must work so freely as to be handled by an ordinary float, it must move from a closed position to wide open during the movement of the float, and it must shut perfectly tight.

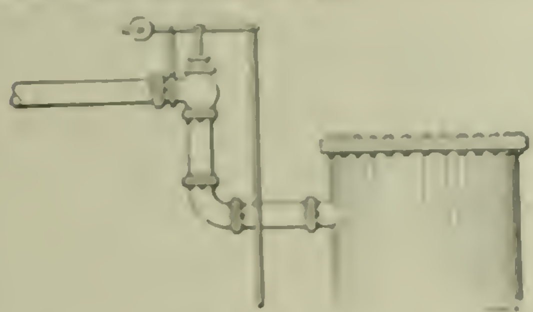


FIG. 1.

I have tried several valves, one of which was made as shown in Fig. 1. The 20-foot head under which it worked would, however, hold it shut until the float was held almost clear of the water. Then, when the valve did operate, it opened wide with a jump and almost deluged the heater with water; in closing it would shut with a vicious bang as soon as the valve got near enough to its seat to be caught in the current of water. Sometimes it would pound on the seat 30 or 40 times before seating.

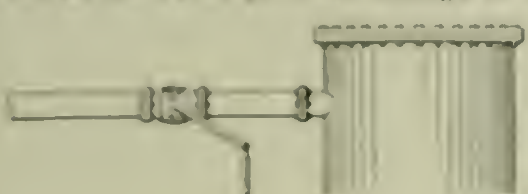


FIG. 2.

The second valve I tried was of the butterfly type, shown in Fig. 2. It had just one fault; it would leak in spite of all that could be done, and if no water was drawn for an hour the heater would be flooded.

Another valve I tried was an ordinary globe valve rigged up as shown in Fig. 3. The fault of this valve was that, although it worked freely, it did not open enough during the travel of the float, and very often small particles in the water would wedge in between the disk and seat and prevent the valve from closing tight.

FIG. 3

Another valve was made from an ordinary brass stop cock with a handle attached, as shown in Fig. 4, but I found that, while it had all the good features of shutting off tight, not clogging, and opening quickly and fully with a small travel, it was too stiff to be operated by the float, and if it was loosened up so that it could be operated by the float it would leak at the washer on the small end. Finally I removed the nut and washer, threw them in the scrap box, and then cut off the small end of the plug so that it lacked 1/4 inch of coming flush with the seat on the body of the valve against which the washer had fitted. Then a small brass disk was soldered over the small opening of the body, making it similar to a marine cock. This put an end to the leakage at the small end of the plug. In order to hold the plug on its seat, I rigged up the pressed spring shown in Fig. 5. The point of the adjusting screw rests in the center plate on the plug and is so arranged that the pressure could be varied. This meets all requirements as it works free, shuts off tight, opens and closes with a small movement and is not affected by the pressure or water head it is controlling.

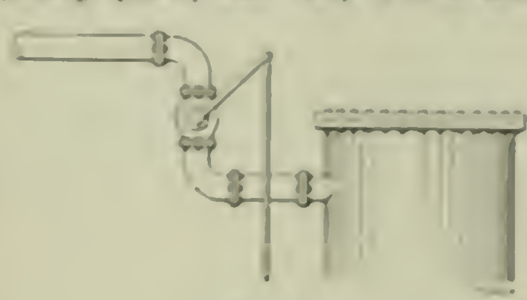


FIG. 4

FIG. 5

R. MANLY ORR.

Brantford, Can.

Estimating Refrigerating Surface

It is often convenient to know the amount of piping required for brewery cellars and the like.

Without knowledge of all of the elements effecting the cold losses from a cold-storage compartment, only general statements can be made, which, while probably fitting the general case, might fall wide of the mark in any isolated special case.

The logical way of computing pipe areas is first to calculate the amount of heat entering through the walls of the cellar and add to this the amount of heat generated by the fermenting wort. For a given back pressure and known number of hours of operation of the refrigerating machine, it is then a simple matter to calculate the amount of pipe required. The estimate of the pipe area is based on the amount of heat that will pass through the metal of the pipe due to the difference between the temperature of the brine or ammonia on the inside and that of the air on the outside.

Obviously, the amount of piping depends on the wall area, insulation efficiencies and differences in temperature. When these factors are not all known, it has been customary to adopt rough rules in the form of "ratios" by which it is assumed that under average conditions a square foot of pipe surface or

RATIOS FOR BREWERY CELLARS

Kind of service	Cubic Feet per Foot of Piping, Running Line, to 1000 Cubic Feet			Temperature
Fermenting room	2" direct-expansion pipe	[illegible]	[illegible]	[illegible]
	1¼" brine pipe	[illegible]	[illegible]	
Storage cellar	2" direct-expansion pipe	[illegible]	[illegible]	[illegible]
	1¼" brine pipe	[illegible]	[illegible]	
Chip cellar	2" direct-expansion pipe	[illegible]	[illegible]	[illegible]
	1¼" brine pipe	[illegible]	[illegible]	
Racking room	2" direct-expansion pipe	[illegible]	[illegible]	[illegible]
	1¼" brine pipe	[illegible]	[illegible]	

running foot of pipe will provide refrigeration for a given number of cubic feet of space. A fermenting room, for example, maintained at a temperature of from 36 to 40 degrees would be piped, according to the practice of one large builder of refrigerating machines, on a ratio of 1 to 14; that is, 1 running foot of 2-inch direct-expansion pipe for every 14 cubic feet of space.

For piping the different cellars in a brewery, the following ratios will offer at least a rough guide, it being understood that they may not fit particular cases and that it is desirable, when it is possible to determine the areas, differences in temperature and nature of the insulation of each wall, floor and ceiling, to compute the cold losses through the walls. Then, after determining the ammonia back pressure and temperature, the required number of square feet and finally the number of lineal feet of heat-absorbing pipes may be ascertained.

The accompanying table will serve as a guide in laying out the piping for brewery cellars of from 10,000 to 40,000 cubic feet in size.

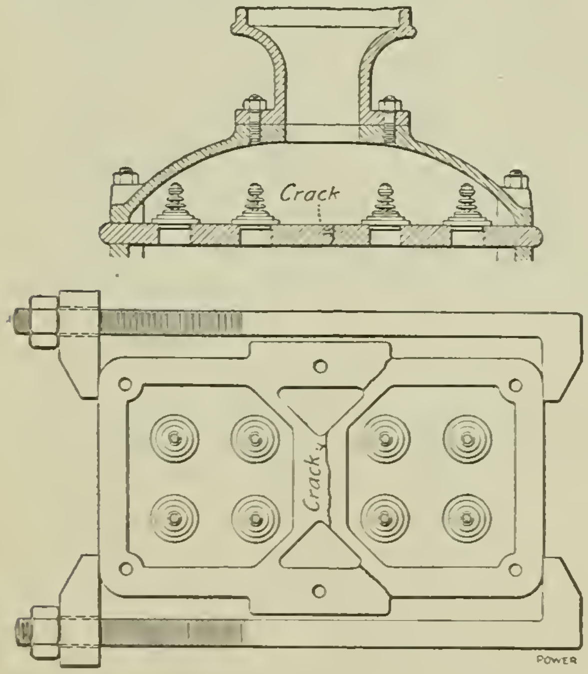
F. E. MATTHEWS.

New York City.

Repairing a Pump Valve Deck

Upon taking charge of a steam plant at one time, I found a broken pump, and nobody knew what ailed it.

Upon removing the cap of the valve chamber it was found that someone, in removing the water-valve plate, had cracked it, as shown in the sketch. This crack was caused by driving a cold chisel under the plate at one end.



CRACK IN VALVE DECK

The plate was repaired by getting two iron clamps from the stop and putting the two broken pieces in place, as shown. A small strand of asbestos wicking was put between the two broken pieces, and the clamps were then tightened.

Next, the top of the valve chamber was put in place and the nuts tightened on the stud. The clamps were then taken off, the pump started, and kept in operation for six months. In the meantime a new plate had been ordered.

In removing a valve plate, use two thin chisels, driving them in slowly, and use a thin knife blade to work the gasket loose before the plate is removed.

CHARLES L. NEFF.

Little Rock, Ark.

Topics for Discussion

After reading mechanical papers and books, I have been able to find but little on the design of breechings for boilers. One thing especially was noticed, the lack of discussion of draft losses.

There are a few subjects I would like to see discussed, and I believe they would be of great benefit to many engineers. They are as follows:

The proper area of a breeching for boilers to be operated at the builder's rated capacity; and for boilers to be operated at high overloads, say 175 per cent. or more of their rated capacity.

Draft losses to be expected in a breeching of excellent design.

Draft losses through the sharp angle turns or sudden changes in shape of the breeching.

Losses in draft, due to radiation, in long runs of bare steel breechings.

Losses in draft due to the cooling of gases by the infiltration of cold air in brick breechings.

One case is that of a plant of three boilers and a brick-lined steel stack, 56 inches in diameter and 135 feet high. The stack was of sufficient size and hight to furnish draft for the plant, yet there was insufficient draft. Eventually an induced-draft outfit was installed with the fan arranged to "pull" on the stack. The draft at the base of the stack was then 1.85 inches; on the stack side of the damper, 0.40 inch; and over the fires, 0.17 inch. Later the breeching was altered and some other changes made, all on the stack side of the boiler. Now it is possible to get a natural draft at the base of the stack of 0.83 inch; stack side of the damper, 0.65 inch; over the fires, 0.23 inch. Better conditions can be had by a little more effort.

It will be noted that after the changes there was more draft available over the fire than before. The alterations were made between 9 p.m. Saturday and 4 a.m. Monday, for four consecutive weeks and cost about $800. The motor on the induced fan took 90 amperes at 220 volts, working 24 hours a day, six and a half days a week.

In another case sixteen 400-horsepower boilers delivered their flue gases to a brick breeching. The temperature at the damper was 550 degrees Fahrenheit and at the stack 380 degrees Fahrenheit. Quite a decrease.

Another case was that of three water-tube boilers. The draft in the breeching near the stack was 0.95 inch; on the stack side of the damper, 0.40 inch.

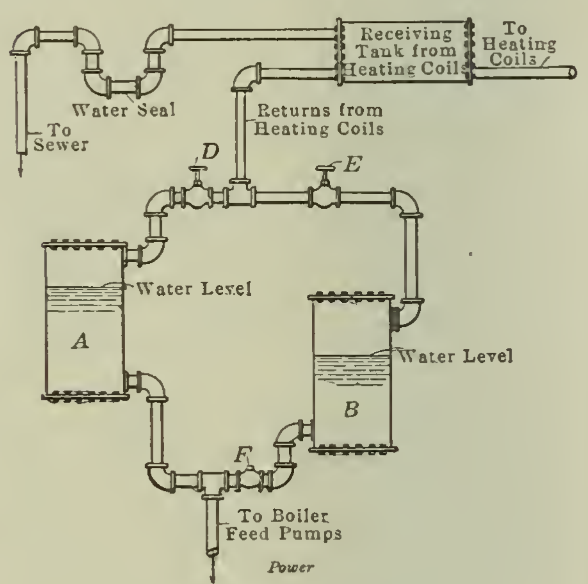
S. H. VIALL.

Chicago, Ill.

Heater and Piping Arrangement

A scheme of arranging two feed-water heaters so that the feed pump can automatically draw water from either heater is shown in the illustration. This arrangement also remedied a trouble experienced from air leaking into the drip receiver of a Paul heating system.

Referring to the cut, *A* and *B* are two open feed-water heaters, and *A* is set 17



ARRANGEMENT OF HEATERS

inches higher than *B*, and receives all of the returns from the heating coils, the valve *D* being open and *E* closed. When there is a sufficient supply of return water the greater head of water in the heater *A* keeps the check valve *F* closed, the water level in *B* being kept constant by a float in the heater *B*, but as soon as the returns are not sufficient to supply the boilers and the water level in *A* falls to a point where the head of water in *B* becomes greater, this heater will furnish the boilers with feed water; heater *B* receives its supply of water from the service mains.

As soon as the returns have again brought the water in *A* to such a level that the head will overcome that in *B*, the check valve *F* is closed and the pump again takes its supply from the heater *A*.

This scheme is entirely automatic and has been in service for over five years, and has given excellent satisfaction.

Trouble had been experienced by air leaking into the receiver in which the condensation from the heating coils accumulate. When air leaks into the receiver, through the joint of the cover, a pressure was established and the water in the receiver would back up into the heating coils, rendering part of the coils useless. The cover of the receiver was tapped out to receive a ¼-inch pipe and a pipe and a thermostatic valve were connected to it. A connection was also made from the valve to the regular pipe line leading to the exhauster of the system.

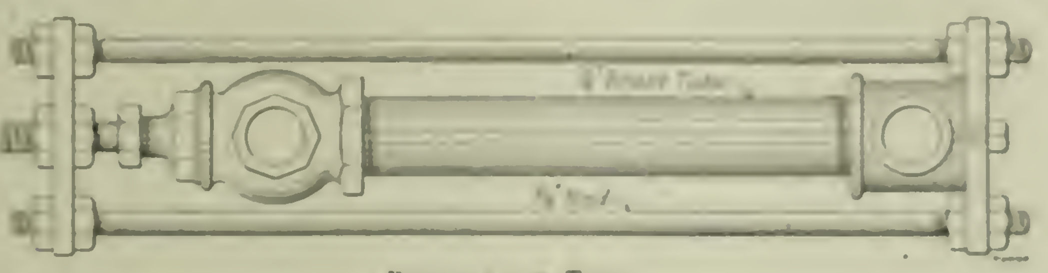
V. T. Kropidlowski.

Winona, Minn.

Homemade Trap

Following is a description of a steam trap that was made with material found lying around the shop. The idea is not new, as I installed such a trap nearly 20 years ago, still I thought, in view of its extreme simplicity, that it might interest someone, as it is perfectly reliable and satisfactory.

The illustration is so clear that a further description is hardly necessary, further than to say that the threads on the valve stem are removed to allow free movement through the stuffing box as the brass tube expands. As the brass tube fills up with water it contracts and draws away from the valve seat, thereby allowing the water to escape. When the water has drained out of the brass pipe it fills with steam, which causes the pipe to expand and close the valve.



Details of Trap

George J. Little.

Passaic, N. J.

Valves in Steam Pipes

Notwithstanding the extensive discussion that has been carried on in technical papers concerning placing valves in steam pipes, as good an authority as William Kent, in his eighth edition of "Mechanical Engineers' Pocket Book," just issued, in his article on "Valves in Steam Pipes," page 852, seems to be under the impression that if a globe valve is connected with the pressure on top of the disk it cannot be repacked under pressure.

As a matter of fact, most valves of good manufacture today are equipped with a packing feature on the stem and in the hub, or on the yoke, which enables the engineer to pack the valve when it is wide open and under pressure. This feature consists of two finished surfaces, one on the stem and one in the hub, or on the yoke, which make a joint when the valve is opened wide so that there can be no leakage up through the stuffing box.

I notice further in this same article that Mr. Kent fails to bring out one point against taking the pressure on top of the disk and that is that in opening the valve it is necessary to lift the weight of the entire steam pressure on top of the disk, which is almost as much a strain on the threads as holding the disk down when the pressure is underneath.

E. G. Greenman.

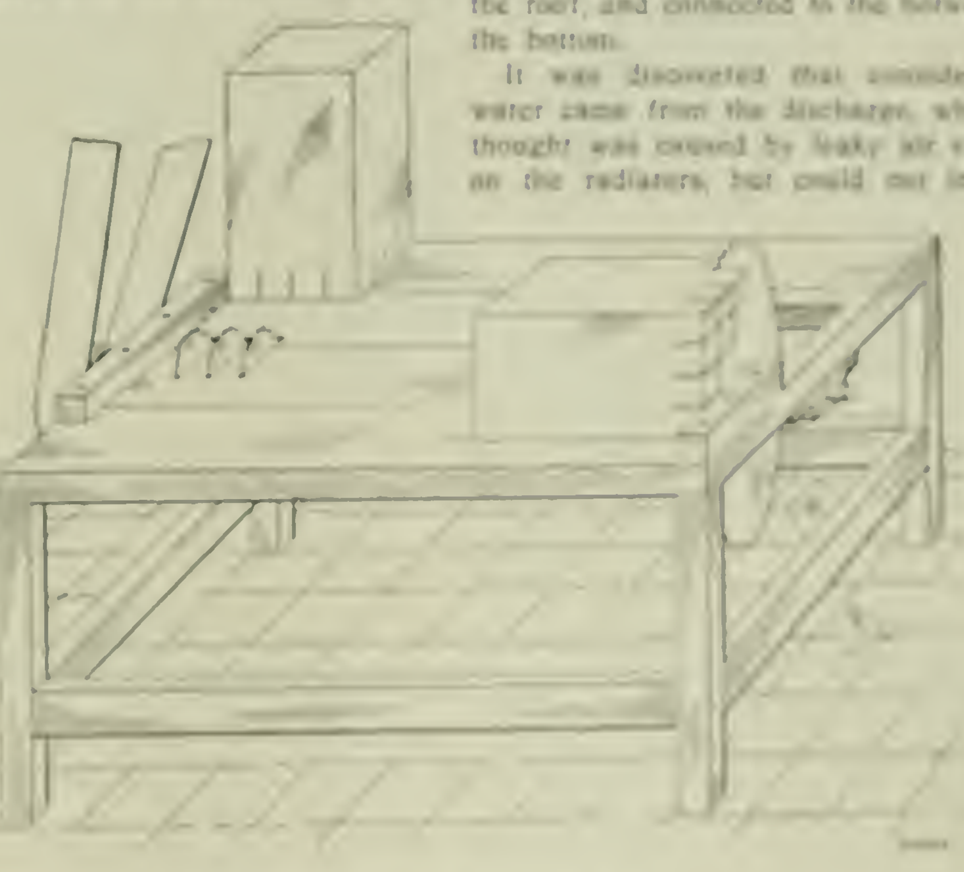
Cincinnati, O.

An Ice Cubing Machine

I was employed for some time at a plant where part of the equipment consisted of a refrigerating outfit. The ice manufactured was in the so called 50-pound blocks, 8 inches square by about 25 inches long.

About this time the manager decided that it was necessary for us to supply the ice to several of the departments in the form of small cubes about 2 inches square. There are machines on the market for doing this work, but the company seemed unwilling to go to the expense of purchasing one, and we were told to make one.

After some planning it was decided to erect a saw bench and use power-driven circular saws to do the work. A carpenter built a stout frame in a convenient position close to a line shaft.



Machine for Cubing Ice

While this work was being done, a 6-inch pulley, three small saws, 8 inches in diameter, and one larger saw, 20 inches in diameter, were procured and secured to a small 1-inch shaft, 4 feet 6 inches long, as shown in the illustration. When the frame was finished the shaft was placed in proper bearings which were secured to the frame. A hard-wood top was made, and slots cut in it for the saws to come up through.

With the top in place the small saws protruded 2 inches at the highest point and the large saw showed a full 9 inches. The slot at the large saw was made large enough to allow the cubes to drop through when sawed off.

A guide was placed 2 inches to the left of the small saws to be used as a gage when cutting.

To operate this saw the block of ice was placed on end and pushed across the small saws, making three cuts in the block 2 inches deep, dividing it into four equal parts. The block was then turned half round and the saws run across the block at right angles to the previous cuts. The ice then appeared something like the sketch.

The 20-inch saw was used to cut these cubes from the block.

William Watt.

Lambton Mills, Can.

Saved Water from Heating System

For more than a year I have had charge of a plant where much of the steam is used for heating through a vacuum system. The vacuum was maintained by a double steam jet and the discharge was led to a tail pipe which went out through the roof, and connected to the hotwell at the bottom.

It was discovered that considerable water came from the discharge, which I thought was caused by leaky air valves on the radiators, but could not induce the management to get new ones, so I connected the vacuum pipe from the heating system to a pump-exhaust pipe leading to a condenser.

It was found that by this method a higher vacuum could be maintained on the heating system than with the jet and [illegible] 1000 pounds of hot water daily.

E. Y. Chapman.

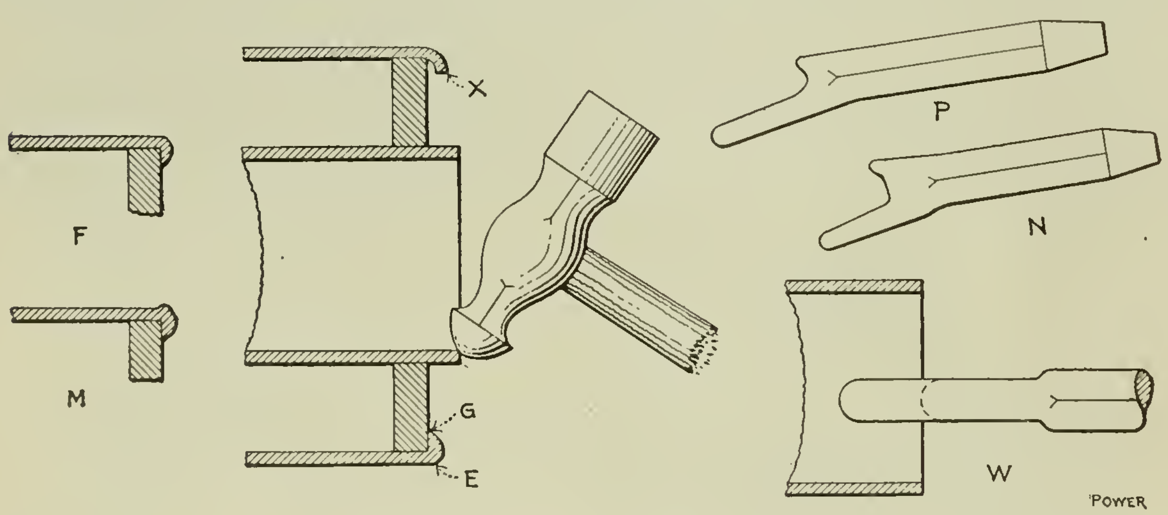
Danville, Ill.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Beading Boiler Flues

In reply to the inquiry in the December 13 number in reference to beading boiler flues, I will say that there is much more skill needed in doing this work properly than is generally considered. As to beading the body of the head down solid, there is no reason why this should not be done. Care must be used, however, not to overbead. When the head is once solid upon the flue sheet any more hammering or beading will stretch the head and tend to loosen it from the plate. The turning of the head should be carefully done from the start. Many workmen start a bead too hurriedly or use too heavy blows. With the ball end of an ordinary hand hammer used as shown in the accompanying figure the bead can be turned nicely. The hammer strokes should not be too heavy, but moderate, until the bead has been started or slightly turned. Flues are too frequently cracked by hammering too much at one point. It is the peening-action of the hammer that stretches the end of the flue; therefore the "licks" must be distributed entirely around the circumference of the flue in order to stretch it evenly. When this has been done (it is fully understood, of course, that the flue has been previously rolled tight in the sheet) the turned edge of the flue will appear as shown at *X* in the illustration.



Beading Tools and Types of Bead

When this has been done the tube is ready for an application of the beading tool. This tool should be properly shaped in order to do the right character of work; for instance, the surface that comes against the end of the flue should be slightly rounded as shown at *W*. With this shape the tool has a stretching effect on the metal. Another view of the tool is given at *P*. It requires a little practice in order to get this little tool just as it should be. Many repairers get the tool shaped as shown at *N;* such a tool makes a poor job, as the surface is too square to do good beading.

Heads are often found that are not properly done; they appear as shown at *M*. A small ridge is thrown up on the inside. In such a case it would be well to use the flue roller.

At *F* is shown a nice form of bead which can be made with a tool like that shown at *P*. Many beads are shaped as shown at *E*, having a rather square corner. With such a bead the edge of the flue does not fit against the edge of the sheet as will a bead shaped as shown at *F*.

To do a beading job properly the sharp edge of the tube hole in the sheet should be taken off with a flue-hole reamer or a half-round file.

I can see no reason for throwing the edge *G* down tight against the head and not beading solid. The beading tool should not reduce the thickness of the metal across the point of turning. One should not attempt to turn a flue that reaches through the sheet too far; usually a distance equal to twice the thickness of the metal is about right, although in some cases three thicknesses is better. If the tube is allowed to stick through too far a bad piece of work will result, as a bead will be formed which will be too full; consequently it is very likely to crack or split in turning down.

Putting in a set of flues and doing the work right is a nice piece of work.

C. R. McGahey.

Baltimore, Md.

Compound Engine Proportions

A. Hoffmann, in an article under the above caption in a recent issue, makes certain statements which are not quite clear to my mind, and with the expectation of receiving more light, I wish to open a discussion on this interesting subject.

In one paragraph he states, "Where both reheater and steam jackets are used, 10 per cent. should be added to the mean effective pressures." Directly below this he writes, "Where an engine operates against a back pressure, the mean effective pressures should be increased about 0.85 pound for each pound of back pressure." The use of reheater and steam jackets is known to be beneficial to the performance of an engine, but is it to be implied from the latter quotation that back pressure is also good?

Further on, he says, "Attention is called to the fact that this terminal pressure is not dependent upon the cylinder ratio nor the cutoff, but is determined solely by the steam pressure and ratio of expansion * *." Is not the latter entirely dependent upon the other? Assuming a compound engine having a cylinder ratio of 4 to 1, with a point of cutoff at 0.25 of the stroke, is it possible to raise or lower the terminal pressure in the low-pressure cylinder under the conditions, assuming normal conditions and neglecting cylinder condensation? In a worked-out example for a highly economical compound engine Mr. Hoffmann states that the cylinder ratio should be 5 to 1, and that the cutoff (presumably in the high-pressure cylinder) should be 27.5 per cent. of the stroke, and that the number of expansions should be 19. Under these conditions, will not most of the expansions take place in the low-pressure cylinder (or in the receiver) and, in consequence, will not the condensation there be abnormal? F. R. Low, in his treatise on the compound engine, teaches us that it is not the total amount of condensation in both cylinders that must be reckoned with, but the greater amount in either, which becomes the factor in the economy of a compound engine.

Suppose a compound engine with cylinders 20 and 40 inches in diameter to be working under conditions that cause a cutoff in the high-pressure cylinder at about 0.2 of the stroke, is it to be understood from Mr. Hoffmann's remarks that if a higher cylinder ratio were used, by making the high-pressure cylinder 18 inches in diameter, that the engine would operate under more economical conditions? It seems to me that his method of proportioning compound engines by arbitrarily fixing the mean effective pressure as referred to the low-pressure cylinder is not commendable, for, as he states, "no definite rule can be laid down giving the proper mean effective pressure upon which to figure." As users of compound engines buy this type with economy of operation in view, and as pounds of steam per horsepower delivered is the true measure of engine economy, why not start designing with this one factor alone given? Suppose a compound engine of a given indicated horsepower were to be designed that should use a predetermined or given amount of steam per horsepower, the total amount of steam could be calculated, and from this the size of the steam pipe, steam chest and valve posts to accommodate that quantity of steam without wire-drawing could be figured. Also, the size of the high-pressure piston and the distance from the heads at which it shall stand at the point of cutoff could easily be determined. Proportioning the rest of the engine would then depend on the price the purchaser wished to pay. The price would determine the length of the stroke and the cylinder ratios.

The designer is in a position to give the buyer what he wants, and by having a high-pressure piston which is more or less of a standard, he will soon be able both in theory and practice to state exactly what the engine is capable of doing when installed, and to quote prices and the degree of economy that he could guarantee with the various cylinder ratios. To design a compound engine based on a given mean effective pressure referred to the low-pressure cylinder or the ratio of expansion, is to forget that the operating engineer is very apt to change the number of effective expansions, and to forget that pistons, valves, etc., are apt to leak.

The reputation of an engine is not made while the engine is brand new, but after some years of service. If the high-pressure cylinder is designed first, then some consideration of future troubles may be employed in the low-pressure cylinder.

N. CASSIDY.

South Framingham, Mass.

Problem in Expansion of Steam

At the present time, when, in technical studies, discoveries are so frequent, and often of so revolutionizing a character, it is necessary for an engineer who wishes to keep abreast of the age to read a large number of technical papers. From the force of circumstances he must read

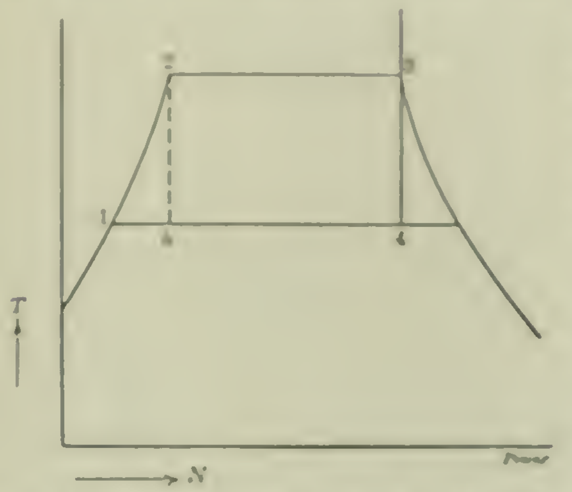


FIG. 1. TEMPERATURE-ENTROPY DIAGRAM

rapidly, and he feels, consequently, that he has a right to demand that these articles be written with especial care; that they be so worded as to leave no shadow of a doubt as to their meaning. It is not fair for the author to expect his reader to puzzle out from indefinite English an important technical fact. Yet not all scientific articles are so written, and in consequence—both of the hasty reading and the poorly stated facts—many wrong conclusions are drawn, and a body of faulty ideas allowed to spring up. Examples of such articles are numerous, but the present writer was impressed with this need for guarded and accurate expression most recently in connection

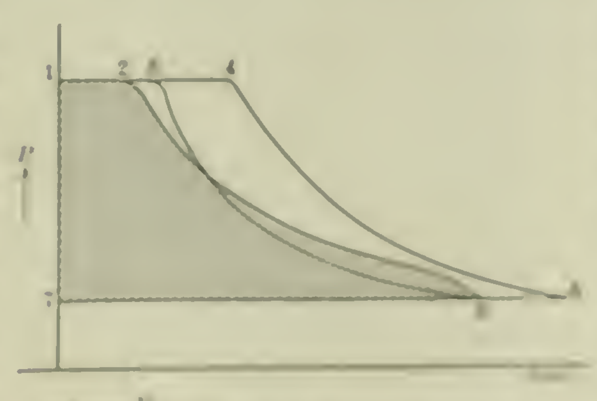


FIG. 2. DIAGRAMS FOR IDEAL ENGINE AND FOR ACTUAL ENGINE

with an article by Mr. French in the December 13 issue of POWER.

Mr. French makes such reference to the Carnot and Rankine cycles as to seem to indicate that they are identical. Now the Rankine, or nonconducting steam-engine cycle may be represented by the area 12541 on the T-N diagram, Fig. 1. The Carnot, or purely theoretical, cycle may likewise be represented by the area 23452. The difference is in the left of the diagram and is due to the necessity of heating up the feed water in the boiler instead of compressing adiabatically from the lower temperature to the upper temperature.

Mr. French goes on to show that an "exact solution" of his problem (i.e., to find the volume of steam at the end of a certain number of expansions in the steam-engine cylinder) can be found by "assuming" adiabatic expansion and figuring for the quality of steam and its corresponding volume. This is perfectly correct, if everyone understands that an ideal Rankine cycle is being considered, but not otherwise, and Mr. French did not make it clear that he meant the former.

The solution of problems similar to those just cited depends, therefore, on what assumptions are to be made. The Carnot cycle is unattainable (although several pumping engines have used cycles having very nearly that efficiency), and while we continue to use metallic cylinders we cannot hope to get a nonconducting engine, but we can reduce radiation and conduction greatly, by using small temperature limits, by polishing

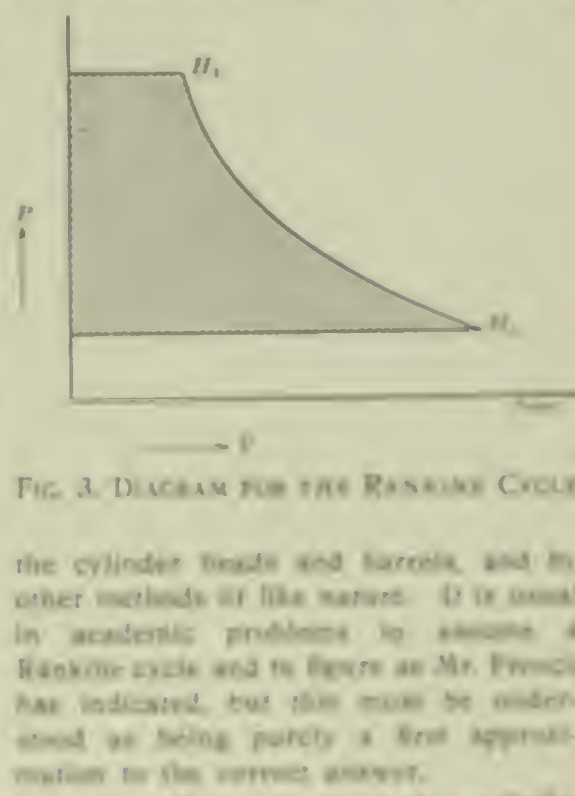


FIG. 3. DIAGRAM FOR THE RANKINE CYCLE

the cylinder heads and barrels, and by other methods of like nature. It is usual in academic problems to assume a Rankine cycle and to figure as Mr. French has indicated, but this must be understood as being purely a first approximation to the correct answer.

In the ordinary steam engine, cylinder condensation and subsequent reëvaporation alter the condition of affairs decidedly. This can be shown by Fig. 2, where 14571 shows the work that could be done in an ideal nonconducting engine by the actual steam admitted to the cylinder. Likewise 13671 represents the ideal amount of work obtainable from the steam, accounted for as dry at cutoff. In distinction from these ideal areas is that of the actual work, shown on the diagram by the [illegible]. The difference between the areas 13671 and 14571 shows the loss in work due to cylinder condensation, radiation, leakages and other losses. The actual volume at the end of expansion is also much less, for the same amount of steam, with the actual cycle than with the ideal cycle.

The actual cycle is affected by a number of factors each varying the work attainable, and the volume at the end of expansion. These are, in part—the temperature range, the per cent. cutoff (the ratio of expansions), the ratio of diameter to stroke, the speed, the clearance and the quality of the steam. The temperature range has the greatest effect on the cylinder condensation, but this is modified by high speed, by small ratio of diameter to stroke or by superheat.

What has just been said shows the impossibility of foretelling how the steam in the cylinder will behave unless some assumptions are permitted as representing typical results, and so we return to the assumption that the real steam-engine cycle is approximated closest by the Rankine cycle. The work done in such a cycle is $H_1 - H_2$, where H_1 is the total heat of the entering steam, and H_2 is the total heat of the exhaust.

Other problems involving total heats are the throttling-calorimeter problems, flow of steam, expansion valves and others involving adiabatic expansion. These problems are greatly simplified by the use of the Mollier total-heat diagram, such as is very admirably given in Marks and Davis' "Steam Tables and Diagrams," a recent publication based on the very latest experimental data. With these diagrams, problems like the above, and also those involving ratios of expansion, are simplified extremely, and made capable of quick solution.

H. J. Mitchell.

Cambridge, Mass.

Power Plant Design and the Operating Engineer

The controversy regarding the operating engineer and the consulting engineer has been waged in the columns of Power for some time. It seems to me that this question as to which is better qualified to design a power plant is entirely uncalled for for the following reasons:

In the small-sized plant where the chief engineer has only one or two helpers, he generally does not get a very large amount of money for his services. As a consequence, a man broad enough to design a new plant, under the best conditions, would not be working at the small salary which that plant warrants. As a consequence, the consulting engineer is called in.

In the large plant, where the chief engineer is something more than the name sometimes implies, there is generally a good mechanical engineer employed steadily by the management, or the head engineer is himself a mechanical engineer. In the latter case, as both are one, there is no cause for argument. In the second case, if the management is good, with no friction between the employees, the chances are that the two would work together and no outside man would be called in.

Any mechanical or consulting engineer would welcome the advice of a capable man who is to have charge of the plant. On the other hand, the chief engineer should certainly welcome the advice of the technical man who, of necessity, makes himself acquainted with the general trend of progress in his line. With two good men working harmoniously together the results should certainly be better than with one alone.

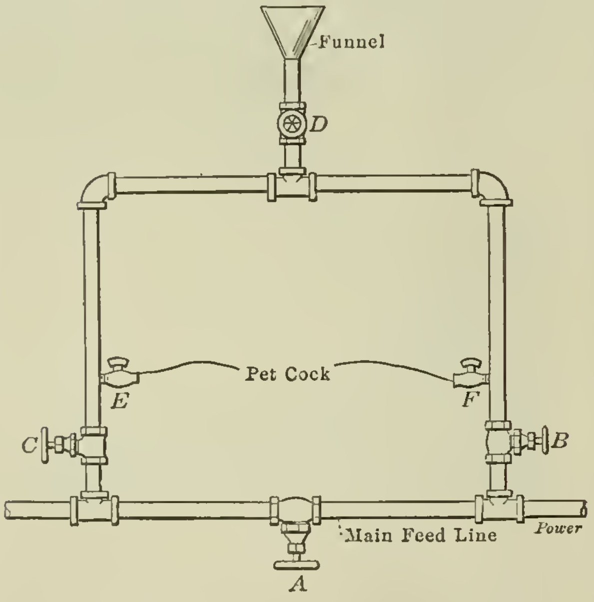
The consulting engineer who knows it all and will not listen to suggestions is not worth having. The running engineer who is afraid to have his ideas criticized by others is certainly not sure that his design is the best under the circumstances. The employer who employs one or both of the above men and brings in an outsider for this work shows a lack of confidence in his own men. If the lack of confidence is unwarranted the best thing the employees can do is to go elsewhere. If it is warranted, the men should realize it and make the best of it.

John Bailey.

Milwaukee, Wis.

Introducing Solvents into Boilers

In the issue of December 6, Charles H. Taylor's letter under the above title is interesting. I agree with Mr. Taylor that solvents should be introduced in small quantities, but it is poor practice to feed them through the suction of the pump. This practice is liable to result



Arrangement for Feeding Solvents

in a scored lining of the water end, scored rods and cut packing.

A much better way is to feed the solvent through the discharge. The accompanying figure shows the manner in which this can be done. Close valves *C* and *B*, open valve *D* and put in a charge of the compound. Close valve *D* and open valves *B* and *C* and close valve *A* for a few strokes of the pump.

M. W. Utz.

Minster, O.

Boiler Efficiency

The efficiency of the Keeler water-tube boiler as reported in the issue of November 29 is exceptionally good; however, it is to be regretted that having so nearly attained maximum efficiency the plant was not arranged to insure getting it.

The temperature of the escaping gases was 473.62 degrees Fahrenheit. This temperature could not be appreciably reduced by enlarging the heating surface of either the boiler or the superheater, the temperature corresponding to the pressure of 188 pounds being 383 degrees; the difference in temperature between the fire-swept and water-swept surfaces of the tubes is 90 degrees. It would be possible, however, to reduce the temperature of the gases by installing an economizer and it should be quite possible with a normal size of chimney to reduce this temperature by 100 to 120 degrees, without impairing the draft. If this were done, then, the gases would impart an amount of heat to the feed water which would depend upon the size of the economizer.

From my calculations it should be quite possible, from the figures given in the test, to so arrange an economizer that an overall efficiency of 80 to 89 per cent. could be obtained from the boiler, superheater and economizer.

It appears that the feed water is at present heated by live steam to 183 degrees Fahrenheit, if this is correct, then the installation of an economizer would save the large amount of steam that must be necessary for this purpose besides effecting the above mentioned saving of 6 to 7 per cent.

It is seen that the makers guaranteed a boiler efficiency of 65 per cent.; from the figures given in the test, it is found that the actual boiler efficiency was nearly 75 per cent., the efficiency of the boiler and superheater together being 82.36 per cent. It is to be hoped, however, that a munificent government paid the bonus upon the latter figure, for the attainment of an efficiency of 75 per cent. with a water-tube boiler is a noteworthy performance.

The attainment of this high efficiency is, no doubt, partly due to the efficient way in which the boiler was incased. The makers' guarantee of a 65 per cent. efficiency, however, is about 5 per cent. lower than is usually obtained.

This test is very instructive and valuable for power-plant engineers as it shows the actual saving in fuel that can be accomplished by a superheater in conjunction with the boiler, and, as is well known, this is not the only saving that is accomplished, for, by superheating, the steam condensation in the steam pipe is prevented, and a great saving in the steam used by the engine is effected if it works with superheated steam.

James Cannell.

Stanford le Hope, Eng.

Does the Crosshead Stop?

Although considerable space has already been devoted to the subject, "Does the Crosshead Stop?" it would be transgressing the requirements of accuracy to let the most unmathematical contribution of Messrs. Stover and Pullen, in the January 3 issue, pass unchallenged. It is merely a problem in the elements of trigonometry to show that the crosshead does actually stop, that is, that its velocity for an infinitesimal moment is zero, but your contributors have gone out of the way to give three different proofs, not one of which is valid.

By reference to Fig. 1, reproduced from the January 3 issue, we are told that the crosshead stops because at the point of dead center the crank-pin center is moving along an arc of a circle described with point H_1 as its center. This, of course, assumes that H_1 will remain

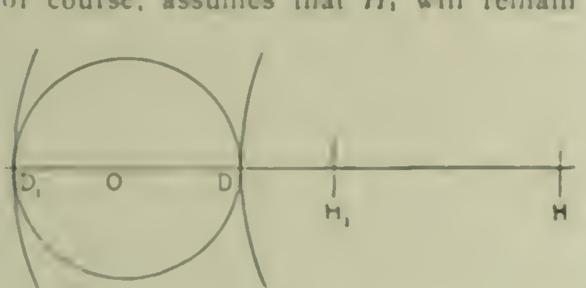


FIG. 1.

fixed while the crank-pin center is moving along this arc. But, if we do not know whether the crosshead stops or not, how can we assume that H_1 is fixed while the crank pin is moving? This is reasoning in a circle.

In proofs 2 and 3 your contributors have attempted to show that the crosshead-pin center has no motion parallel to its axis at the dead center, because the crank-pin center has then no motion parallel to the same axis. That this is not a valid proof may be easily shown by reference to Fig. 2. Here we have a rod AB sliding along, so that its extremities

FIG. 2.

always touch two perpendicular axes. At all times, point A has no motion parallel to OY, yet it is obvious that point B is always moving along the axis OY.

By simple trigonometry, however, it is proved that the velocity of the crosshead center is at any time equal to the angular velocity of the crank pin (which remains constant) multiplied by the perpendicular distance from the crank-shaft center to the connecting rod. At the point of dead center this distance is 0 (see Fig. 1), which makes the velocity of the crosshead center

$$a\ constant \times 0 = 0.$$

This is the only way that I can see of attacking this problem, because this solution deals with the velocity of the crosshead center, which is the only point under consideration, as we know that the crank-pin center is revolving at a constant velocity.

LOUIS GRUSSBAUM.

New York City.

Why Engineers Do Not Write

The question often raised in regard to why engineers, as a class, do not write, may be answered in various ways, each truthfully. I believe that chief among the reasons is the fact that the average practical operating engineer who is not a technical graduate fears that his words may sound uncouth or that his statements may be criticized from an angle from which he is incapable of viewing them before presentation and that if his communication be published a later copy of the paper will contain articles written by some "high brow" who, in terms which are Latin and Greek to him, will inform him that he is a "rough neck" or a "hill billy" and that what he thinks he knows is a delusion and that science and textbook learning can prove that black is a shade of white by another name and he is afraid that some of his friends will read both articles and tease him about it. If he conceives the idea of benefiting his fellow craftsmen by relating his experience he is liable, too, to forsake the idea owing to an attack of "editor shakes." To one who has never screwed up the required nerve to approach an editor the first effort usually causes dreams at night of said party wearing horns and banding back papers with sarcasm. Those of the craft who are in the habit of overflowing should dispel this by splashing and yelling "The water's fine!"

The fact that a practical man lacks the ability to write in technical language or to describe conditions fully in technical terms should not keep him from coming in on any discussion as, after all, it is the "proof of the pudding" which is of most value to us all, and if he does not sometimes differ with the textbooks there must be something wrong with him.

For instance, it may be gathered that water-tube boilers are preferable to flue boilers for any installation. Are they? He might also read that the spring pop-safety valve is always better than the old reliable, easily understood, easily adjusted lever. Is it? He might also get the impression that any expenditure for equipment would be justified if economy in operation were secured, regardless of conditions and size of installation. Would it? He might also, for another instance, find good authorities giving as efficient belt speeds anything between 3900 and 5000 feet per minute, most of them under 5000, and yet all of the big engines he knows of may be running the flywheel rim at a speed of a mile a minute. He may probably have read lately where an eminent authority stated that 11,290 feet per minute belt speed was common in Europe, becoming very popular in America and had exhibited the greatest economy.

In all of the printed matter on power transmission he has at hand he may not find one case where the author states whether his figures are based on a straight, cross or quarter-turn belt; what the size of the belt is, distance between centers, or whether an idler is used or not; whereas he may have an overloaded belt in his plant running under an idler and breaking pulley after pulley without perceptible slippage or any noticeable injury to the belt and a statement of the facts would bring him a satisfactory solution from two dozen readers.

This last is not imaginary. I had a chance once to help a fellow out who had brought about that condition by reducing the belt speed still transmitting the same quantity of power. He thought that the pulleys were defective.

In the little things, at least—those are all that I am competent to speak about—I know that the words of the "old boys" who have had to wiggle out of their own difficulties, are the most valuable that we can read.

W. R. SMITH.

Alton, Ill.

Chimney Problem

In regard to L. G. Watry's "Chimney Problem" in the December 27 issue, I do not think that the stack with the larger opening would draw cold air down the other one, for the reason that the area of both stacks combined is a little on the small side of the right area to give good results for two 50-horsepower boilers. A stack 22 inches square should be at least 50 feet high to give good results for one 50-horsepower boiler. So, with two boilers and two 22-inch stacks the hot gases would naturally fill both and rise in one [illegible].

In Mr. Watry's case I think it would be better to divide the smoke flue, making separate smoke flues for each boiler, and have the flues and openings slightly larger than the area of the stack so as not to retard the draft. Better results would be had if the stacks could have at least 10 feet more added to make their height not less than 50 feet.

GEORGE H. HAMMER.

Newburgh, N. Y.

Burning No. 3 Buckwheat Coal

In the issue of December 27, 1910, Warren O. Rogers, as a result of a visit to the New York Steam Company's plants in New York City, furnishes a description of his visit with some very positive conclusions.

It is with considerable regret that I note Mr. Rogers' visit was entirely confined to the plants above stated, because by no means are his conclusions either accurate or confined to facts.

Wherein does Mr. Rogers err in his conclusions? He errs in the fact that he visits a plant to see something with which he is unacquainted and as a result of his observations in that one plant sets out a set of rules as being the only possible means of burning No. 3 buckwheat coal. If Mr. Rogers had visited the Brooklyn Bridge power house, located in Brooklyn, he would have found that they have been burning at that plant No. 3 buckwheat coal for several years back in place of lump coal which they were previously using, and he would have formed some radically different conclusions from those reached after his inspection.

In addition to the Brooklyn Bridge power house a list of over 100 plants in the city of New York could be furnished, all of which would give him some different ideas in regard to the conclusions which he would put forward as the only means of burning No. 3 buckwheat coal. The rules that he supplies are:

1. "Fire light and often."
2. "Keep a forced draft of from 0.5 to 0.6 inch."
3. "Keep the damper 5/16 open."
4. "Never use a slicing bar."
5. "Level the fires about every two hours or when necessary."
6. "Never throw green fuel on other than incandescent fuel."
7. "When cleaning fires, keep 1 inch of ash on the grates."
8. "Always use a shaking grate."
9. "Never handle the fire as other fuels are handled."

The conclusion is that "A small steam plant with one or two boilers would have trouble in running on this grade of fuel, because it would be difficult to force the fires in case a sudden demand was made for steam."

Commenting upon the foregoing:

No. 1. This rule is imperative.

No. 2. A forced draft must be used but it may be anywhere from 0.5 to 1½ inches, according to the fuel burned per square foot of grate surface, which may be anywhere from 12 pounds (as cited in Mr. Rogers' article as the amount burned at the New York Steam Company's plant) up to 28 or 30 pounds, which is the practice maintained in some of the plants which would be on the list I have previously referred to as being able to furnish. This rule, therefore, should be changed to read: "Use forced draft with such pressure as may be required to burn the amount of fuel necessary."

No. 3. The opening of the damper would be governed entirely by natural-draft conditions of the plant; if natural draft was poor the damper might be entirely open; if the draft was excellent then the damper should be choked down to a point so that no excess of air may be drawn in above the fire.

No. 4. It is good policy not to use a slicing bar on any grade of fuel, but if a clinker formation is prevalent it may be necessary to use a slicing bar to raise the fuel from the grate in order that the air may work through it, but a slicing bar should not be used to break through the fire and elevate the ash on top of the live fuel.

No. 5. The leveling of the fires should be done as often as required and is not governed by any specific time. There are fuels which can be leveled successfully at least twice between each time of firing; this would apply to fuel which is very hard in its character and slow burning.

No. 6. This rule can stand as given.

No. 7. If shaking grates are used, the 1 inch of ash might be of benefit to prevent loss of fuel through the grate bars, but there is no reason to keep ash on the grate for any other purpose than to prevent the coal falling through the grate openings; and if this is the condition, then the grate in use is not a proper one for the burning of No. 3 buckwheat coal as the openings in any grate used for this class of fuel should be small enough to practically prevent the fuel from falling through it. A much hotter fire will be established if the 1 inch of ash is cleaned out and the fresh fuel brought over on the grate.

No. 8. A shaking grate is not necessary; in fact, it is a positive detriment unless arrangements are made for disposal of the ash without opening the ashpit doors, and the larger percentage of power plants have no means of cleaning the ashpits except by hand tools. There is no positive rule as to whether a shaking or stationary grate shall be used to burn No. 3 buckwheat coal. The only feature about the grate is that it should have small openings in it which can retain the coal without the coal working through it in any perceptible percentage.

As to whether a shaking or stationary grate should be used, it depends entirely on the method of disposing of the ash; if a tunnel exists by which the ash can be withdrawn from the ashpit through a hopper bottom, a shaking grate is preferable, but if the ashpits must be cleaned by shoveling out (as the vast majority are cleaned), then a shaking grate is of no advantage as the cleaning can be done more readily from a stationary grate, through the firing doors. Particularly is this true as forced draft must be used in burning No. 3 buckwheat coal and the disturbing of ashpit doors for cleaning simply destroys the use of the forced draft as long as the cleaning is in process.

No. 9. This rule is not at all necessary as it will be found that No. 2 or No. 1 buckwheat or even pea coal will give better results in firing if the fuel is placed uniformly over the grate and not piled in any considerable quantity at any one point. It is furthermore unnecessary to put green fuel on the spots of fire where the fuel has not already become ignited.

Regarding the conclusions, No. 3 buckwheat coal is in successful use in a very large number of plants in New York City as well as other places where they have but one or two boilers. If a proper forced draft is in use, it is an easy matter to overrate the boiler to cover any extra demands for steam, provided the boiler is properly cared for. In a plant with one boiler where they are using No. 3 buckwheat coal if a proper forced draft is in use a fire can be run from six to eight hours, using a fair grade of No. 3 buckwheat coal, prior to cleaning, and with a little head work a time of cleaning can be established where cleaning can be accomplished without detrimental loss of steam, especially so if the furnace and its equipment have been properly designed together with the forced-draft equipment so that cleaning can be accomplished quickly and thoroughly.

Other features of the use of No. 3 buckwheat coal with which the ordinary engineer will come in contact are that there are fuels of this size placed on the market which are so hard that they do not burn freely enough to be a satisfactory steam coal, in which event a small percentage of soft coal added to them will be found beneficial. On the other hand, there are fuels of this size sold which burn out too quickly to be a satisfactory fuel, as their excessive amount of ash will prove a hardship as to disposal.

It will be well, therefore, for anyone contemplating using No. 3 buckwheat coal because of its attractiveness in price, to carefully study the supply of coal offered, and, before jumping at conclusions, investigate the subject broadly so that when he purchases equipment he will be in possession of something of a permanent value and properly studied to give him the best service.

Charles H. Parson.

New York City.

A few small bolts were handed to the writer, with the request that they be charged with electricity to prevent the nuts from coming off. Further questioning proved that my predecessor had simply immersed them in the sal-ammoniac solution of the battery, which caused them to rust fast.

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POWER

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Precautions against Damage from Bursting Tubes

Much is written from time to time about the numerous failures of tubes in water-tube boilers, and recommendations are made that better workmanship and better material be used, and that manufacturers be compelled to stamp each tube with their name, so that responsibility for disaster may be properly fixed. All these recommendations are necessary and good, but in the meantime let us do what we can to protect the personnel in the boiler room and, until a perfect tube is found, let us fit all boiler furnaces with in-swinging doors. With all the doors in a setting of this type there is but one door opening outward—that leading into the smokestack, through which steam and hot water are discharged in the event of the rupture of a tube. In such a furnace, when a tube lets go, all the doors in the setting, if they happen to be open, are closed by the rush of the steam, or if closed they tend to stay closed tighter. This prevents any scalding of the attendants in the boiler room, and the steam and hot water are passed harmlessly up the smokestack, unless it blows down the setting, but this contingency is nothing against the use of the in-swinging doors because all that needs to be done is to make the setting stronger.

Many of the furnaces in continental Europe in many countries by governmental requirement are so equipped. In our own navy in-swinging doors have been fitted to all the battleships and their use is gradually spreading to other naval vessels.

Closely allied with the in-swinging doors to the furnace is the use of check valves in the steam lines. We firmly believe the day is close at hand when a steam line without a check valve close to the boiler will be as rare as a feed line at the present time without its check valve. The use of check valves tends greatly to reduce the damage as a result of the rupture of a tube or of the steam pipe, inasmuch as the valve itself operates either way. If a steam pipe breaks, it shuts off the steam to prevent the boilers from emptying themselves through that break. If a tube in a boiler lets go, it prevents the other boilers connected to the same header from emptying themselves through the rupture of the tube.

It is bad to have to almost roast all day in a hot fire room, it is worse to get only two dollars a day for doing it, but it is worse still to be in constant danger of being scalded when that is not necessary.

Flywheel Explosions

There was a time when the dangers of generating and producing power from steam were confined to the boiler room. Occasionally a flywheel exploded, but steam-plant accidents were, as a rule, in the boiler room.

When engines were made larger, more powerful and designed to run at higher speeds, the engine room took on an added element of danger. Under the old practice the rim speed of the flywheel was so far below the safe speed limit that in case anything did happen to the governor, the engineer had a chance to shut down the engine before an accident occurred.

Nowadays conditions are vastly different, because most flywheels are run with a rim speed very close to the safe limit, and a slight increase in the speed of the engine brings the rim speed up to the bursting point.

Sometimes the cause of a flywheel explosion is easily discovered, but usually it is a difficult matter to determine.

Neglect on the part of the engineer is frequently responsible for such accidents, and usually consists of failure to properly adjust this or that thing on the valve or governor gear. Sometimes this is due to ignorance of the danger incurred by not taking the necessary precautions, but more often it is simple neglect to make a thing right that is known to be wrong.

Some engineers make a practice of examining the governor gear once a day besides making a careful test and inspection of the flywheel as well. To some this may seem "fussy," but it is better to err on the side of safety.

It is true that an engineer might inspect his engine every day for years and never find an adjustment out of its proper position; on the other hand, if the governor were found to be deranged, the valve cams so placed as to be useless, or a cracked flywheel discovered, the time that had been spent in these daily examinations would be a profitable investment.

An investigation would undoubtedly show that thousands of flywheels are seldom examined, the engineer trusting to chance that no crack has developed since the last hasty look, and in all probability would disclose hundreds of engineers who seldom test their engine safety cams in order to determine positively that they will prevent the steam valves from opening in case the governor drops to its lowest position. If governor inspection is a part of the work you have been neglecting, see to it; do not wait until tomorrow, but test it out today and see if the safety cams will work. Then complete the work by giving the flywheel a thorough inspection.

Two Diagrams

Two indicator diagrams alleged to have been taken from the same engine within the space of a few hours show a marked difference in outline and area. One is the conventional Corliss engine type of diagram with a compression line rising to about two-thirds of the initial pressure and there meeting a vertical induction line showing a lead of the steam valve which gives full initial pressure on the piston at the very beginning of the stroke. The cutoff, expansion line and exhaust opening appear to be in accord with good practice. On the other diagram the compression does not rise higher than the terminal pressure. The admission line slants inward so much that it is clear that full pressure is not realized until the piston is well started on its way; the point of cutoff and the expansion are the same as in the other, but the exhaust does not open until the piston has reached the end of the stroke. All of the valve events except cutoff are late, as though the eccentric had been turned backward several degrees.

There is a noticeable difference in the areas of the diagrams, the one with low compression and late admission being appreciably smaller than the other. It is said, however, by the engineer who took the diagrams that the load in both instances was identical and he is asking why, with an apparent maladjustment of the valves, the engine requires less steam and consequently less fuel for a given load than when the valves are properly set.

There is no reason to doubt the sincerity of the man who furnished the diagrams, and there is no attempt on his part to deceive anyone. But has he deceived himself? Can an engine showing a certain indicated horsepower in the cylinder deliver a greater brake horsepower than when showing a greater indicated output? Does it or can it ever happen as this engineer says it does with him? Is compression to any degree economical or otherwise? The clearance space must be filled with steam at or near initial pressure before the piston starts and this steam must give up some of its heat to the cylinder and piston before it can do other work.

What is the source of supply from which this steam can be most cheaply obtained? It is heat and pressure that are wanted. Can these be furnished at a lower cost by the engine or by the boiler? Is it cheaper to fill the clearance directly from the boiler than it is to use the engine part of the time as a compressor taking energy from the flywheel in one stroke and putting it back in the next?

These questions can be answered from the mechanical laboratories of half a hundred colleges and schools in this country. They have been answered by Professor Dwelshauvers-Dery, from the school at Liège, Belgium. But the correctness of the answers has been questioned. Experiments made thus far do not prove conclusively the truth or untruth of the contention. Academic discussion which starts nowhere, applying laws which do not apply, assuming conditions which do not exist and drawing conclusions from false premises ends nowhere and is not conclusive or even enlightening. What is the real answer, and why does not some college laboratory find and announce it?

Engineer or Laborer

In the "Want Columns" of a daily paper there recently appeared the following advertisement:

> "Applications will be received from 9 to 12 o'clock, noon, Tuesday, December 27, 1910, for the position of night engineer for municipal electric-light plant. Duties to commence January 2, 1911. Engineer will be required to do his own firing, salary $60 to $65 per month. Applicants to have necessary qualifications; state age, if married or single, and enclose copies of testimonials."

This advertisement modestly announces an opportunity for a man to act as night engineer and fireman, seven nights a week, for $60 a month; $720 a year, or $1.97 a night of twelve hours' run. It also implies that there will be more than one reply and that the engineer possessing the best qualifications will secure the place—and, worst of all, there *will be* several applications for the vacancy.

Anyone with sufficient intelligence to shovel the coal necessary to keep up the steam pressure would earn all that it is proposed to pay a man for not only firing the boiler, but attending to the engine and generator as well.

The necessary qualifications are, of course, that the night engineer shall have a knowledge of the steam boiler, how to fire and care for it, know something about a boiler-feed pump and injector, steam gage, safety valve, piping and the danger to be avoided in operating a steam boiler.

The successful applicant for this remunerative position must also know about engines and generators, switchboards and a hundred and one other things that are necessary to know before a man can safely operate even a small electric-light plant.

A town treasurer when assuming office is obliged to give bonds, and nobody would think of permitting him to handle the funds of the town without such a safeguard against loss, and yet probably not one word of objection will be raised against placing the machinery in this electric-light plant, costing thousands of dollars, in the care of a man who is capable of demanding a wage of but $1.97 per day.

In all probability those having the authority to hire a night engineer have not given much thought to his competency, and perhaps do not know that the man who obtains the night job can more than save the amount that is offered per month—if he knows how; but a $1.97 a day man will not cut much of a swath in that direction.

Another thing that apparently has not been considered is that in one night the $1.97 man is liable to do more damage to the machinery in the plant than can be repaired with the entire amount paid him for a year's wage.

It does not take much of a mistake to cause several hundred dollars damage; it has been done by merely carrying the water too high in the boiler to allow a longer time to sit down before attending to the feed apparatus, with the result that a cylinder head has been blown out, causing a shutdown and a lot of dissatisfied customers. Doubtless the $60 a month man will be able to make the wheels go around, but that is not economical engineering. A real engineer is needed and cannot be hired at a rate of $1.97 per night.

The same old story, only the number is ever increasing—Three boilers and a steam header exploded during the first half of January. On January 4 the new power house of the Lorain Coal and Dock Company, near Blaine, O., was badly wrecked by the explosion of a steam header. Rushville, Mo., was the scene of another boiler explosion on January 14, which killed two men. Two days later a boiler exploded at the Cleary stone quarry, Marietta, O., and as a variation from the usual a boiler on the towboat "T. N. Davis" blew up on the same date, when the boat was six miles north of Cairo, Ill., on the Ohio river. This disaster resulted in one death.

The master mechanic of a Massachusetts mill is publishing—and evidently believes—the report of a test in which he claims to have gotten an evaporation of *over sixteen pounds* of water from and at 212 per pound of combustible.

Ignorance on the part of the buyer of the good points of high-class machinery compared with the cheap and inefficient, is what keeps the cheap factory running.

Be prepared to make repairs before the breakdown occurs; after it has happened may be too late.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Dry Sheet

What part of a boiler is the dry sheet?

B. D. S.

It is the extension in front of the tube sheet of a horizontal tubular which forms what is often called the smoke box.

Safe Stress on Stays

What is the safe stress on a boiler stay, and how is the stress calculated?

B. S. S.

The Massachusetts Board of Boiler Rules specifies a maximum working stress of from 6000 to 9000 pounds per square inch of minimum cross-sectional area, depending on material, construction and size. The stress on a stay is the number of square inches supported by the stay multiplied by the pressure per square inch, less the minimum cross-sectional area of the stay itself.

Valve Setting

How shall I set the valves of a 16x30-inch Corliss engine to get a diagram such as the POWER blueprint calls correct?

C. V. S.

With the wristplate in the middle of its travel, give the steam valves 5/16-inch lap and the exhaust valves 1/32-inch lead; that is, instead of having lap the valve will be open 1/32 inch. With the engine on the center, give the steam valves 1/32 lead.

Using Steam Expansively

What is meant by the term using steam expansively in a steam engine?

U. S. E.

When steam is admitted to the cylinder for a portion of the stroke and then cut off. The steam in the cylinder after cut-off stilll has pressure and expands, furnishing the energy to complete the stroke.

Horsepower of Engine

What is the horsepower of an engine 16x20 inches making 120 revolutions per minute with a mean effective pressure of 45 pounds?

H. P. E.

The horsepower of an engine is expressed by the formula

$$\frac{PAS}{33000} = horsepower$$

in which

P = Mean effective pressure;

A = Area of the piston in square inches;

S = Speed of piston travel in feet per minute.

The mean effective pressure is 45 pounds per square inch. The area of the piston, neglecting one-half the area of the rod, is 201 square inches. The piston speed is 400 feet per minute. Substituting these values in the equation, it reads

$$\frac{45 \times 201 \times 400}{33000} = 109.6 \text{ } horsepower$$

Strength of Boiler Seam

How is the strength of a boiler seam found?

S. B. S.

The strength of a boiler seam is the strength of its weakest part. This may be either in the sheet or in the rivets. The strength of the sheet is proportional to the length of the seam less the diameter of the rivet holes in the outer row. The strength of the rivets is the resistance they offer to shearing. The strength of the sheet is found by subtracting the diameter of the rivet hole from the pitch and dividing the remainder by the pitch. The quotient is the efficiency of the plate at the joint. The strength of the rivets is the shearing strength of one rivet multiplied by the number of rivets in a given section. The strength of the weaker of these two is the strength of the seam.

Pumping Hot Water

Why will a pump not lift hot water?

P. H. W.

Because the water which a pump handles is forced to it by the pressure of the atmosphere on the surface of the water outside of the suction pipe as fast as the pump removes the pressure from the water inside the pipe. When the water is hot the reduction of pressure inside the pipe lowers the boiling point of the water and instead of rising to the pump it gives off steam which the pump cannot remove fast enough to reduce the pressure to a point where it will rise in the pump cylinder.

Opening of Throttle Valve

Should the throttle valve of an engine be wholly or only partially open when running?

O. T. V.

The valve should be opened wide but not "jammed." As little obstruction as possible should be offered to the flow of steam from the boiler to the engine and a partially opened throttle is an obstruction.

Sluggish Gage Glass

What would cause the water to rise slowly in a gage glass immediately after it had been blown out?

S. G. G.

A partially stopped pipe or a valve not fully opened.

Pressure on Crank Pin

What would be the pressure on the crank pin of a 16x20-inch engine with 120 pounds steam pressure in the cylinder?

P. C. P.

The area of a 16-inch piston is 201 square inches and the total pressure on the pin with the crank on the center will be

$$201 \times 120 = 24{,}120 \text{ pounds}$$

Counterbore

What is the counterbore in a cylinder, and what is it for?

C. C. C.

It is that portion of the cylinder which is bored slightly larger than the portion through which the piston sweeps. It furnishes an edge over which the edge of the piston ring travels, thus preventing the formation of a shoulder at the end of the piston travel.

Relation of Pump to Heater

What is the difference in the location of open and closed feed-water heaters in regard to the pump?

L. P. H.

The pump is between the boiler and the open heater, but the closed heater is usually between the boiler and the pump.

Two Peculiar Flywheel Explosions

One of these flywheels was wrecked by two waterwheels running away with an engine connected to the same shaft. The other flywheel was crushed in by a driving belt which was cut by the bursting of an 11 foot line-shaft pulley, the belt wedging between the engine flywheel and the cement floor.

Two flywheel accidents occurred recently, the first on Monday morning, January 9, at the B. C. and R. Knight textile mills No. 3, Manchaug, Mass. The flywheel was entirely demolished and the engine badly wrenched. This accident was due indirectly to a fire, as water used in putting it out soaked a belt, which later parted and allowed two waterwheels to run away with the engine.

The power plant consisted of two Corliss engines and two waterwheels. Both waterwheels were set in a basement room under the mill and back of the engine room. One of the engines was run on high-pressure steam and was set at one side of the engine room, with the flywheel next to the mill. The other engine was located on the opposite side of the engine room, with the flywheel set away from the mill; this second engine was run as the low-pressure side of the other engine, but was placed some 25 feet distant. Each engine was controlled by a separate governor and the only connection between them was the 8-inch steam pipe extending from the high- to the low-pressure cylinder. Fig. 1 gives an idea of the general layout of the power plant.

It seems that neither of the waterwheels was equipped with a governor, and the low-pressure engine was not equipped with a speed-limit safety stop. Although the high-pressure engine was protected by such a device, it had no control over the low-pressure engine.

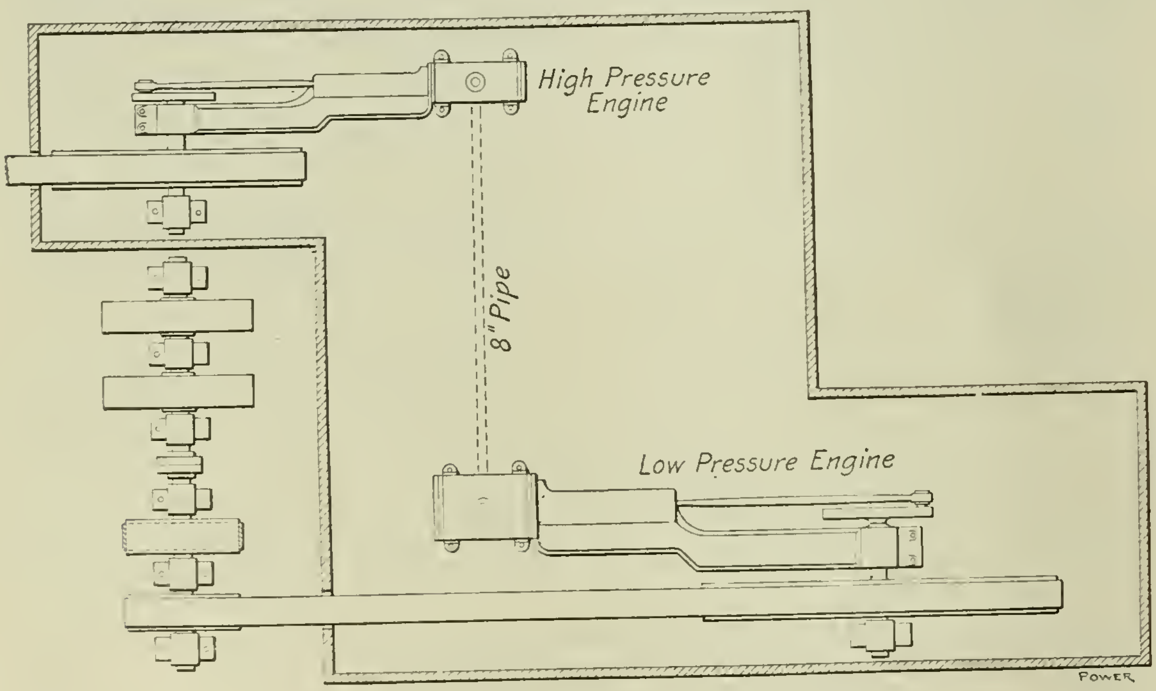


Fig. 1. General Layout of Engine Room

About 8 o'clock on Monday morning, a fire occurred in the mule room of the factory, but was quickly extinguished by water from the company's fire hose. Water, however, saturated a belt that ran from a pulley on a shaft that was connected to the waterwheels. This shaft also supported a driven pulley on which the main driving belt from the engine ran. About half an hour after the fire had been put out, the water-soaked belt parted, relieving the two waterwheels and the low-pressure engine of all load, and, there being no governing apparatus on the waterwheels, they ran away with the engine, the speed becoming so great that the 26-foot flywheel, having a 36-inch face and weighing about 25 tons, burst into dozens of pieces.

Some of the parts passed up through the engine-room roof, some through the rear wall and others into the wheel pit and back into the mill basement through a thick stone wall, wrecking piping, pulleys and shafting which were connected to the waterwheels.

As the engineer noted the increase of speed, an attempt was made to shut down the high-pressure engine and thus cut off the steam supply to the low-pressure engine, but before this could be done, the crash came. Fortunately, no one was killed, or seriously injured. Beside wrecking the flywheel, the main pillow block was broken at the jaws and the outer pillow block wrenched out of place. The engine will require extensive repair before it will be fit to run again.

No photographs were obtainable as the wreckage had been cleared away before a Power representative could get on the field.

The second accident occurred at 1:30 p.m. on Wednesday, January 11, when a flywheel was wrecked at the works of the American Axe and Tool Company, East Douglas, Mass., which is but a few miles distant from Manchaug.

A line shaft on which was mounted an 11-foot pulley was belted to a 310-horsepower compound single-acting Westinghouse engine by a 19-inch belt. The flywheel on the engine was 7 feet in diameter and had a 21-inch face. The belt was given a large arc of contact on both of these pulleys, by means of two idlers which were placed as shown in Fig. 2. The 11-foot pulley was made with a cast-iron hub and spokes and a steel rim made in two sections and riveted to the spokes. The idler next to the line

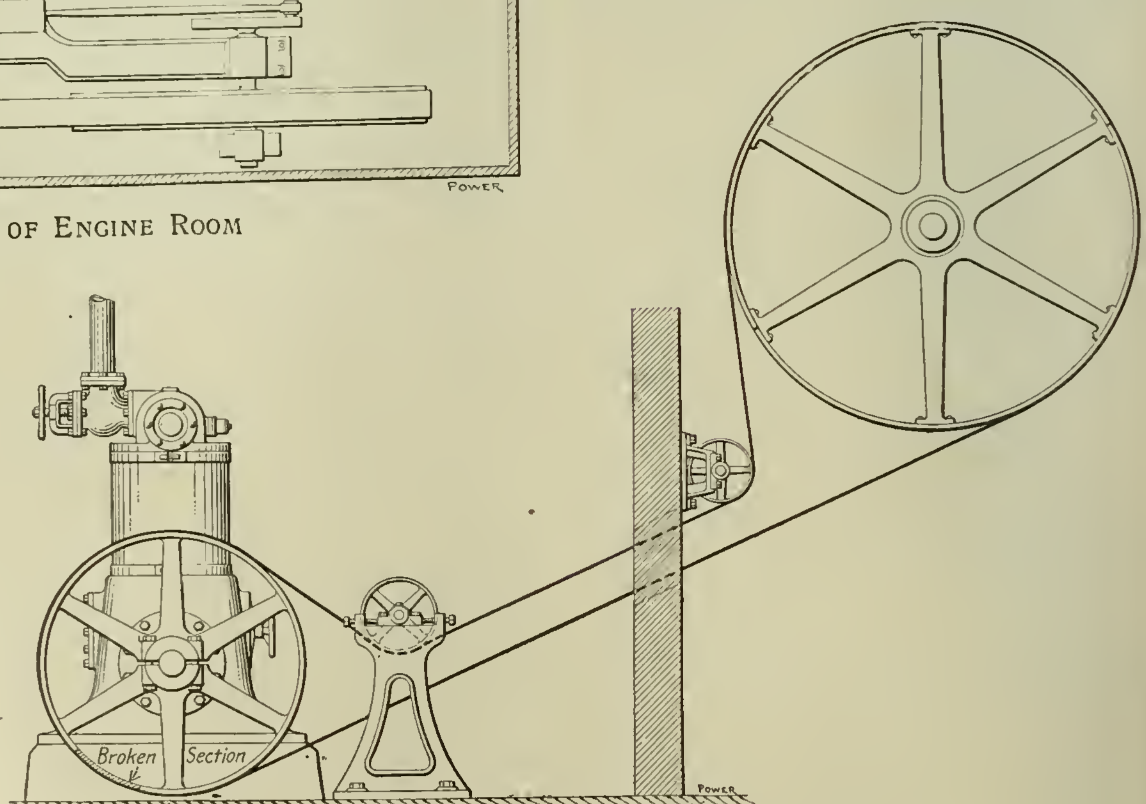


Fig. 2. Arrangement of Belt and Pulleys

shaft was attached to the wall forming a partition between the engine and forge rooms. The other idler was supported by a stand placed back of the engine flywheel, and the top side of the belt was made to travel between the two idlers, a distance of one foot from the bottom, or tight side, of the belt.

FIG. 3. TWO VIEWS OF THE STEEL RIM

This accident was doubtless due to a weakness in the 11-foot driven pulley. The initial rupture started at one of the joints of the rim where it was riveted to the spoke. As the rupture of this wheel was not instantaneous, warning was given to the men employed in the vicinity who got to a safe place before the rim parted from the spokes.

Fig. 3 shows two views of the rim section and portions of the hub and spokes. One-half of the rim was bent double at a point near the center, the face of the rim being on the inside. The other half of the rim was bent into an ogee shape.

When the pulley burst, the 19-inch driving belt was torn in two and, owing to the large contact on the face of the flywheel, instead of coming off the pulley, was wound around the rim, which ran close to the cement floor of the engine room, and so great was the pressure of the belt on the rim of the engine flywheel at the point between the floor and the wheel that a section of the rim between the spokes, 38 inches long, was forced in toward the hub, leaving the break as shown in Fig. 4.

On the inside of the rim is a crack extending part way through the metal that was made as the fractured section of the rim was forced inward. The wheel was made with a solid rim and split hub.

Owing to the prompt action of the engineer, steam was shut off over the boilers before the engine, which was running at a speed of 151 revolutions per minute, did any material damage to itself. In fact, the shaft was not even sprung, although the concrete floor directly under the flywheel was crushed in about 1½ inches, and the anchor bolts were drawn up into the foundation ½ inch.

The damage was small, as it will only be necessary to replace a new pulley on the line shaft, a new flywheel on the engine and a new idler. No one was hurt and a portion of the plant will be operated by water power until repairs are completed. Photographs and data were obtainable through the courtesy of Superintendent W. J. Griffin.

FIG. 4. FRACTURED WHEEL

Award of Perkin Medal to Charles M. Hall

The fifth annual award of the Perkin medal for important discoveries in applied chemistry took place on January 20 at the Chemists' Club in New York, when the Society of Chemical Industry presented this medal to Charles M. Hall for his achievements in the production of aluminum at low cost. The medal was first awarded (1906) to Sir William Henry Perkin for his discovery of mauve. The other medalists have been J. B. F. Herreshoff (1907), Arno Behr (1908), Edward G. Acheson (1909).

Prior to Mr. Hall's invention, aluminum had been almost a precious metal. In 1855 the metal was worth $90 per pound; in 1862 it was worth $12 per pound; in 1889 aluminum was selling at $4 per pound, this reduction having been brought about by Castner's process of producing aluminum by the use of sodium.

Hall's discovery, made in 1886, when he was but 22 years old, consisted in finding in cryolite an anhydrous solvent for alumina and then electrolyzing the alumina out of the cryolite solution. He applied for a patent in 1886, the same being granted in 1889, its validity being later passed upon by Judge William Howard Taft, now President of the United States. After experimenting with two sets of partners for several years, the work was finally taken up by the Pittsburg Reduction Company, now the Aluminum Company of America. At present this company has five establishments in the vicinity of Niagara Falls, and produces annually about 30,000,000 pounds of aluminum at a cost much below the figures given above.

Annual Entertainment and Banquet of the Combined Chicago Associations of the National Association of Stationary Engineers. Held at the Grand Pacific Hotel, Saturday Evening, January 14. A Total of 355 Members and Guests Were Present at the Banquet of which Fred Gielow Was Toastmaster. Among the Speakers Were John Erickson, Former City Engineer, Samuel Forse, of Pittsburg, National Treasurer of the National Association of Stationary Engineers, and John Lane, Editor of the "National Engineer." A Pleasing Feature of the Occasion was the Entertainment by Billy Murray and Jack Armour, of New York. Many Guests Were Present from Milwaukee and Other Surrounding Cities

St. Louis Convention of Marine Engineers

The National Marine Engineers' Beneficial Association made a departure from its usual custom by holding its thirty-sixth annual convention at St. Louis instead of at Washington, where its meetings have been held for eighteen out of thirty-six years. About one hundred delegates were in attendance, representing associations from Seattle, Wash., to Portland, Me., and from the Lakes to the Gulf. The convention was called to order at the Planters hotel, by National President William F. Yates on Monday, January 16, and continued in session throughout the week.

SUPPLYMEN AT ST. LOUIS CONVENTION

The balloting for national officers resulted as follows in the reëlection of the entire board, except the second vice-president: William F. Yates, president; Art Hyde, first vice-president; George H. Bowen, second vice-president; Charles N. Vosburg, third vice-president; George A. Grubb, secretary, and Albert L. Jones, treasurer.

The social features of the convention consisted of theater parties, automobile rides, visits to the local plants, including an inspection of the Anheuser-Busch brewery, and the usual smoker, at which some four hundred of the prominent engineers of St. Louis and vicinity accepted invitations.

The supplymens' association connected with this convention chose the following officers: Frank Martin, president; F. E. Ransley, vice-president; C. A. Willett, secretary.

The next annual meeting will be held at Detroit during January next.

DELEGATES AND VISITORS AT MARINE ENGINEERS' CONVENTION IN ST. LOUIS

SOCIETY NOTES

The third annual entertainment and reception of the Combined Associations of Engineers of the Borough of Brooklyn was held at Kismet Temple, Brooklyn, N. Y., on the evening of January 21. After a very interesting vaudeville entertainment, dancing was indulged in for several hours. The affair was the most successful ever held by the combined associations. The large auditorium with its several galleries was filled to overflowing by a representative gathering of engineers.

The National Electric Light Association has voted to hold the next annual convention in New York City during the week May 29 to June 2, with four days of business sessions. The meetings will be held in the United Engineering building at 29 West Thirty-ninth street, where the offices of the association are located. No hotel has been selected for headquarters but a hotel committee had been formed with Frank W. Smith as chairman, which this year will undertake to make definite reservations. The manufacturing members of the association, in view of the fact that there is another electrical show in New York in October, have voted to dispense this year with the collective exhibit.

BOOKS RECEIVED

THE SCIENTIFIC AMERICAN CYCLOPEDIA OF FORMULAS. By Albert A. Hopkins. Munn & Co., New York. Cloth; 1077 pages, 5¾x8½ inches; 200 illustrations. Price, $5.

HYDRAULIC TURBINES. By V. Gelpke and A. H. Van Cleve. McGraw-Hill Book Company, New York. Cloth; 293 pages, 6¾x9 inches; 200 illustrations; plates; tables; indexed. Price, $4.

ELECTRICIANS' OPERATING AND TESTING MANUAL. By Henry C. Horstmann and Victor H. Toulsey. F. J. Drake & Co., Chicago, Ill. Leather; 359 pages, 4¼x6½ inches; 211 illustrations; indexed. Price, $1.50.

Water Power in New Zealand

It is reported that the New Zealand government has already passed an appropriation of $1,250,000, which is to be followed by more grants later on, to develop several of its water-power possibilities.

The government has absolute control of all the water power. Altogether there is estimated to be 3,000,000 horsepower undeveloped and available in the islands, which are only 1000 miles long and 150 miles wide at the widest part. Owing to the land being so suitable for agriculture and to the European market being so distant, very little attention has been given to manufacturing and so heretofore the water power has not been utilized. New factories are springing up and with cheap electric power a great impetus will be given the growing industries. American manufacturers will surely do well to pay attention to this promising field.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

INTERNAL COMBUSTION ENGINE. Thaddeus W. Heermans, Chicago, Ill. 980,946.

WIND MOTOR. Alexander Norman, Dos Palos, Cal. 980,995.

TURBINE. William E. Snow, Dedham, Mass., assignor to B. F. Sturtevant Company, Boston, Mass., a Corporation of Massachusetts. 981,021.

TURBINE. Julian H. Rivers, Niotaze, Kan., assignor to Kaessmann-Rivers Development Company, St. Louis, Mo., a Corporation of Missouri. 981,311.

ENGINE. Joseph Z. Savoie, Providence, R. I. 981,316.

TWO-CYCLE INTERNAL COMBUSTION ENGINE. Donn Irving Twitchell, New York, N. Y., assignor to George H. Benjamin, New York, N. Y. 981,331.

BOILERS, FURNACES AND GAS PRODUCERS

GAS PRODUCER. George P. Davis, Detroit, Mich. 980,923.

STEAM BOILER. John E. Fernstrum, Menominee, Mich. 981,078.

STEAM GENERATING APPARATUS. Wilberforce B. Hammond, Brookline, Mass., assignor to General Fire Extinguisher Company, New York, N. Y., a Corporation of New York. 981,081.

OIL BURNER. Henry J. Hennings, San Gabriel, Cal. 981,083.

APPARATUS FOR GENERATING STEAM OR OTHER VAPORS. Edward C. Newcomb, Boston, Mass., assignor to the Newcomb Motor Company, a Corporation of New York. 981,216.

DOWNDRAFT FURNACE. William H. James, Cincinnati, Ohio. 981,275.

WATER-TUBE BOILER. James L. Butler, Akron, and Norman Slee, Barberton, Ohio, assignors to the Babcock & Wilcox Company, New York, N. Y., a Corporation of New Jersey. 981,377.

GRATE STRUCTURE. John R. Fortune and Harold S. Wells, Detroit, Mich., assignors to Murphy Iron Works, Detroit, Mich., a Corporation of Michigan. 981,408.

LIQUID FUEL BURNER. William A. Wallace and Albert Crume, Brush, Colo. 981,504.

POWER PLANT AUXILIARIES AND APPLIANCES

COUPLING PIPE. Joseph H. Glauber, Cleveland, Ohio. 980,939.

ROTARY VALVE. Brinay Smartt, Nashville, Tenn., assignor to Thomas Maddin Steger, Nashville, Tenn. 981,019.

PUMP. Frank L. Antisell, New York, N. Y., and David W. Blair, Perth Amboy, N. J. 981,518.

AUTOMATIC TIME VALVE. Frederick S. Hutchins, San Francisco, Cal., assignor of one-half to Irvin Silverberg, San Francisco, Cal. 981,271.

AUTOMATIC SAFETY VALVE FOR WATER GAGES. William H. Bray, Manchester, N. H., assignor of one-half to Hattie L. Healey (now by marriage Hattie L. Felch), Manchester, N. H. 981,370.

LUBRICATOR VALVE FOR STEAM CHESTS. Frank W. Edwards, Logansport, Ind., assignor to the Chicago Lubricator Company, Chicago, Ill., a Corporation of Illinois. 981,544.

ELECTRICAL INVENTIONS AND APPLICATIONS

ALTERNATING - CURRENT ELECTRIC MOTOR. Hans Sigismund Meyer, Bremen, Germany, assignor to General Electric Company, a Corporation of New York. 980,986.

RENEWABLE FUSE FOR ELECTRIC CIRCUITS. Joseph A. Volk, Jr., South Norwalk, Conn. 981,038.

ROTARY CONVERTER. Joseph L. Burnham, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 981,059.

AUTOMATIC ARC LAMP. Ernst Sai'er, Rochester, N. Y., assignor by mesne assignments, to Bausch & Lomb Optical Company, Rochester, N. Y., a Corporation of New York. 981,121.

ROTARY CONVERTER. Charles P. Steinmetz, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 981,134.

ELECTRIC SWITCH. Philip Thos. McNally, Mandan, N. D. 981,452.

ELECTRIC HEATER. Milton H. Shoenberg, San Francisco, Cal., assignor to Presto Electrical Manufacturing Company, San Francisco, Cal., a Corporation of California. 981,481.

APPARATUS FOR MEASURING AREAS BY MEANS OF ELECTRIC RESISTANCE COILS. Julius Josef Götz, Offenbach-on-the-Main, Germany. 981,552.

RHEOSTAT. Charles D. Kestner, New York, N. Y., assignor to the Meyrowitz Manufacturing Company, a Corporation of New Jersey. 981,572.

POWER PLANT TOOLS

SCREW DRIVER. Willey B. Lane, Philadelphia, Penn., assignor of one-half to J. C. McCarty & Co., a Corporation of New York. 981,202.

WRENCH. James F. Wright, Canton, Ohio. 981,234.

WRENCH. Rudolph J. Bomblatus and Frank Caviola, Forbes Road, Penn. 981,523.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York. Next meeting in New York City, May 29 to June 3.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., Prof. J. D. Hoffman; sec., William M. Mackay, P. O. Box 1818, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting at Detroit, Mich., January, 1912.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION.

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec.

POWER

NEW YORK, FEBRUARY 7, 1911

A WELL KNOWN engineer recently made the statement that he secured his first position as chief because he had formed the habit of doing his work right.

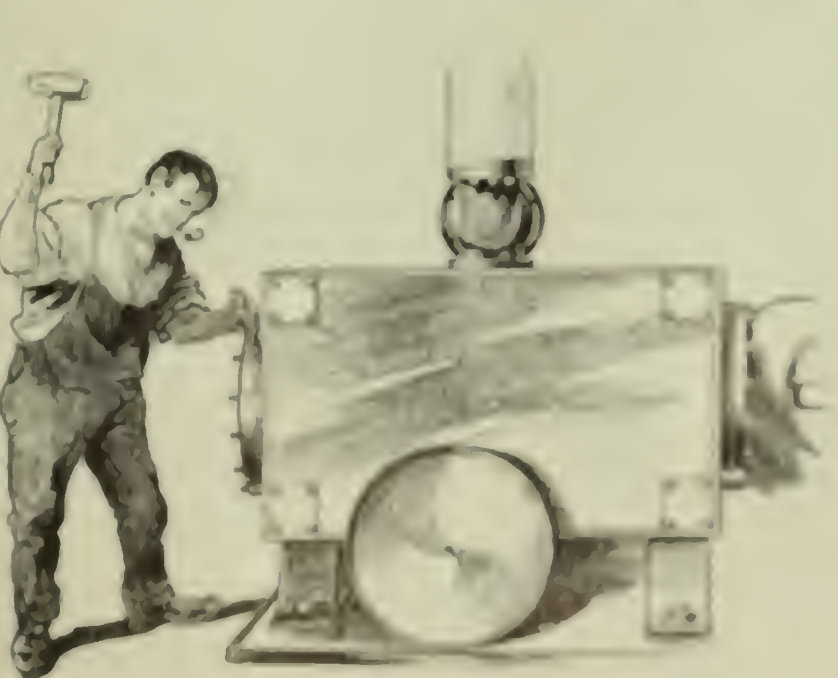
He had been an erecting man for an engine company, and was one of half a dozen men sent to make a new engine run satisfactorily. Five of them simply expressed their opinion as to the cause of the trouble and went away. This engineer used common sense, took off his coat and fixed the engine by making proper adjustments.

He did not know that an impression had been made with the head of the steam plant, but two years later, when he had forgotten the incident, he was offered the position of chief engineer of the very same plant where he had been sent to fix the engine.

The biblical maxim about casting bread upon the water and its return after many days worked out in this case. It usually does, and this man's experience is evidence that when a piece of work is to be done, it pays to do it the very best one knows how.

Some engineers are born, others are made and a whole lot are misfits.

Some engineers pride themselves on the appearance of their steam plant, and take as much care of their engines as if they were living things. Others, from lack of ambition, or because they have never learned to do things right, misuse everything under their care, and do so with apparent relish. Imagine a big, strong, bare-armed engineer taking a delicate steam gage and pounding the pointer in place on the spindle with a heavy hammer. It has been done.



Imagine this same individual, in an attempt to remove a cylinder head, gripping a cold chisel in one hand and a small-sized sledge hammer in the other and mauling with main strength until the heavy head is forced from the cylinder.

Such practice is enough to make a real engineer grind his teeth and protest against such methods of treating power-plant apparatus. Doing work in this way is often the direct reason why certain engineers are never given the opportunity of taking charge of a better plant than the one they have been operating for years.

No sane man expects to obtain something for nothing, and if a return is desired an investment must be made.

On the part of the engineer this means an intelligent understanding of steam engineering and the gumption to do the work around the plant in a workmanlike manner.

A pig will never be invited into the parlor, a common laborer will never be offered work as a skilled toolmaker, and an engineer using sledge-hammer methods cannot expect that an opening in some new, up-to-date power plant is awaiting his coming.

A position of this kind demands a real engineer. Such a man is easily recognized by his methods and the results he obtains in the plant.

Boilers and Piping of Wieboldt Bl'dg

By Osborn Monnett

The main points of interest in this small plant of a Chicago department store are the boiler setting, which was specially designed for restricted head room, and the piping layout.

A new plant which has lately been installed for W. A. Wieboldt & Co., of Chicago, contains some features deserving of attention. The boiler room contains four Kroeschell 72-inch by 18-foot horizontal, return-tubular boilers, arranged in two batteries, as shown in Fig. 1, and fitted with Green chain-grate stokers. Owing to the fact that the sewer level at this point is close to the surface, severe restrictions as to the amount of headroom were imposed. The ordinary setting, which requires considerable excavation, was not desirable, not only because of its first expense, but also because of the continued expense for pumping into the sewer. Therefore the stokers were equipped with ash drags, as shown in Fig. 2, by which the ashes are pushed from the rear of the ashpit to a shallow pit at the front. The drag is composed of angle-iron sections attached to a chain operating over two sprockets which are driven from the stoker lineshaft through a ratchet arrangement keyed to the front drag shaft.

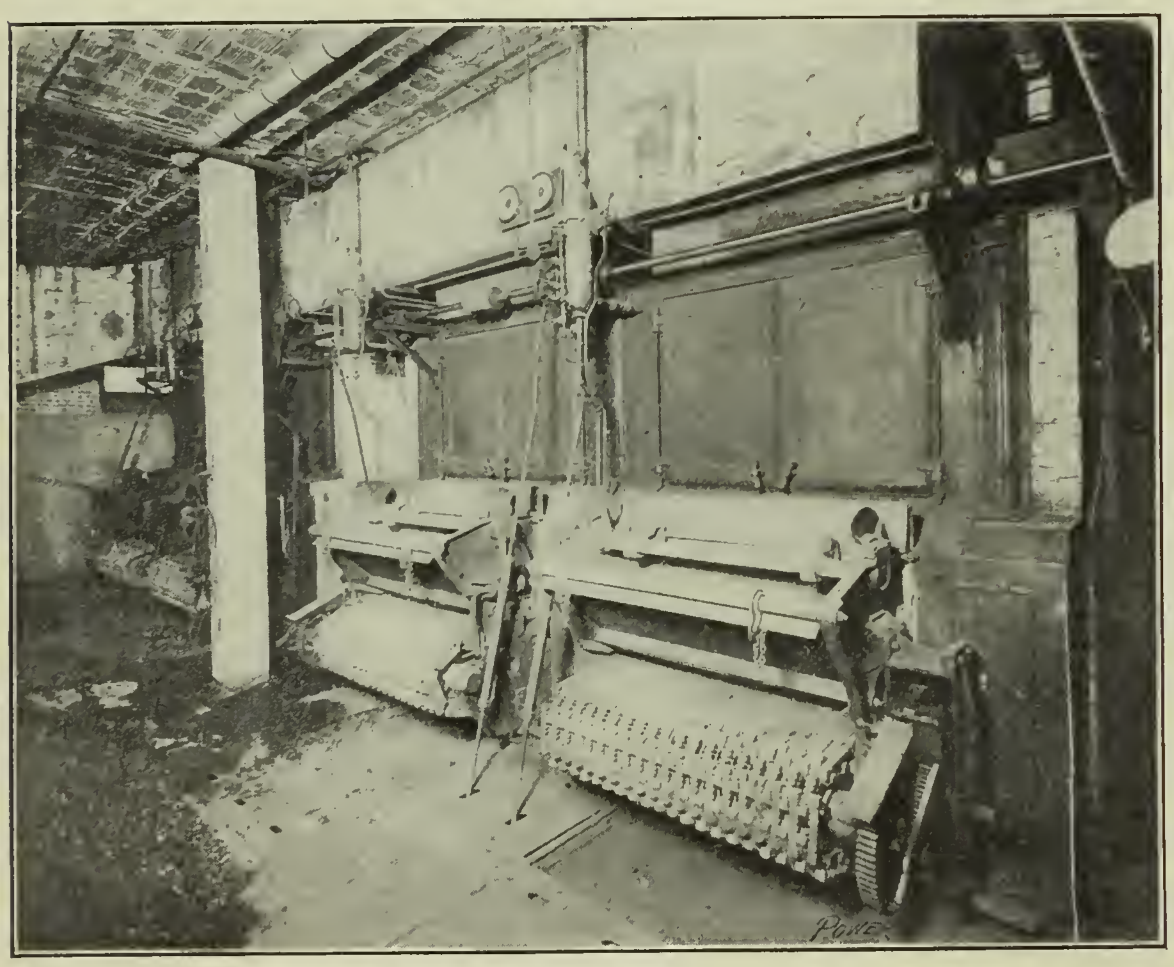


Fig. 1. Fronts of Boilers

The system of piping is unique, and has been found very satisfactory. It conforms to the standard practice of W. L Fergus & Co., the consulting engineers who laid out the new installation, and consists chiefly of a number of small headers and large receiver-separators, the latter located at the engine throttles and designed to furnish a reserve steam capacity to draw upon when the steam valves are open. A portion of the main piping is shown in Fig. 3.

The nonreturn valves connect with long-radius bends which terminate in a manifold located between the two batteries of boilers. At this manifold are located the boiler stop valves, all of which can be manipulated from this point by the operator, standing on a platform provided for the purpose. From the manifold a 6-inch straight header extends directly to the engine room, where branches are provided to distribute the live steam to the engines.

In the engine room there are three direct-connected Ball & Wood units, one of 50, one of 150 and one of 200 kilowatts capacity. Directly over each throttle is located a Cochrane receiver-separator of unusually large capacity for the size of engine. In the case of the 200-kilowatt unit a steam connection 8 inches in diameter is provided at the throttle, although the main steam line to this unit is only 4 inches in diameter. The steam line to the 150-kilowatt unit is 3 inches in diameter, the separator 30 inches in diameter and the throttle-valve connection as provided on the engine is 7 inches. Fig. 4 is a striking illustration of the comparative sizes of piping and separators. Another important feature is the use of an angle throttle valve, which affords a more direct passage for the steam.

The advantages claimed for this system of piping are lower first cost, greater safety, less maintenance cost for bolts and gaskets, reduced radiation, less surface exposed to the steam and consequent minimum condensation, avoidance of dangerous pulsations in the header over the boilers, as is sometimes found in ordinary layouts, and lower maximum velocity of the steam than in standard practice. It is claimed that a steady, constant flow of steam from the boilers to the separators is realized, which takes up any unevenness in the demand for steam

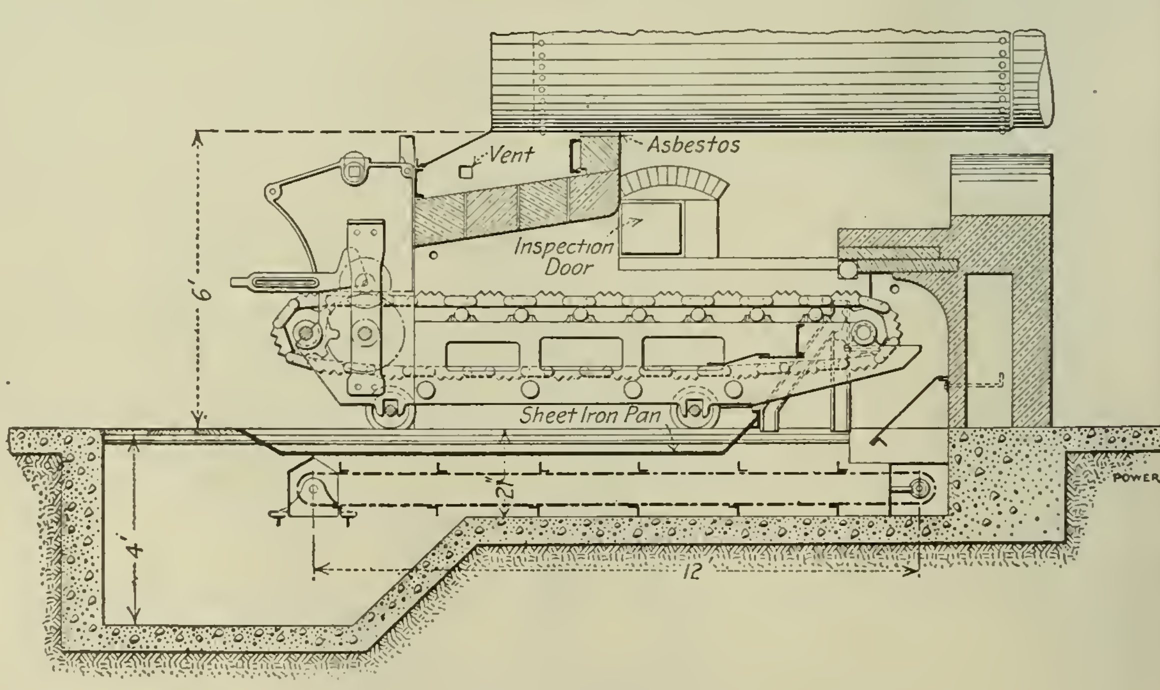


Fig. 2. Section through Furnace

to the engines. No drain is used on the header system, as it is contended that condensation will cause the least trouble at the separator, where the steam is comparatively at rest, and the water will naturally gravitate to the bottom, where it is easily removed.

Fig. 5 shows an indicator diagram taken on one of the engines running under full load, and serves as an indication of how well the system is working out.

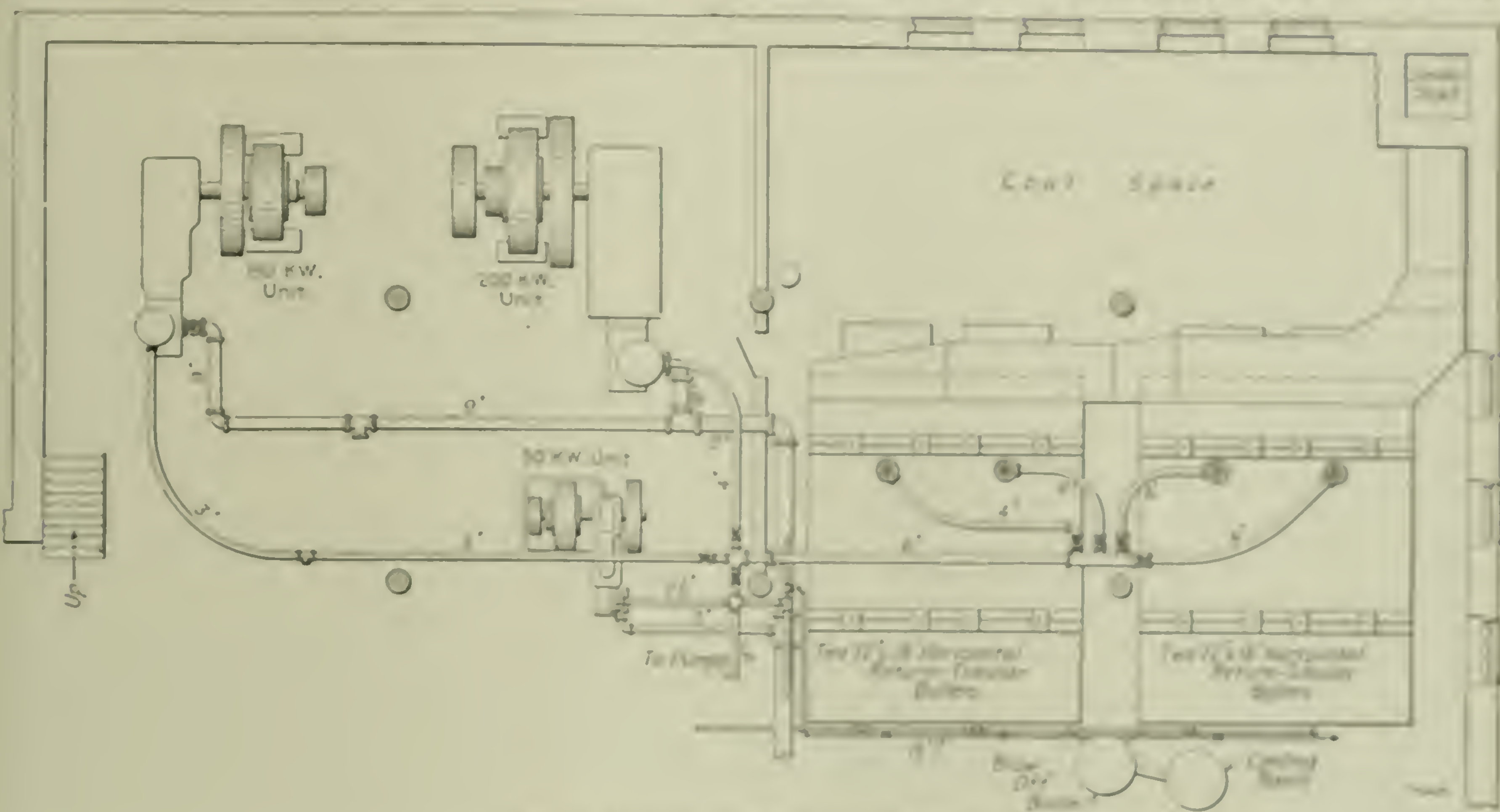


FIG. 3. LAYOUT OF MAIN STEAM PIPING

The Oldest Complete Locomotive in America

At the National Museum in Washington, is exhibited the locomotive "John Bull," No. 1 of the Camden & Amboy Railroad Company, which was built by George Stephenson & Son at Newcastle-on-Tyne in 1830-31 and shipped from Liverpool on July 14, 1831, on the ship "Allegheny," bound for Philadelphia. On November 12, 1831, in the presence of members of the New Jersey legislature, with Isaac Dripps acting as engineer, and a train with two cars, this locomotive made the first movement by steam in the State of New Jersey, at Bordentown, where the railroad monument now stands. The "John Bull" was in continuous service from 1831 to 1865, during which time it was altered and added to. It was exhibited at the centennial exposition in 1876 and at the exhibition of railway appliances in Chicago in 1883. It was placed in the United States National Museum in 1883 and remained there until 1893, when on April 17 to 22 it was run under steam from New York to the World's Columbian Exposition, where, for a time, it made daily trips on the exposition tracks. In December, 1893, it was returned to Washington, having made the last trip under steam on the thirteenth of that month. The original weight was 22,425 pounds. The boiler was 13 feet long, 3 feet 6 inches in diameter; the cylinders, 9x20 inches; the driving wheels, 4 feet 6 inches in diameter, with locust spokes, cast-iron hubs, with tires of wrought iron shrunk on; the flanges, $1\frac{1}{2}$ inches deep; 62 flues, 7 feet 6 inches long, 2 inches in diameter; furnace, 3 feet 7 inches by 3 feet 2 inches high; steam ports, $1\frac{1}{8}x6\frac{1}{2}$ inches; exhaust ports, $1\frac{1}{8}x6\frac{1}{2}$ inches; throw of the eccentric, $3\frac{1}{2}$ inches; grate surface, 10.06 square feet; fire-box surface, 36 square feet; flue surface, 213 square feet. There is also exhibited in the same section one of the original driving wheels of the "De Witt Clinton."

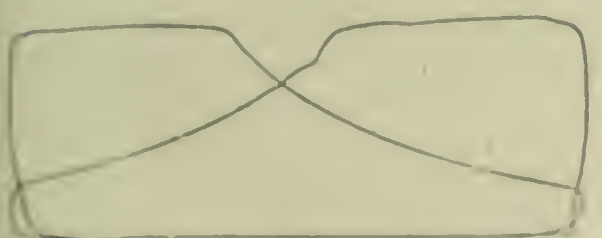


FIG. 5. DIAGRAMS SHOWING EFFECT OF STEAM RECEIVERS


FIG. 4. ENGINE ROOM, SHOWING LARGE RECEIVERS

One of the best preventives of scale in a boiler is good circulation of the water contained within.

Design of Steam Power Plants

By William F. Fischer

In a previous article under the above caption are taken up the location and type of plant, the building and the foundations. The present article deals with the selection of boilers.

In aiming for economy of fuel the whole equipment of boilers, engines, condensers, pumps, heaters, piping, etc., must be considered individually and collectively. An inefficient boiler will counteract the virtues of a good engine, and likewise an engine extravagant in steam may render useless the economy obtained with a good boiler.

Selection of the Boilers

Before the plans for the boiler house are completed, the type of boiler to be used should first be decided upon and its exact dimensions and setting obtained from the manufacturer.

As the efficiency of a steam-power plant, both thermally and commercially, depends primarily upon the boiler installation, it is evident that the selection of proper boilers is of utmost importance. A well selected boiler may give fairly economical results even when poorly installed, but a type of boiler entirely unfitted for the duty imposed upon it may have the best setting and still not give good results. The first cost, though important, should not be the first consideration in selecting any piece of apparatus for a power plant; selecting steam boilers wholly on account of their low first cost frequently means a sacrifice in efficiency and with it the profits on the investment. If, on the other hand, boilers are selected with reference only to their thermal efficiency, the cost of the installation may be prohibitive, and for this reason may forbid a decision wholly upon that basis.

Evaporation

The principal item affecting the cost of operation of a boiler is its evaporative efficiency, which should be a maximum at normal load in a well designed boiler. When forcing to a great extent, although the rate of evaporation is increased, the efficiency is lowered owing to a large proportion of the heat being wasted. Therefore, a boiler plant should be of ample capacity to carry the greatest steady loads without forcing. It is always well to install one or more spare boilers, for use when any of the others are out of service for repairs or for cleaning.

With most boilers the best efficiency under ordinary working conditions is obtained when evaporating about three pounds of water per hour, per square foot of heating surface, from and at 212 degrees. This is equivalent to allowing nearly twelve square feet of heating surface per boiler horsepower.

As the efficiency of the heating surface will be more or less impaired by the accumulation of scale and soot, it is well to provide ample heating surface for the work to be done. This results in a saving of fuel at ordinary rates of evaporation, and also makes it possible to run the boiler considerably above its rating and still maintain a fair efficiency.

Most of the various types and grades of boilers on the market are capable of producing practically the same evaporation per pound of fuel fired, provided they are designed with the same ratio of heating to grate surface and are operated under exactly similar conditions. They differ, however, with respect to space occupied, weight, capacity, first cost and adaptability to particular conditions of operation.

Boiler Horsepower

Strictly speaking, there is no such thing as the horsepower of a steam boiler, for the power from the steam is developed in the engine, the boiler itself doing no work. This phrase was originally intended to mean that a boiler having a certain stated horsepower would furnish all the steam required to develop that amount of power in a given engine. According to the American Society of Mechanical Engineers' standard, a boiler to develop one horsepower must evaporate 30 pounds of water from a temperature of 100 degrees Fahrenheit into steam at 70 pounds gage. This is equivalent to evaporating 34½ pounds of water from a temperature of 212 degrees Fahrenheit into steam at atmospheric pressure, or "from and at 212 degrees," as it is called, which corresponds to 33,305 B.t.u. per hour.

This measure of capacity is merely conventional, as one boiler horsepower will furnish sufficient steam to develop about three actual horsepower in the best compound-condensing engine, but only about one-half horsepower in a small noncondensing engine.

The term "horsepower" should not be used when purchasing a boiler unless the amount of heating surface is also specified, as one bidder might offer a boiler with five square feet of heating surface per horsepower, and another with ten square feet. Both boilers would be capable of the required evaporation, but the boiler having the smaller heating surface, although probably much the cheaper of the two, would do so only at an increased fuel consumption.

Water-tube versus Fire-tube Boilers

Engineers differ as to the design of boiler best suited to certain conditions. As experience has shown that boilers of the water-tube and the fire-tube types give equally good economy if well designed and operated under the same conditions, it is impossible to give any general rule as to which type should be given the preference. The principal considerations with which an engineer has to deal when selecting a type of boiler for a given plant are: The character of the fuel, the character of the feed water; the kind of service and safety, the available floor space, the steam pressure to be carried, the expense of operation and maintenance, and the influence of the locality.

Water-tube boilers are usually employed in medium- and large-sized central stations in high-pressure units of from 300 to 650 horsepower. Where the service is such that large quantities of steam are often wanted with but very little warning, water-tube boilers should always be given the preference. This is because they contain relatively less water than the shell, or fire-tube, type; consequently steam can be raised in them within a shorter time. On account of the larger passage for the gases and the better circulation of water in contact with the heating surfaces, more water can be evaporated per square foot of heating surface in a water-tube boiler than in one having fire tubes, although, as before mentioned, the efficiency of the two types is about the same. On account of their lower first cost, return-tubular boilers are still used to a considerable extent in central-station work in preference to the water-tube type, but as the practice of such initial economy frequently proves to be the most expensive in the end, the consideration of low first cost should not be given too much weight. By this, however, is not meant that the boiler of highest first cost is always the most economical one. Regarding repairs, the water-tube boiler is the more expensive if it is to be kept in first-class condition.

Waters that abound in scale-forming matter warrant a decision in favor of the use of a boiler of the plain cylindrical or horizontal return-tubular types, because of the comparative ease with which they can be cleaned at a minimum cost. Because of their ability to stand almost continual service with a minimum amount of overhauling, horizontal return-tubular boilers should be given the preference where the time allowable for repairing, cleaning and overhauling is limited.

As to safety, water-tube boilers are generally accepted to be superior to those of the fire-tube type. Therefore, in selecting the boilers for a building where a number of people are employed, or are likely to be gathered, the water-tube type should undoubtedly be given the preference, regardless of its additional first cost and cost of operation and maintenance.

Another important consideration in the selection of a steam boiler is the amount of space available. For shallow basements and out of the way corners, probably no boiler is as suitable as the horizontal return-tubular, but where space is plentiful, other considerations may cause a different type of boiler to be selected. As return-tubular boilers are seldom made in sizes over 200 horsepower, they should not be considered for large units.

Vertical Boilers

Where ground space is expensive and overhead room permits, vertical tubular boilers may be considered. As a rule, such boilers are rapid steamers and are comparatively low in first cost. They have the disadvantages, however, of being inaccessible for thorough inspection and cleaning, have a considerably small steam space, resulting in excessive priming at heavy loads, and are poor in economy except at light loads, as the products of combustion escape at a high temperature on account of the shortness of the tubes. Another disadvantage of the vertical tubular boiler is its small water capacity, which usually results in rapidly fluctuating steam pressures with varying demands for steam.

Vertical fire-tube boilers are usually of small size, seldom being over 60 horsepower. An exception, however, is found in the Manning vertical fire-tube boiler, which is constructed in sizes up to 500 horsepower, and suitable for steam pressures of 200 pounds or more. In sizes above 300 horsepower they are usually arranged with a brick furnace and may be equipped with mechanical stokers. As far as safety and efficiency are concerned, the Manning boiler ranks with any of the other first-class types. Vertical boilers are also made in the water-tube type, and in efficiency compare favorably with the horizontal water-tube boiler.

Available Labor

Another important consideration which should not be overlooked in selecting steam boilers is the class and amount of labor available to operate and take care of them. A plant in which there is only one attendant should, as a rule, never be equipped with water-tube boilers, as the attendant will not have sufficient time to care for them properly.

Grate Surface and Draft

The maximum evaporative capacity of a steam boiler is limited mainly by the amount of coal which can be burned upon the grates. With sufficient draft a good boiler can develop a horsepower upon one-half the surface ordinarily recommended. The item of grate surface is one of vital importance, and should conform to the demands imposed upon it by the particular grade of fuel to be used.

Some coals, having less heating power per pound than others, cannot be burned at as high a rate of combustion on account of their peculiar properties. Therefore, the grate surface depends chiefly upon the character of the coal and the rate of draft. With good coal low in ash, approximately equal results may be obtained with a large grate surface and light draft as with a small grate surface and strong draft, the total amount of coal burned per hour being the same in both cases. With good bituminous coal, low in ash, the best results are obtained with a strong draft and a high rate of combustion, provided the grate surfaces are cut down so that the total coal burned per hour is not too great for the capacity of the heating surface to absorb the heat produced. With coals high in ash, especially if the ash is easily fusible, tending to choke the grates, large grate surface and a low rate of combustion are required unless means, such as shaking or rocking grates, are provided to get rid of the ash as fast as it is made. The amount of grate surface required per horsepower under various conditions may be estimated from the accompanying table, which is taken from Kent's "Mechanical Engineers' Pocketbook."

GRATE SURFACE PER HORSEPOWER

	[illegible]	[illegible]	Pounds of Coal Burned per Square Foot of Grate per Hour.								
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			Square Feet of Grate per Horsepower								
Good coal and good boiler	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fair coal or fair boiler	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Poor coal or poor boiler	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lignite and poor boiler	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

This shows that a high-grade coal will permit of a more compact grate than a low-grade coal. When it is intended to burn a low-grade coal the grate should be made as ample as possible and if it is afterward desired to change to a coal of better grade, a portion of the grate may be bricked over, providing the draft, fuel or other conditions render it advisable. As a high rate of combustion is undoubtedly the best for many coals for the reason that the gases are much more thoroughly consumed when the furnace temperature is high, sufficient draft should be provided, either by a fan or chimney high enough to produce not only the proper rate of combustion for ordinary demands, but also to enable the boilers to operate with the desired overload. Not less than one-third square foot of grate surface should be furnished per horsepower.

Boiler Efficiency and Heating Surface

With the best types of boiler having the grate area and heating surfaces carefully proportioned, an efficiency of 75 to 80 per cent. is attainable with a clean boiler in exceptionally good condition and carefully managed.

It is a general practice among manufacturers to furnish about 11 to 12 square feet of heating surface for vertical fire-tube boilers and horizontal return-tubular boilers; ten to twelve square feet per horsepower for water-tube boilers, twelve to fourteen square feet for stationary locomotive boilers, and about eight square feet per horsepower for Scotch marine boilers. As this practice is not uniform, however, bids and contracts for boilers should always specify the amount of heating surface to be furnished.

Boiler Inspector's Fees

J. J. Kelly, State boiler inspector for Allegheny county, Penn., whose office Governor Stuart recommended in his message to the legislature to be made a salaried one instead of being remunerated by fees, gave out recently, according to a newspaper report, some figures in relation to his office and its income, wherein he stated that the fees of his office would approximate about $18,000 annually, out of which he has to pay aldermen's fees incurred in collecting fees of the owners for inspection and the wages of five assistants for inspecting boilers as well as office rent and telephone bills.

According to Mr. Kelly, there are less than 6000 boilers to inspect in the county, due to the fact that the gas and gasolene engines are used to such an extent that the number of boilers is decreasing, also that manufacturers are using fewer boilers but of greater horsepower.

The development of the central power plant is replacing the numerous small boilers in public buildings, which Mr. Kelly asserts has cut down the fees of his office.

Experiences on Construction Work

By S. Kirlin

Attention is called to the fact that on construction work the conditions are often such that when a breakdown occurs repairs must be made immediately. With the limited facilities at hand the repairs often tax the ingenuity of the engineering force. A few of such instances are cited.

Engineers of stationary plants sometimes think they have their share of trouble in keeping their plants in good operating condition, and they undoubtedly do have plenty of it at times; but, when it comes to having all kinds of trouble, and usually that of an unexpected character, the engineers and mechanics of outside contracting plants, such as canal construction, mine development and other plants of this kind, often have difficulties which make the ordinary troubles of the stationary engineer appear comparatively small.

On works of this kind, good buildings or foundations are not attempted, as the work is usually of a temporary character and the machinery must be moved about frequently; consequently, the machinery is operated under conditions which make accidents and breakdown much more liable to occur than in a plant which is installed to be operated permanently. On account of the nature of the work, it is often necessary for the boilers, engines and pumps to be placed in the bed of a stream and protected by a cofferdam, the water being pumped out continuously night and day, to prevent the works from being flooded. This makes quick action on the part of the men in charge necessary in case of a breakdown, especially if it happens to the pumping machinery. They must be resourceful, and quick to find a remedy for any emergency which may arise.

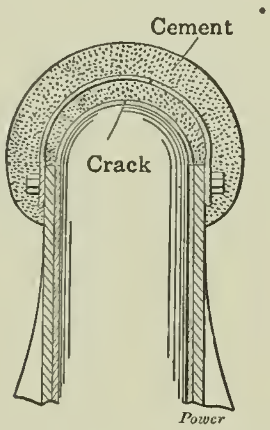


FIG. 1. SECTION THROUGH REPAIRED PORTION

While visiting plants of this kind in various parts of the country, the writer's attention frequently has been called to repairs that had been made to the machinery, many of which would have done credit to the best equipped machine shop. In most cases the work had been done with whatever tools were available, and in the shortest possible time in order to get the machinery in service again. One example of a quick and effective repair was that made on a large centrifugal pump on a hydraulic dredge. It began to leak on one side of the rim, and upon examination it was found that the rim was cracked and almost worn through for a distance of several feet. As there were no facilities at hand for patching it, the master mechanic decided to try repairing it with cement. Fig. 1, showing a cross-section of the pump, and Fig. 2, which shows an elevation of the finished repair, give an idea of how the job was accomplished. A number of pieces of strap iron were cut to the proper length with holes drilled in the ends to fit over the studs which held the sides of the casing. These were bent over the rim and were allowed to stand out about 3 inches to form a reinforcement for the cement. A form was then made, and, after being placed over the rim of the pump, was poured full of cement. As soon as this had set, the form was removed and the pump placed in service.

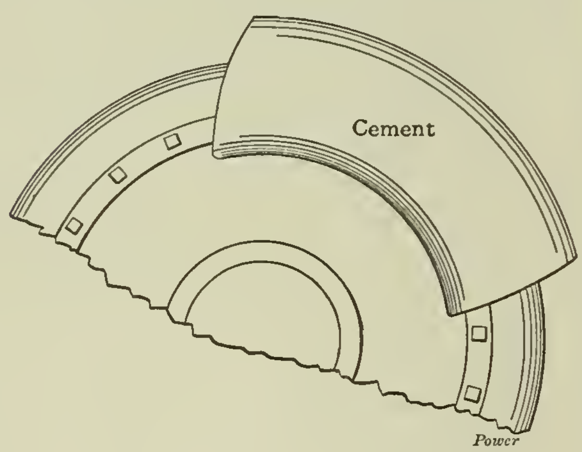


FIG. 2. ELEVATION OF REPAIRED PORTION

Another interesting repair was that made on a broken eccentric rod of a high-speed engine which drove an air compressor. The compressor furnished air for operating a large number of drills, and as all work was stopped while the air pressure was off, it was up to the engineer to make a quick repair and get things running again. He at once put two men to work filing grooves on each side of the break, as shown in Fig. 3. A piece of pipe 10 inches long and about ½ inch larger in diameter than the rod was then slipped over it, the ends of the broken rod being butted together. The rod was then centered in the pipe, the ends of which were stopped with clay, and the pipe was poured full of babbitt. As the rod had not been changed from its original length, it was not necessary to reset the valve or to disturb any of the connections. The engine was running again in less than an hour after the break had occurred.

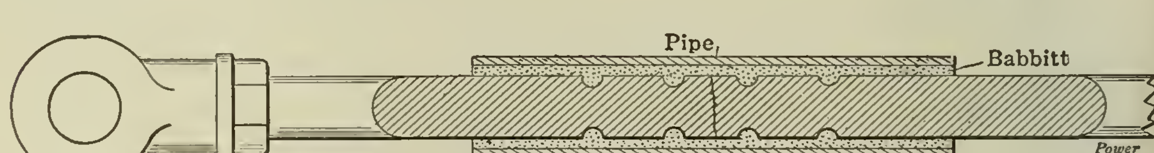


FIG. 3. SECTION THROUGH ROD AND BABBITT

The master mechanic of a large contracting firm who had a reputation for making quick repairs in case of a breakdown, was asked how it was that he was always ready with a remedy for all accidents that occurred. He answered that he made it a point to study the construction of every machine at the works, to ascertain just about what was most likely to break down, and to decide upon the method he would use to repair it in case it did let go. In this way he was prepared with the necessary material for making the repairs on breakdowns which were most likely to occur, and did not lose any time studying out a way to go at it. His system of being prepared for trouble before it occurred might be adopted by a great many others to good advantage.

There is probably no place where it pays better for the companies to furnish their mechanics with plenty of good tools than on work of this kind. It is usually a long distance from any machine shop where repairs can be made, and delay in making repairs is often a serious matter, as a small accident will frequently stop all work and possibly cause heavy damage by flooding work under way.

The chief engineer of a construction company which was notoriously lax when it came to furnishing tools, remarked, that they had a sledge, a monkey-wrench and a screwdriver, and were supposed to repair everything from the Ingersoll air compressor down to the master mechanic's watch of the same make.

Hen Simpkins packed th' piston rod uv his ingin tother day an' sez he'll bet thet he don't hev ter pack it agin fer a year. Sed his darter hed jist graddiated frum th' cookin' school an' he used sum uv her doughnuts, 'stid uv ring packin'.

Boiler Thirty Years Old Explodes

By Albert F. Dedrick

A 40-inch return-tubular boiler which had been in continuous service for twenty-four years in a grist mill, was taken out, left exposed to the weather for four years, and then installed in an electric-light plant where it operated for two years under a working pressure of 100 pounds.

On the evening of January 14, while a committee of engineers in St. Joseph, Mo., were busily engaged in drafting a proposed law relative to the licensing of engineers and firemen and the inspection of steam boilers throughout the State, the boiler of a small electric-light plant in the neighboring town of Rushville exploded. The fireman and his son, who had just dropped in to see his father, were instantly killed, and the entire plant was demolished. Fortunately the engineer, who was also the owner, had left the plant a few minutes before. If the explosion had occurred three-quarters of an hour later, it is probable that a dozen or more lives would have been lost, as it was customary for a number of the men and boys of the town to congregate around the plant every evening.

The boiler was built in 1881 for a Kansas grist mill, and after twenty-four years of service was sold to a mill in Rushville. The purchasers, after making a careful examination of the boiler, decided that it was not worth the expense of installing and therefore let it remain in the yard. After being exposed to the weather for four years it was installed in the electric-light plant where it had been in service for about two years when the explosion occurred.

FIG. 1. HEAD AND TUBES HURLED THROUGH KITCHEN WALL

It was of the horizontal return-tubular type, 40 inches in diameter by 11 feet 6 inches long, and had single-riveted lap joints. The shell, which originally had been 1/4 inch thick, was badly pitted on the inside and rusted away on the outside until in many places it measured less than 1/8 inch. The regular working pressure was 100 pounds per square inch and, with the safety valve, which was of the ball-and-lever type, set at 108 pounds the plate must have failed at a tensile strength of 17,000 pounds per square inch, providing the actual steam pressure did not exceed 108 pounds.

FIG. 2. DOME AND SHEETS

Some idea of the extent of the explosion may be gained from the accompanying views. The two heads with some of the flues intact were blown a distance of fifty feet through the kitchen wall of the owner's house, narrowly missing three small children who were asleep in an adjoining room. The dome and

FIG. 3. 200-POUND PIECE ON HILLSIDE, 300 FEET FROM ORIGINAL LOCATION

several sheets landed in the main street of the town, a distance of about 300 feet from the plant, while another large piece took a direction at right angles to this and landed in a brook.

Upon being questioned after the explosion, the engineer admitted that there was a hole in the sheet just above the fire, through which water oozed, but he had not considered it serious enough to affect the safety of the boiler. From the

Fig. 4. Section of Shell Thrown 350 Feet

Fig. 5. Remains of Dynamo

directions in which the various parts of the boiler were hurled it is evident that the initial rupture occurred at the bottom of the shell, and in the absence of other indications it would seem more than likely that it took place at or near this hole, although the tremendous force exerted by the explosion would suggest a rupture above the water line.

Use of High Gas Speeds in Boilers

> *In this experimental boiler a gas speed of over 200 feet per second was attained, resulting in the transmission of 48,000 B.t.u. per square foot of boiler-heating surface and 2785 B.t.u. per square foot of economizer surface per hour. This resulted in a high rate of evaporation without decreasing the thermal efficiency.*

At a recent meeting of the Institution of Engineers and Shipbuilders of Scotland, Prof. J. T. Nicolson delivered a paper on "Boiler Economics and the Use of High Gas Speeds," based upon the tests of an experimental boiler of the Cornish type, this boiler being arranged as shown in Fig. 2. Within the last 10

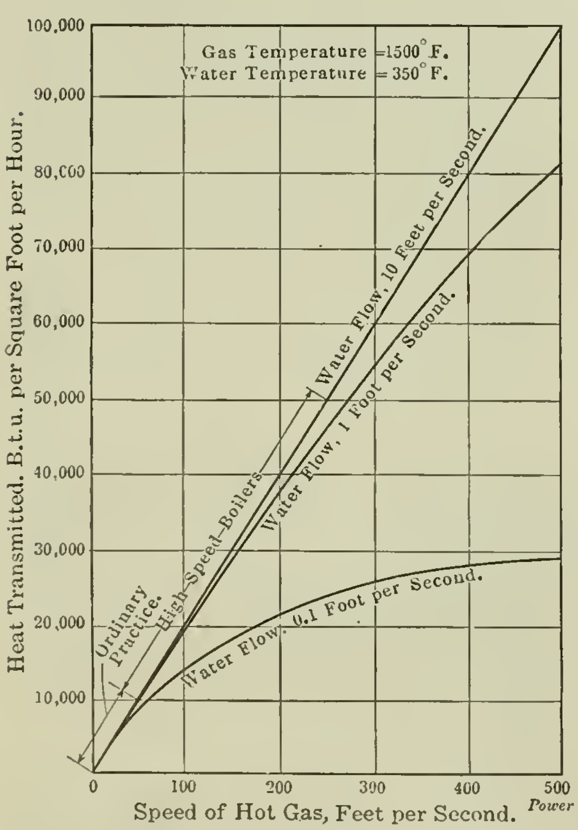


Fig. 1. Effect of Velocity of Gases Upon Heat Transmission

feet of boiler flue was placed a brick plug of such a diameter as to leave an annular space 1½ inches around it for the passage of the hot gases. These, after leaving the boiler, passed over the tubes of an evaporator and then through an economizer. The tubes of both the evaporator and the economizer had square iron rods inserted within them so as to cause the feed water to travel at a rapid rate, yet bring as much water-heating surface into use as possible. It was arranged that the feed upon leaving the economizer should go either directly into the boiler, or go there after mixing with the circulating water drawn by a rotary pump from the boiler and forced through the tubes of the evaporator so as to accelerate the circulation.

The results of the tests with this arrangement were as follows:

Coal fired per hour, pounds	840
Coal fired per square foot of grate surface per hour, pounds	44.2
Temperature of gases in combustion chamber, degrees Fahrenheit	3000
Temperature of gases leaving brick plug, degrees Fahrenheit	1200
Temperature of gases leaving evaporator, degrees Fahrenheit	620
Temperature of gases leaving economizer, degrees Fahrenheit	140
Temperature of feed entering economizer, degrees Fahrenheit	70
Temperature of feed leaving economizer, degrees Fahrenheit	270 to 340
Temperature corresponding to boiler pressure, degrees Fahrenheit	340
Draft at fan suction, inches	23½
Draft at bottom of economizer, inches	23
Draft at top of economizer, inches	7
Draft at back of water drum, inches	6½

It will be observed that the temperature of the waste gases fell to within 70 degrees of that of the entering feed. Compared with a boiler plant in which the waste gases reach the chimney at 540 degrees, this corresponds to an increased evaporation of about 1½ pounds per pound of coal. The transmission through the heating surface surrounding the plug was,

$$840 \times 15 \times 0.25 \times (3000 - 1200) = 5{,}670{,}000 \text{ B.t.u.}$$

per hour, or 48,000 B.t.u. per hour per square foot of heating surface. In a similar manner it was found that the rate of heat transmission in the economizer was 2785 B.t.u. per square foot of tube surface per hour.

The effect of gas speed in promoting rapidity of heat transference was definitely established, as plotted in Fig. 1, and there seemed to be a possibility by its use of greatly reducing the ratio of heating to grate surface without causing a diminution in efficiency which heretofore has always been associated with forced rates of combustion and evaporation.

It was accordingly decided to keep the boiler in operation for several months, making regular temperature observations and weighing the coal and feed water. Some little difficulty was experienced at first with the fan, but slight alterations enabled it to successfully hold up under the severe service. The principal object in making this continuous test was to ascertain whether the narrow gas passages would become choked with soot, and to observe what would become of the sediment and gases contained in the feed water when set free in the narrow water channels of the economizer and evaporator.

As feared, the passages around the economizer tubes did become choked with soot, and in order to burn the required quantity of coal it was found necessary to remove about one-third the number of economizer tubes (which were 7/8 inch in diameter and pitched 1 1/4 inches center to center) and repitch them. With this change the temperature of the waste gases no longer remained at 140 degrees, but rose to 240 degrees with a thin layer of soot upon them.

As regards the water spaces of the economizer (that remaining after a 1/2-inch square rod had been inserted in a 3/4-inch pipe) no deposit was found upon either the rods or the pipe and there was practically no corrosion. Below the water level, however, the evaporator tubes had become partially obstructed by a white sediment. This was accounted for by the fact that during the night the water-circulating pump was always shut down owing to lack of current; consequently the only circulation through the evaporator was that due to gravity.

The results of a test after fifty-one days' steaming without overhauling, except for the removal of some of the sediment below the water level of the evaporator, are given in the accompanying table.

RESULTS OF CONTINUOUS RUN.

Coal burned per square foot of grate per hour	37.8	35.0	23.9	26.1	46.5	40.7
Water evaporated per pound of dry coal from and at 212 degrees	10.342	10.278	10.790	11.005	11.416	11.640
Evaporation from and at 212 degrees per square foot of boiler and evaporator surface	16.24	14.02	11.87	12.41	22.77	22.18
Evaporation from and at 212 degrees per square foot of total heating surface, including economizer	10.63	10.1	8.98	8.24	12.16	12.72
Thermal efficiency of boiler, per cent	77.4	76.8	79.1	77.9	73.8	74.0
Net efficiency, deducting steam for fan, per cent	89	88.8	88.3	89.1	84.4	86.1
Chimney loss, per cent		6.7	6.7	6.3	9.4	5.8
Loss by incomplete combustion, per cent		2	2.8	0.2	1.1	0.0
Loss due to coal dust blown away, radiation, etc., per cent		15	11.9	15.2	16	15.9

In conclusion it may be said that the tests show:

1. That the rate of evaporation in pounds per square foot of total heating surface per hour increases directly with the gas speed.

2. This increased evaporative power can be attained without any sacrifice in evaporative or thermal efficiency.

3. The scouring action of the high-speed gas is sufficient to prevent choking by the accumulation of soot to such an extent as to affect materially the rate of heat transmission.

4. With continuous running, and a high rate of flow of the feed water in small-bore tubes the deposit of sediment is avoided, and corrosion due to pitting is eliminated; that is, if the water is passed through the narrow spaces at a high speed while throwing off its impurities, and is then led into a large space where these may settle without danger of trouble before being passed through the evaporating tubes, the incrustation difficulty which has been advanced against the adoption of small tubes is obviated.

5. High drafts do not necessarily involve high rates of burning on the grate.

6. That the drop in temperature between the furnace and the stack does not depend upon the mere magnitude of the heating surface, but upon the ratio of the total heating surface to the cross-sectional area of all the flues through which the gases pass.

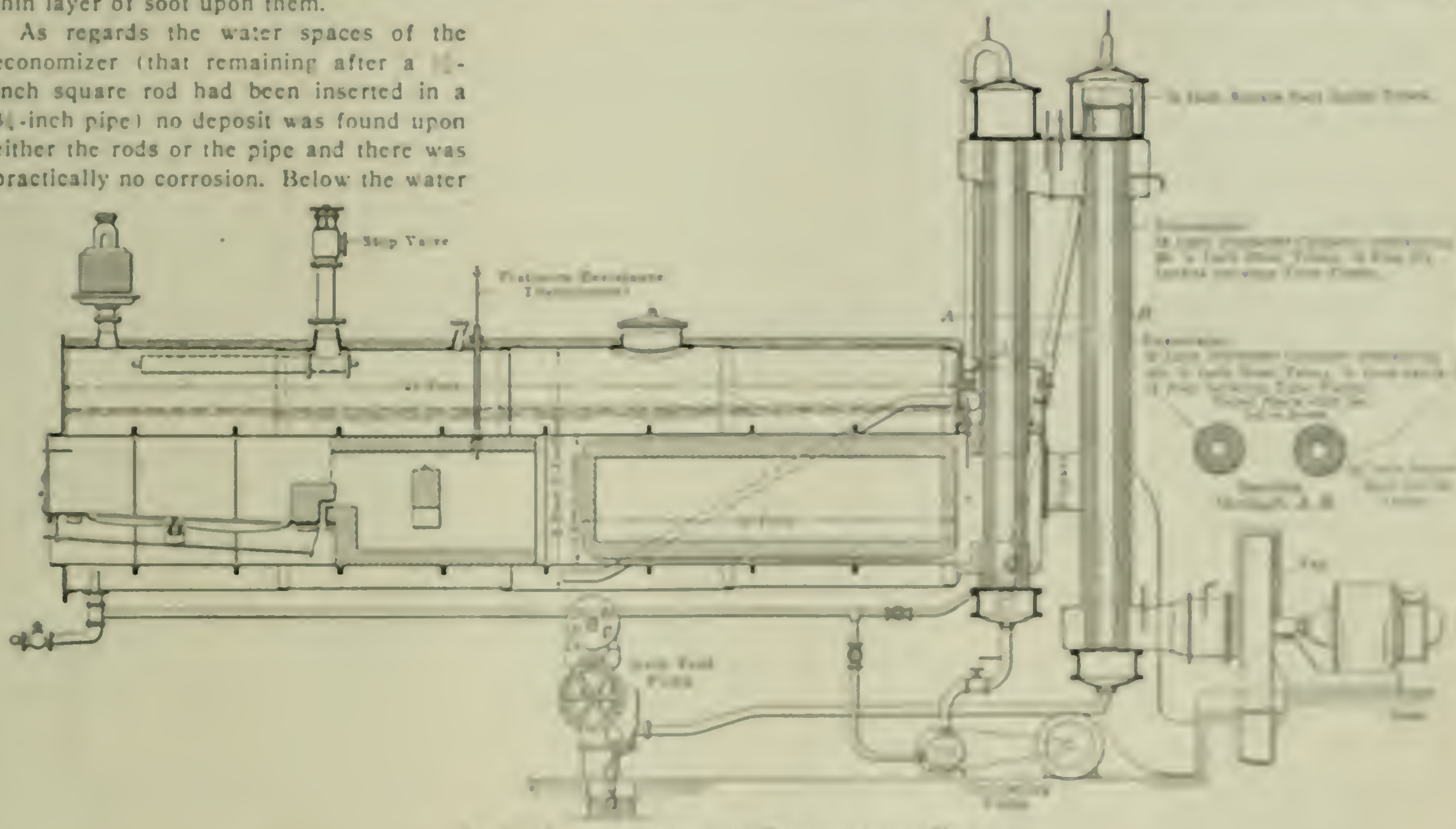


Fig. 2. Section through Experimental Boiler

Petroleum Competition

The Royal Dutch Shell group, according to the *Daily Consular and Trade Reports*, has entered into competition with the Standard Oil Company and is placing oil in France, and, it is reported here, has also determined to sell benzine in the United States, and four big tank steamers carried cargoes of this commodity some time ago to Boston.

Heretofore the Dutch combination has disposed of its products in the vicinity of production and consequently placed its oil on these markets at a very cheap rate. It will be another thing to transport oil 13,000 miles and face a great competition in its home markets, but the Dutch group seem to believe that they have sufficiently developed to succeed in the wider field, and this makes the situation interesting.

Oil is very cheap at Singapore with the price under competition going slowly down from day to day, so that 14 cents would buy as much oil at the end of October as 20 cents would in August. The result of the bitter fight between the great oil interests in the Far East is a reduction of prices to such an extent that the Chinamen are laying in good stocks at very low prices in hope of future profits, while the native consumers enjoy the luxury of plentiful light.

The Steam Turbine in Germany

By F. E. Junge and E. Heinrich

The thermodynamic efficiency as a measure of comparison of steam turbine economies and an outline of the development of the Allgemeine Elektricitäts Gesellschaft turbine.

Before entering into the details of the discussion it is necessary to agree upon a common measure of comparison. Formerly the thermodynamic efficiency was used exclusively, this being the ratio of the energy actually utilized to the energy theoretically available, in other words, the ratio of the theoretical steam consumption of an ideal engine to the actual steam consumption. Those German firms which build only the steam end of the unit, generally base their steam-consumption figures upon the actual work transmitted, measured at the coupling between the turbine and generator shafts. In most other cases, however, the thermodynamic efficiency includes the electrical output of the generator.

Let

H_o = Theoretical heat drop, that is, the amount of heat which is available in an ideal engine per pound, or kilogram, of steam introduced into the cycle (adiabatic expansion);

H_e and H_{el} = Available heat per pound of steam, corresponding respectively to the work delivered to the generator coupling, and the electrical output;

D_o and D'_o = Theoretical steam consumption per horsepower-hour and per kilowatt-hour, respectively;

D_e and D_{el} = Actual steam consumption per horsepower-hour and per kilowatt-hour, respectively;

η_e and η_{el} = Thermodynamic efficiency referred to the output delivered by the turbine and by the generator, respectively.

In accordance with the foregoing the following ratios may be expressed:

$$\eta_e = \frac{H_e}{H_o} = \frac{D_o}{D_e} \qquad (14)$$

$$\eta_{el} = \frac{H_{el}}{H_o} = \frac{D'_o}{D_{el}} \qquad (15)$$

and if η_g represents the efficiency of the generator, then

$$\eta_{el} = \eta_g \times \eta_e$$

When making an efficiency test of a steam turbine, the values D_e and D_{el} are found by the test, the amount H_o being taken either from the Mollier or the Stodola steam tables. In this connection it should be noted that one metric horsepower-hour = 75 meter-kilograms per hour = 632 French units = 2510 B.t.u. per hour, and one kilowatt-hour = 632 ÷ 0.736 = 860 French units per hour = 3410 B.t.u.

In one kilogram of steam only H_o heat units are available; therefore,

$$D_o = \frac{632}{H_o} \textit{ kilograms}$$

of steam are theoretically required in order to produce one horsepower-hour. Similarly,

$$D'_o = \frac{860}{H_o} \textit{ kilograms}$$

is the theoretical steam consumption per kilowatt-hour. Furthermore, expressed in French units,

$$\eta_e = \frac{632}{D_e H_o} \qquad (16)$$

$$\eta_{el} = \frac{860}{D_{el} H_o} \qquad (17)$$

or in English units,

$$\eta_e = \frac{2510}{D_e H_o} \qquad (16a)$$

$$\eta_{el} = \frac{3410}{D_{el} H_o} \qquad (17a)$$

The comparison of two steam turbines on the foregoing basis alone is not free from objections and needs supplementary data. For the economic efficiency of steam turbines the ratio of the circumferential velocity of the blades to the jet velocity is essential. For a single stage the most favorable value of this ratio is, theoretically, 0.5, but on account of the losses which occur, this is reduced in practice to 0.4 or 0.45. Considering two turbines of the same type and having the same number of stages, one working with high superheat and high vacuum, and the other with a lesser degree of superheat and vacuum, this ratio will be considerably smaller with the former than with the latter, because the jet velocity is higher in the first case; therefore, the thermodynamic efficiency of the former will be inferior to that of the latter, although the steam consumption of the former is superior on account of the additional energy available. Besides the influence of this ratio upon the thermodynamic efficiency, constructive features are apt to affect the efficiency with a high heat drop. With a high vacuum the specific volume of steam grows to such an extent that the cross-sectional areas through the last stages and the length of blades cannot be enlarged so as to utilize the heat drop with the best possible efficiency; hence it is useless to go below a certain vacuum. Furthermore, the high-pressure part of turbines built upon the reaction principle is not capable of safely withstanding high working temperatures. If such turbines are destined to work with high temperatures the clearances between the fixed and the rotating parts must be considerably larger than when the working temperature of the turbine is low; hence the leakage losses increase and the thermodynamic efficiency decreases. Summing up, it may be said that the thermodynamic efficiency alone does not give conclusive evidence of the all-round economy of a turbine, but that the rate of energy drop which is utilized in the turbine must be taken into account.

The A. E. G. Steam Turbine

The steam-turbine factory of the Allgemeine Elektricitäts Gesellschaft, in Berlin, is the largest concern of its kind in Germany, employing more than 3000 workmen who are exclusively engaged in this specialty. On October 1, 1910, the total number of Allgemeine Elektricitäts Gesellschaft turbines built and ordered was 1339, representing a total capacity of 1,514,418 horsepower, and prior to 1902 the company had not taken up the manufacture of steam turbines. There were at that time two systems on the market which had given fair results and had proved their usefulness for general power work even in large units; these were the Parsons and the Curtis types. The De Laval turbine, which was to be found in nearly all markets on the continent, could not be used as a model for the manufacture of large steam turbines, on account of its limitations in capacity, it being incapable of producing, economically, greater outputs than 300 horsepower. Therefore the Allgemeine Elektricitäts Gesellschaft adopted an entirely novel system, known under the name of the Riedler-Stumpf turbine. The basic idea was to build a turbine wheel which could utilize the whole energy of the steam in a single stage, at speeds which were to remain within the limits of direct generator drive. Tangential impinging of the steam upon the blades, which were milled with a cutter from the solid wheel-disk, was a special constructive feature of this type; and for low speeds and heavy loads, velocity staging and, when necessary, pressure staging were provided. Although this system is no longer on the market, it possesses historical value, representing the attempt to utilize the single-stage principle for high capacities without having recourse to transmission gearing. The highest possible number of revolutions for turbines driving electric generators—at 50 cycles, such as is used in Germany—is 3000 revolutions per minute, for a generator having two poles. In order to obtain an economic ratio of circumferential velocity to steam velocity, which is essential for steam economy, very large wheel diameters had to be adopted.

Fig. 19 shows a wheel 0.57 feet in diameter, built for 3000 revolutions per minute, corresponding to a circumferential velocity of 314 meters per second or 1003 feet per second. Such extremely high speeds had never before been used in practice and, therefore, necessitated very careful construction of the wheel as well as the employment of first-class material. A high stress upon the material was allowed for and with the best material (nickel steel) a factor of safety of three to four was deemed sufficient. The guide blades for large capacities and low speeds, serving to conduct the steam back to the wheel to impinge upon it again, are shown in Fig. 20. A turbine of this type of 2000 horsepower capacity and single stage was erected at the Moabit central station of the Municipal Electric Works, of Berlin, and was subjected to a careful test in 1903 by F. Rötscher. (For details see "Research Work, Heft 50, Verein deutscher Ingenieure.")

In order to show the essential working conditions of the Riedler-Stumpf turbine the following figures are selected from the various tests:

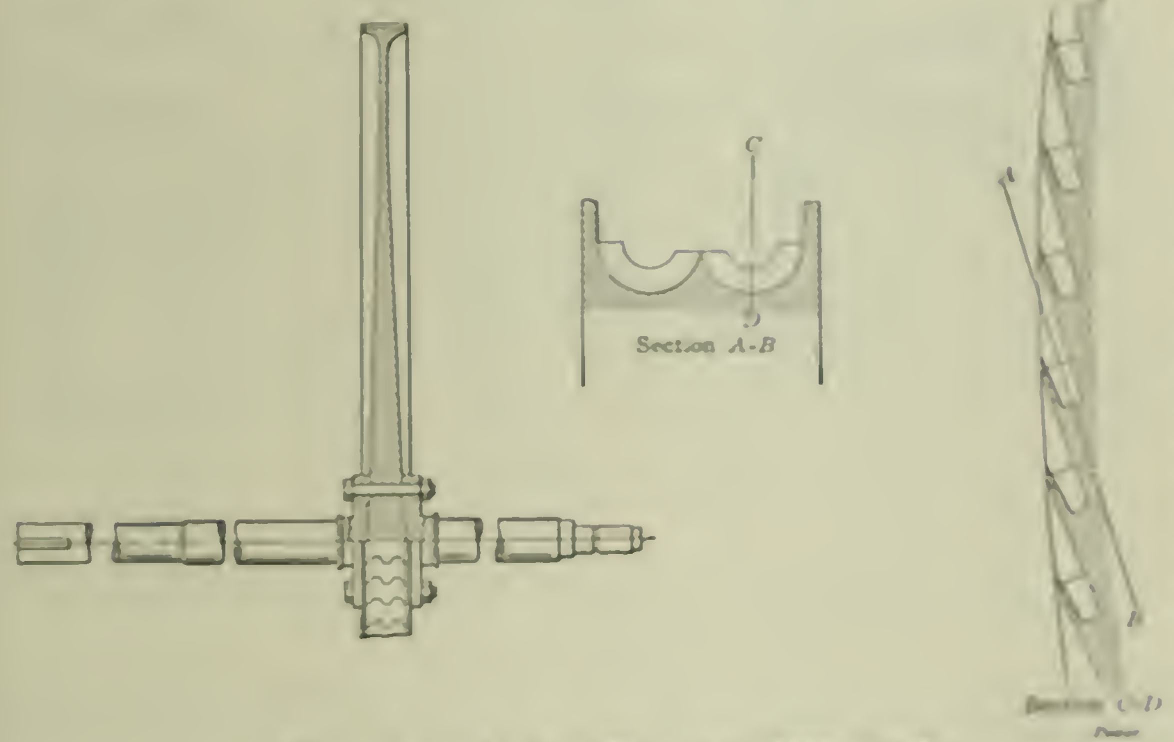


FIG. 19. LARGE DIAMETER, HIGH-SPEED WHEEL

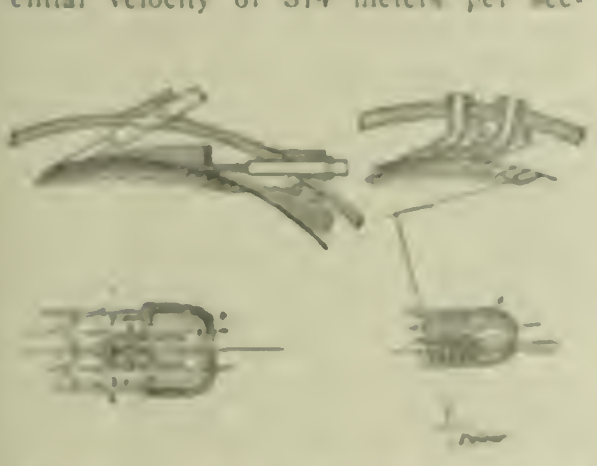


FIG. 20. GUIDE BLADES USED FOR LARGE CAPACITIES AND LOW SPEEDS

	Steam Pressure		Exhaust Pressure—Vacuum		Steam Temperature		Steam Consumption	
Load, Kilowatts	Kilograms per Square Centimeter	Pounds per Square Inch	Kilograms per Square Centimeter	Pounds per Square Inch	Degrees Centigrade	Degrees Fahrenheit	Kilograms per Kilowatt-hour	Pounds per Kilowatt-hour
1241	12.61	164	0.16	2.28	290	554	8.98	19.75

Therefore,

$$H_a = 183\ WE$$

$$H_a = \frac{860}{183} = 4.70$$

and

$$e_d = \frac{4.70}{8.20} = 0.573$$

Supposing e_g to be 91 per cent., then e_t would be 0.577 per cent.

The theoretical velocity of efflux at the nozzle is

$$c_0 = 91.5\sqrt{183} = 1240$$

meters per second = 4070 feet per second. The actual velocity, assuming a coefficient of loss in the nozzle of ϕ = 0.93, is

$$c_1 = 1150$$

meters per second = 3775 feet per second. This gives as the ratio of circumferential to efflux velocity

$$\frac{u}{c_1} = \frac{314}{1113} = 0.282$$

These figures show at once the weakness of the single-stage type. The value 0.282 is far below the most favorable value of this ratio. But considerations of strength forbid further increasing the wheel diameter so as to attain better efficiencies. The number of revolutions is fixed. Moreover, the drop of 183 heat units is very small, on account of the bad vacuum; but a higher drop would only decrease the efficiency, even if the steam consumption were better. The losses in the nozzles and blade pockets were very high in this turbine.

It will be remembered from the preceding articles that with Rateau stages, efficiencies as high as 67 per cent. were attained, while in this case the corresponding figure (including all additional losses through bearing friction, conduction and radiation) is only 58 per cent.

FIG. 21. RELATIVE SIZES OF FOUR TURBINES OF EQUAL CAPACITY AND SPEED

Therefore, the underlying idea of single-stage action for high capacities could not be realized in practice, so that the Allgemeine Elektricitäts Gesellschaft was forced to adopt another system. However, the attempt proved that circumferential velocities of from 300 to 400 meters per second can be safely used. Also, it might be mentioned that American designers of small turbines have readopted the characteristic blade form of the Riedler-Stumpf turbine.

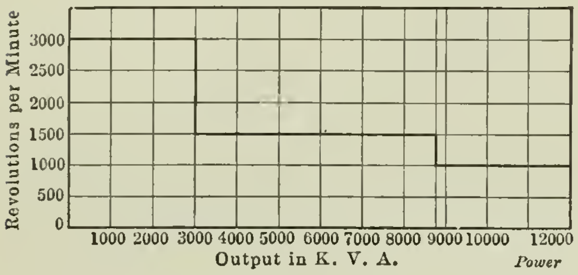


FIG. 22. LIMITS OF OUTPUT OF THREE-PHASE 50-CYCLE GENERATORS

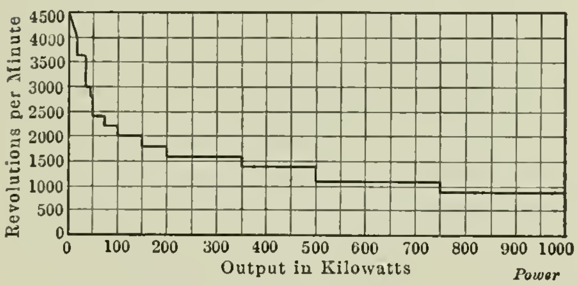


FIG. 23. VARIATION OF SPEED WITH LOAD IN DIRECT-CURRENT GENERATORS

As early as October, 1903, the Allgemeine Elektricitäts Gesellschaft had come to an agreement with the owners of the Curtis patent in America, especially with the General Electric Company, and by this agreement a sort of community of interests, scientific technical exchange, mutual exploitation of patents and a division of the markets, preventing the products of one firm from competing with those of the other in certain territories, was established. As regards the Curtis turbine, the German manufacturers preferred an independent course of construction, adopting the horizontal instead of the vertical type, the main reasons being that for the sake of steam economy in the larger types, the Rateau stages were adopted for the low-pressure portion, and as this necessitated a greater number of stages and therefore a greater total axial length of turbine, the vertical construction was rendered difficult.

Another problem to be considered was that of attendance. The same arguments which make the horizontal construction in steam engines, except in a few special cases, superior to the vertical type, hold true also for the turbine. The horizontal construction affords better accessibility to all parts and a better survey over the whole plant, especially easier control of bearing, governor, safety devices, etc. It also permits the machine to be dismantled and the interior exposed for inspection with much less trouble than with the vertical type. In view of the necessity of ease in dismantling, the pipe fittings, governing mechanism, etc., should be connected preferably to the lower part of the casing. The step bearing of the vertical type of turbine, which now seems to give satisfactory service, was regarded in the early days as a sensitive organism which was likely to give trouble. So it was deemed wiser in this respect by the builders to profit by the tests of Lasche

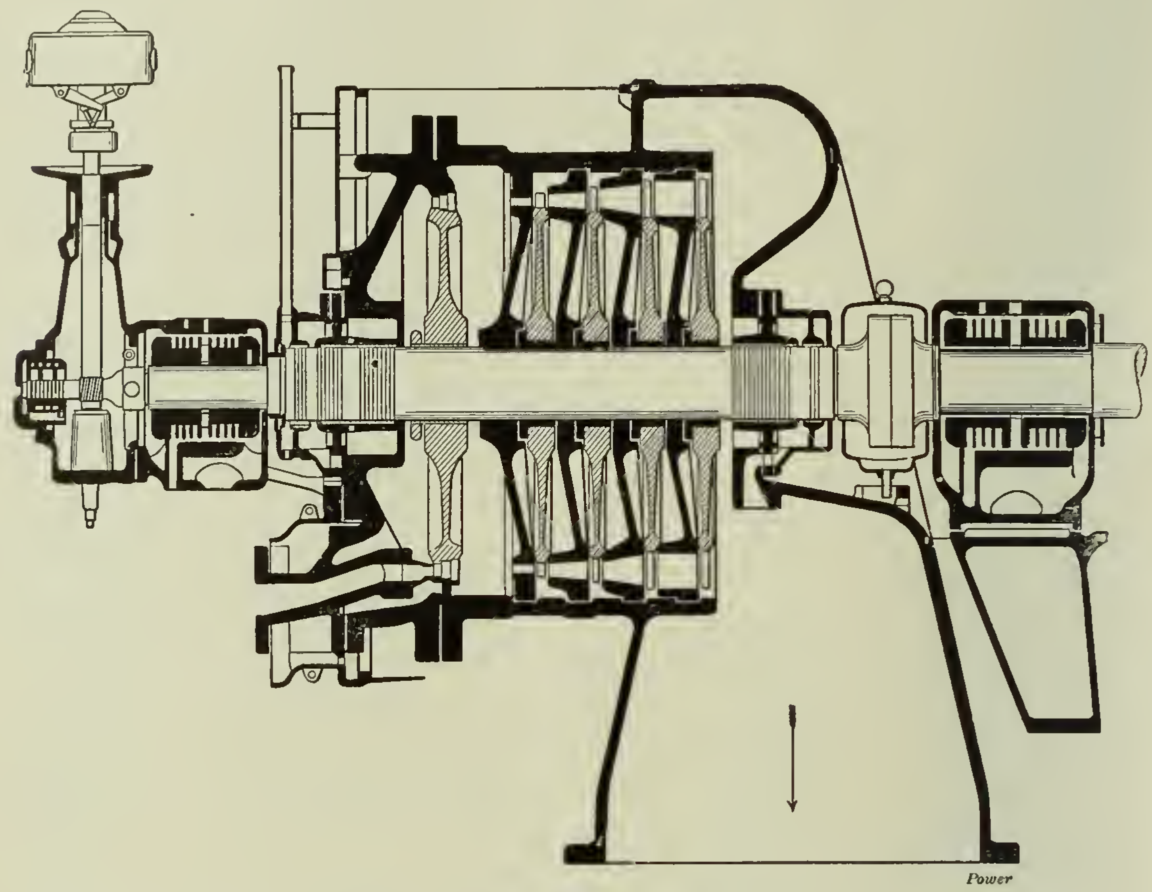


FIG. 25. A. E. G. TURBINE OF 3000 REVOLUTIONS PER MINUTE AND OUTPUTS GREATER THAN 1000 KILOWATTS

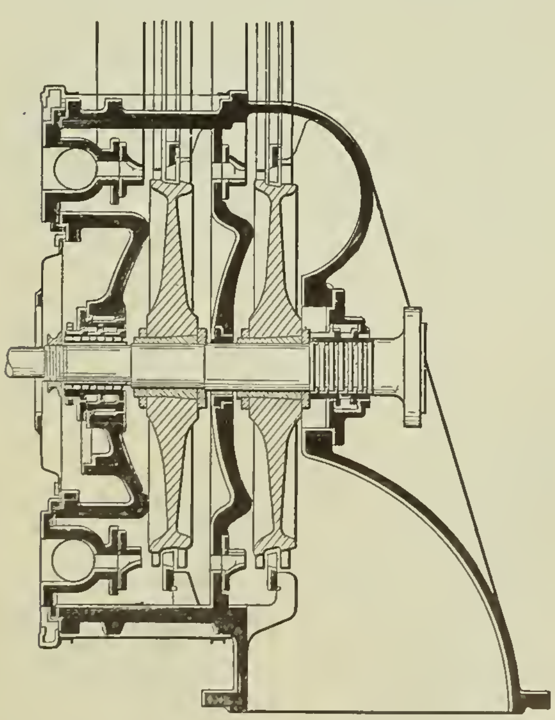


FIG. 24. A. E. G. TURBINE FOR SPEEDS OF 3000 REVOLUTIONS PER MINUTE AND LOADS UP TO 1000 KILOWATTS

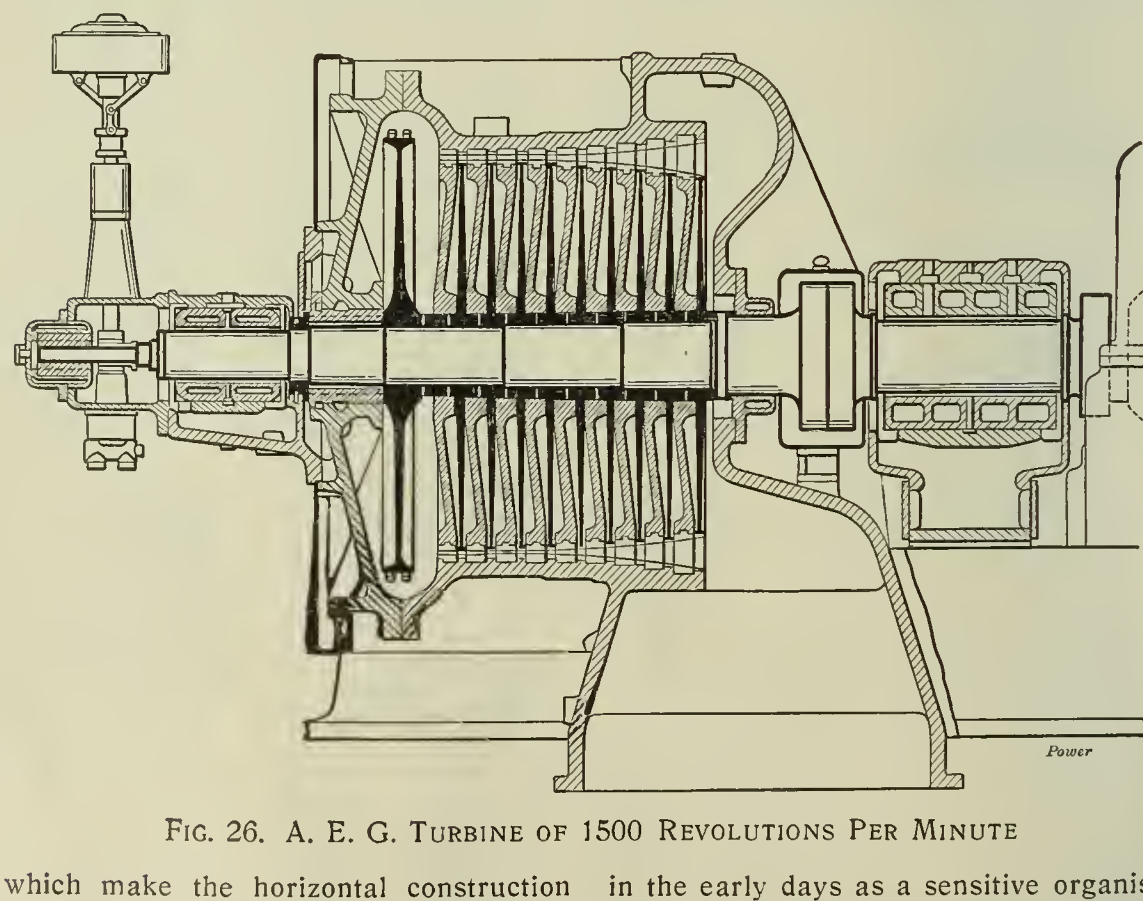


FIG. 26. A. E. G. TURBINE OF 1500 REVOLUTIONS PER MINUTE

and by the good results attained with horizontal bearings in the high-speed electric-railway trials.

As to bulk of plant, the floor space required is approximately the same for both types, if the condensing plant is taken into account (which has the same dimensions in both cases). Considering a turbine room containing several units, the centers between two units become somewhat greater with the vertical types; hence, the length of the plant is greater, while the width of the room will be smaller with vertical turbines than with horizontal ones. However, the hight of the room will be considerably greater for vertical than for horizontal turbines; hence it is safe to assume that the cost of the building for vertical units is greater than for horizontal units.

These and other considerations made it advisable for the Allgemeine Elektricitäts Gesellschaft, instead of copying the General Electric style of the Curtis type, to develop an entirely new and original form of horizontal turbine. With the style once agreed upon, the dimensions of turbines are dictated by three main considerations: First, reliability of operation; second, fuel economy; third, cost per horsepower. These three points of view do not exactly coincide. For instance, in reaction turbines safety of operation and economy stand in direct contrast, in so far as economy requires very small clearance between the guides and the rotating parts in order to keep the leakage as small as possible, while reliability of operation demands larger clearances. On the other hand, with impulse turbines this does not hold true, and in designing these there is only a compromise between economy and cost.

It is obvious that turbines can be built cheaper if the specifications for steam consumption are less stringent. In one of the preceding discussions it was shown that, beginning at certain capacities (somewhere around 100 kilowatts) the Curtis and Rateau systems in the high-pressure portion are approximately on a par, as far as economy is concerned, there being only a slight superiority of the Rateau system, while, in the low-pressure portion, even for smaller outputs, Rateau wheels seem superior.

A common feature of all Allgemeine Elektricitäts Gesellschaft turbines, regardless of capacity, is the employment of the Curtis wheel in the high-pressure portion. Experience leads us to believe that for very large capacities the Rateau action principle is superior whenever a high economy is to be attained, although the building cost is higher. For medium outputs of from 700 to 1000 kilowatts the combined Curtis and Rateau turbine seems the more favorable. For very small capacities, of about 300 horsepower, the Curtis principle (wheels having two rows of blades) is preferable, especially if low speeds are desired for driving direct-current generators. Another point of division lies in the change from wheels having two to wheels having three rows of blades.

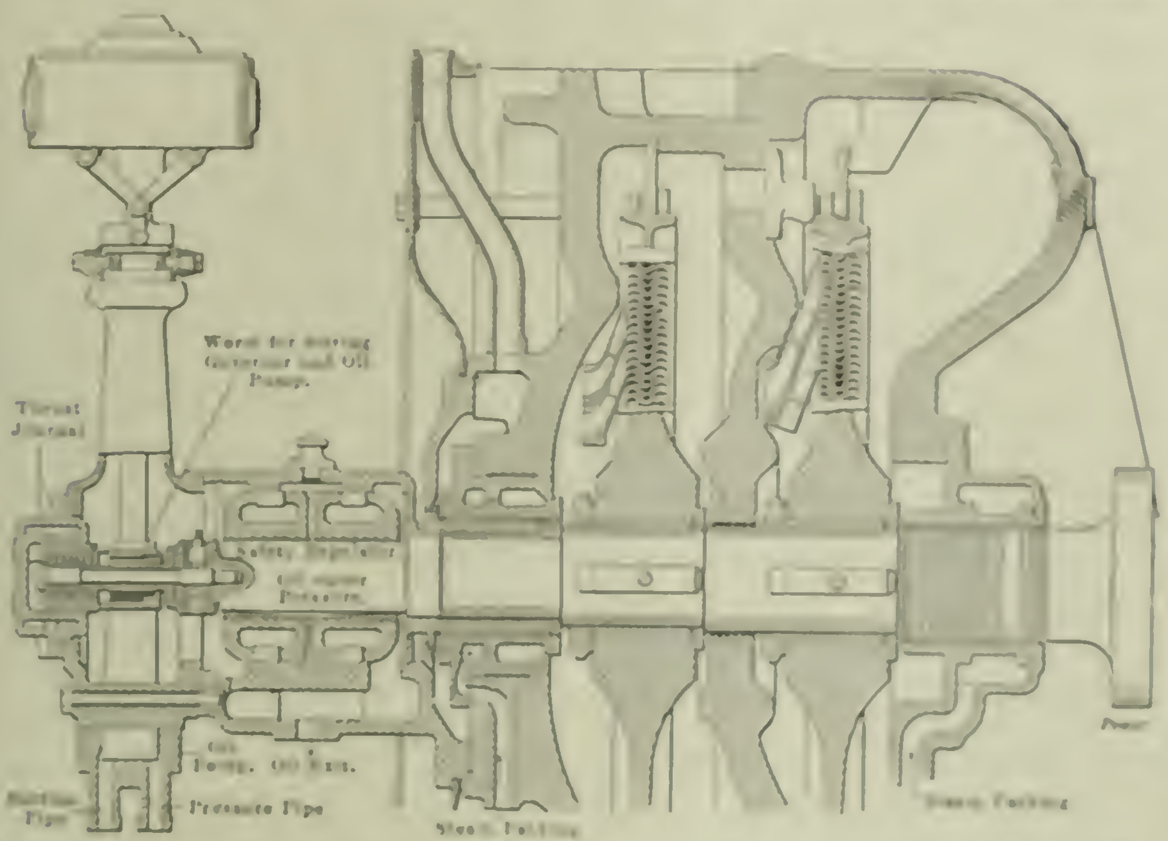


Fig. 27. Sectional Elevation through A. E. G. Turbine Having Two Pressure Stages to One Velocity Stage

One of the problems which the Allgemeine Elektricitäts Gesellschaft had to solve is indicated in Fig. 21, which represents the utilization of a certain heat drop through four turbines of equal capacity and equal speed, and affords an illustration of the size and proportions of these turbines. There will be a certain (very low) capacity for which the efficiencies of the four are equal.

The number of revolutions, at the maximum output for a certain speed, is, as a rule, not determined by the turbine but by the generator. The rotor of the generator is a much more complicated mechanism as regards strength and dynamic conditions than are the rotating wheels of the turbine. The former is an unhomogeneous part, containing besides the iron of the shaft and the iron of the magnetic field, copper and insulating materials, which in the course of operation are subjected to dislocation, necessitating careful and repeated balancing and careful treatment.

Fig. 22 shows the limits of output for 50-cycle three-phase generators at the respective speeds of 3000, 1500 and 1000 revolutions per minute. The units running at 3000 revolutions per minute are built up to the limit of 3000 kilovolt-amperes. The limit of the 1500-revolutions per minute

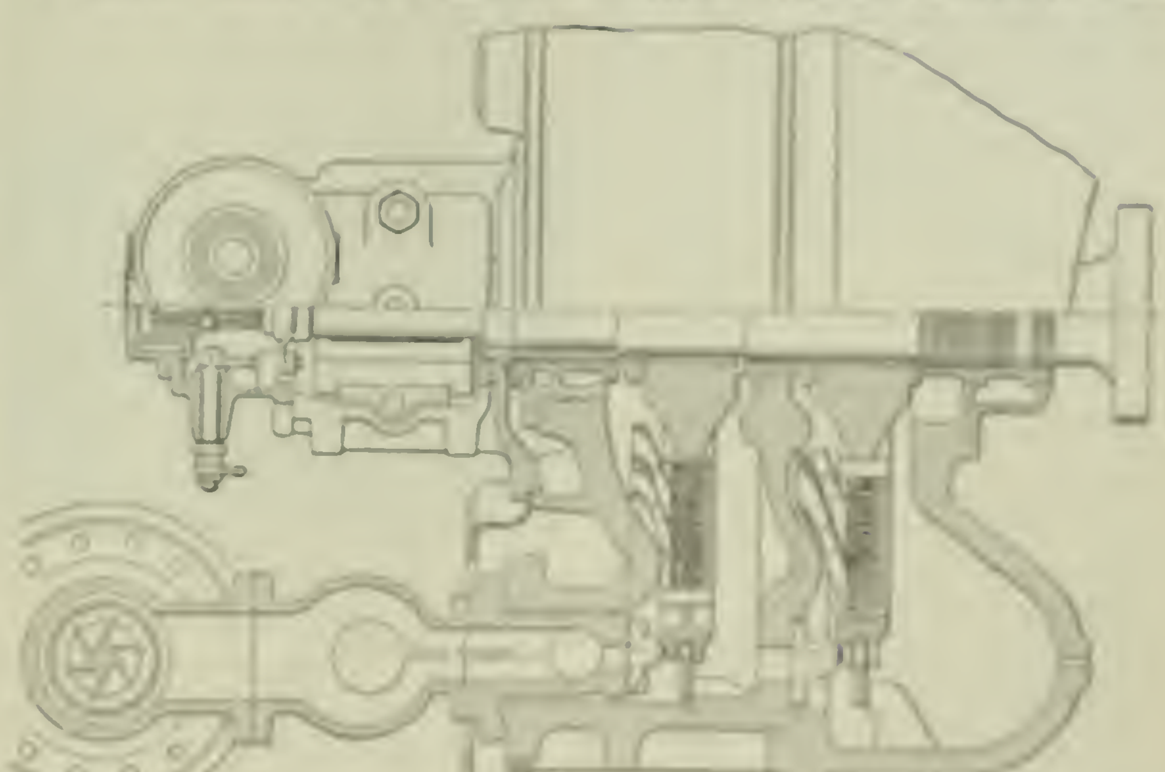


Fig. 28. Sectional Plan of A. E. G. Turbine

ute type lies at 8800, and that of the 1000-revolutions per minute type at 12,000 kilovolt-amperes. The capacities at high speeds increase year by year. In 1905 it was considered a risk to build a generator of 1000 kilowatts capacity running at speeds of 3000 revolutions per minute; today they are built up to 3000 kilowatts for the same speed. Considering that the specifications and guarantees are becoming more stringent year by year, whereby larger and larger wheel diameters are made necessary, and that higher vacuums are being employed, whereby the blades of the last wheels are subjected to heavy stresses, it goes without saying that designers are forced to approach very close to the limit of safe load.

In the Riedler-Stumpf turbine a wheel of 2000 millimeters, or approximately 79 inches diameter, running at 3000 revolutions per minute, was possible only by avoiding the employment of separate blades set in the rim, using instead, pockets milled in the rim. But in the case under consideration we have to deal with inserted blades of considerable length, exercising great additional centrifugal force on the circumference of the wheel.

Direct-current generators afford greater elasticity of speed but have a very sensitive makeup, the collector and the brushes militating against building direct-current generators beyond outputs of 1000 kilowatts. Fig. 23 shows how the normal speeds of direct-current generators vary with the change of load. It is seen that driving direct-current generators requires a greater variety of turbine types than driving three-phase generators. Comparatively small outputs, such as 600 kilowatts, are to be attained at 1200 revolutions per minute. Figs. 24 to 26 show the normal construction of the Allgemeine Elektricitäts Gesellschaft turbine in its various characteristic forms. Fig. 24 is the 3000-revolutions per minute type for outputs below and up to 1000 kilowatts, having the Curtis principle with two pressure stages to one velocity stage each. For higher outputs than 1000 kilowatts at 3000 revolutions per minute the action wheel in the low-pressure part is replaced by four or five Rateau wheels; see Fig. 25. The same holds true for the 1500-revolutions per minute type with the difference, however, that from nine to twelve Rateau wheels are employed in the low-pressure part, as shown in Fig. 26. Figs. 27 and 28 show the first named type of turbine, 3000 revolutions per minute up to 1000 kilowatts, in sectional elevation and plan with details of design to be discussed later.

The Mason Mechanical Laboratory

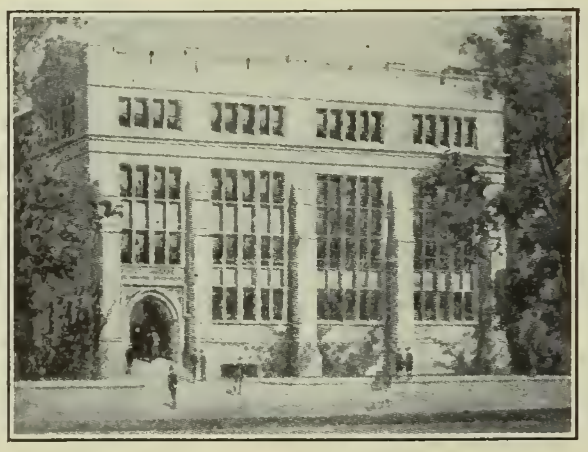
A three story building, 85 by 200 feet, donated to the Sheffield Scientific School of Yale University. The entire space will be devoted to laboratory work; no recitation or drawing rooms.

The accompanying illustrations show the new mechanical-engineering laboratory which is now being built for the Sheffield Scientific School, Yale University, New Haven, Conn. The funds for this laboratory were given to the Sheffield trustees by two graduates of the school, George Grant Mason, of New York City, and his brother, William Smith Mason, of Evanston, Ill., both of the class of 1888.

Work on the building is now in progress and the contract calls for its completion in the early summer of 1911. The frontage is about 85 feet and its length 200 feet. The architect, Charles C. Haight, of New York City, has worked out a very pleasing design, as Fig. 1 will testify. The long windows at the right are at the end of the testing floor, above which is a clear head room of 35 feet; at the left the smaller windows indicate the location of the main gallery and the mezzanine floors—which are possible on this side of the building throughout a greater part of its length. The building will have three stories above the basement. The front rectangle will be of Indiana limestone, and the extension will be of brick, with suitable stone trimmings. The entrance from Temple street will be sufficiently large for the admission of a team so that heavy pieces of machinery may be delivered directly under the traveling electric crane which will extend the entire length of the building with a span of about 40 feet.

An examination of the floor plans will indicate, in a general way, what is to be the distribution of the equipment and the arrangement of the rooms for offices, lectures, computation, research and general experimental work. No provision for recitation or drawing rooms has been made in the building—the entire space being devoted to instruction in experimental work for undergraduates and for research work in engineering science for graduate students, research fellows and special investigators.

The main floor of the laboratory will contain the larger part of the equipment —especially the heavy pieces of machinery—such as machines for testing the strength of materials, steam engines and gas engines of various types, steam turbines, steam and centrifugal pumps, air compressors and refrigerating machinery, together with the auxiliary equipment of condensers, fans, electric motors, scales, tanks and smaller appliances for testing. This equipment will be erected under the crane. The units will, for the most part, be small and self-contained. A large part of the floor under the crane will consist of heavy concrete, suitably arranged with parallel grooves for bolting the equipment at any point. The steam, water, gas and other pipes will be run in the basement below, provision being made for their extension to the testing floors through a series of auxiliary tunnels which occur at frequent intervals. All testing-floor areas are suitably drained so that an abundance of water may be used whenever it is necessary or desirable.



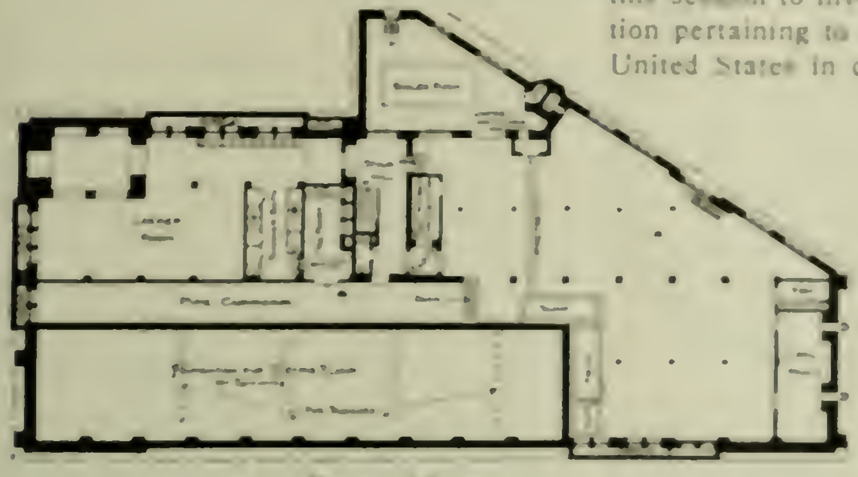
Mason Laboratory of Mechanical Engineering

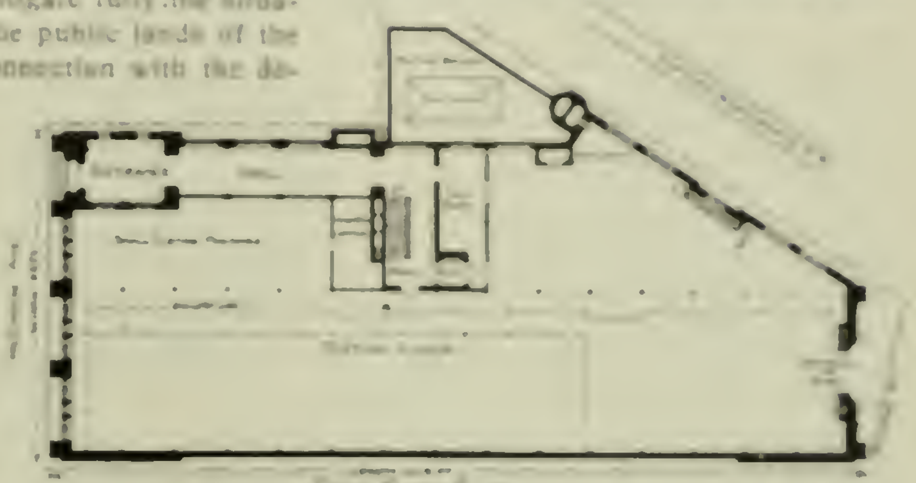
In the front basement will be located the toilet and locker rooms. There are several shower baths. The boiler-room extension provides for the heating and power boilers. An auxiliary power plant, both steam and gas-electric, will be located near the boiler room. Tanks of concrete will provide water storage and a large sump below the level of the street drains will receive all drainage not otherwise provided for. The sump will be automatically emptied by an electric centrifugal pump. Coal-storage bins and ash-elevating machinery will be located at the Temple street end of the building. Access to the basement is provided for heavy machinery through a large trap door suitably located under the crane, as well as by the electric elevator which connects all floors.

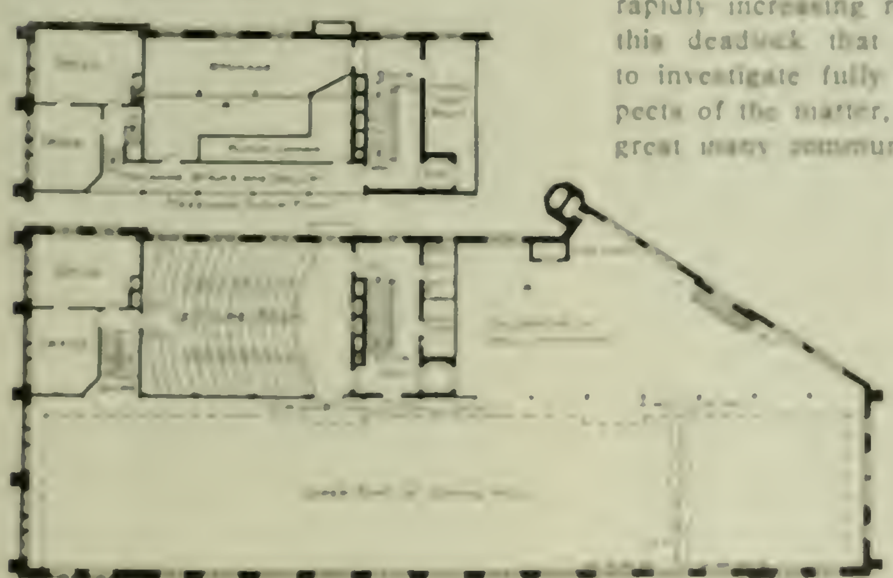
No attempt has been made to provide mechanical ventilation for any of the rooms except the lecture room and the computing room directly above it. For these rooms the fresh-air supply will be furnished through the ducts as shown. A gravity circulation will frequently be sufficient to provide the ventilation required, but a motor-driven fan will be installed to augment the natural circulation at such times as it may be necessary.

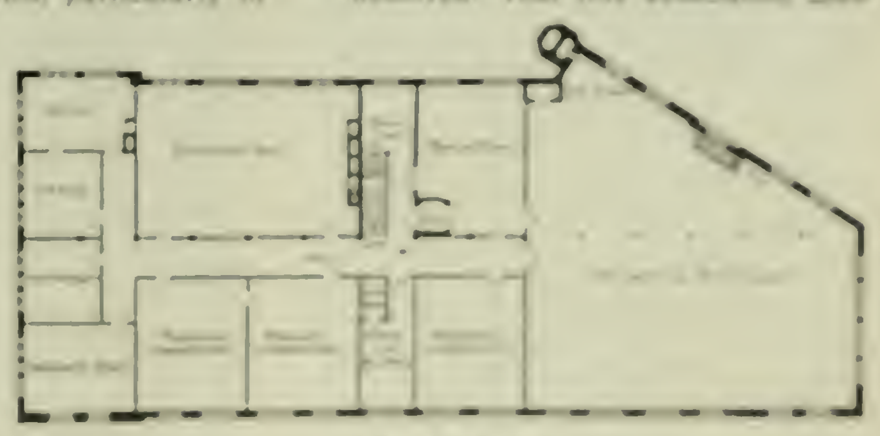
The gallery floor contains considerable space available for lighter machinery, several small offices and the general lecture room, with a seating capacity for 150. There are two landing platforms on this floor so that the traveling crane may deliver heavy pieces under a trolley rail extending through the lecture room or across the open floor space at the east end of the laboratory.

The distribution and use of the space on the third floor are sufficiently evident from an inspection of the plan of that floor. The room devoted to mechanical technology will be used as a laboratory for instruction in machine design, machine construction and mechanism. It is planned to have, not a museum, but an exhibition of modern machines of special and complex design. Power will be available for the operation of such machines as may be placed here for study. In many instances the machines may be on exhibition for only a short time and a representative of the company furnishing the machine may be asked to demonstrate its working.


Basement Plan


First Floor Plan


Second Floor Plan


Third Floor Plan

The completion of this laboratory will give to the Sheffield Scientific School many needed facilities available for all its engineering departments, and it will give to mechanical engineering what the Hammond laboratory gives to the students of mining engineering.

It will be remembered that the gift for this laboratory included $300,000 for the building and its equipment, and $100,000 for its endowment.

The general contractors for the construction of the building are P. C. Stuart & Co., New York City.

Congress Urged to Investigate Water Power Question

At the January 12 meeting of the executive committee of the National Electric Light Association, a set of resolutions were adopted urging that a joint commission of Congress be appointed at this session to investigate fully the situation pertaining to the public lands of the United States in connection with the development of water powers. The association represents about two billions of investment in central stations for electric light and power and the apparatus they employ, with 100,000 employees, and includes within its ranks 90 per cent. of the investment and capacity for public service thus represented. There are already nearly 1000 central stations in this country using water powers, but under the present conditions that have tied up such development very few new water-power plants can be undertaken, and the result is that for lack of such utilization of such water power, the consumption of coal and other fuel goes on at a rapidly increasing rate. It is to relieve this deadlock that Congress is invited to investigate fully at once all the aspects of the matter, with the idea that a great many communities, particularly in the West, which are seeking to advance the development of unused water power sites, may be enabled to gratify their natural wishes in this respect.

The resolution reads as follows:

"Whereas the condition of the laws and regulations relating to the public lands of the United States Government is so complicated, unsatisfactory and unsettled that the financing and commercial development of new enterprises in connection with public lands is rendered practically impossible; and

"Whereas the immediate development of the idle water powers of the nation is of importance to the whole people in that it brings to immediate use an indestructible natural resource that would be otherwise lost or idle and conserves coal, oil, gas and other fuels that are limited in amount and subject to replacement; and

"Whereas the National Electric Light Association is particularly interested in the situation pertaining to public lands of the United States in connection with the development of water powers; and

"Whereas much of the difference of opinion upon the subject of water powers arises from the difficulty of obtaining a clear comprehension of all the facts.

"Now, therefore, be it

"Resolved: That this association does respectfully urge that a competent commission, composed of members of the Senate and House of Representatives of the United States, together with persons familiar with the financial and other practical aspects of the situation, be appointed with full authority to collect the evidence, and for that purpose to hold full and complete open hearings in different sections of the country, and be it further

"Resolved: That this association does respectfully urge that such commission be appointed at as early a date as possible, to the end that its meetings may be held between the adjournment of the present session of Congress and the reassembling of the new Congress in the hope that such commission should report upon such reassembling and Congress be thereby enabled to take prompt action in the enactment of such laws as will permit the development of the natural resources of the country in such a manner as shall render them of the greatest possible use to all of the people."

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Hand Controllers for Multi-Speed Induction Motors

By R. H. Fenkhausen

The present article is devoted to a practical consideration of the principal types of apparatus now available for controlling the speed of induction motors. The motors themselves have already been explained in a previous article (June 9, 1908); the present article, therefore, is restricted to the controllers alone.

The controlling apparatus for any induction motor of the wound-rotor type provided with external resistance must consist of two separate and distinct devices; namely, a line switch, by which

Fig. 1. Simple Oil-break Starting Switch

the current supply to the stator windings may be cut off or on and, in the case of a reversing motor, reversed; and a drum controller by which the resistance in the rotor circuit may be varied to obtain different speeds in the motor.

When the secondary resistance is for starting duty only, a controller of the type shown in Fig. 1 will often fill all requirements. A knife switch, preferably of the oil-break type, is used to close and open the leads from the supply circuit to the stator or primary, and when reversal of the motor is desired, the switch may be double-throw.

Owing to the short duration of the starting period the resistance does not need to be of large capacity and is therefore inclosed within the same case with the drum controller, making a very compact outfit and one that requires the least possible labor to install, as all the connections between the controller and the resistance are permanent. For large motors an independent short-circuiting switch should be installed near the motor in order that the resistance of the collector rings, controller contacts and wiring will not cause too large a full-load slip in the rotor.

When the secondary resistance conductor is used for speed regulation, the resistance is in circuit at all times, and in order to obtain sufficient ventilation to keep the temperature rise within a safe limit, the resistance is usually mounted separate from the controller. Fig. 2 shows a set of resistance grids suitable for this service. Flexible cables are attached to the various taps, which connect to similarly numbered cables from the controller.

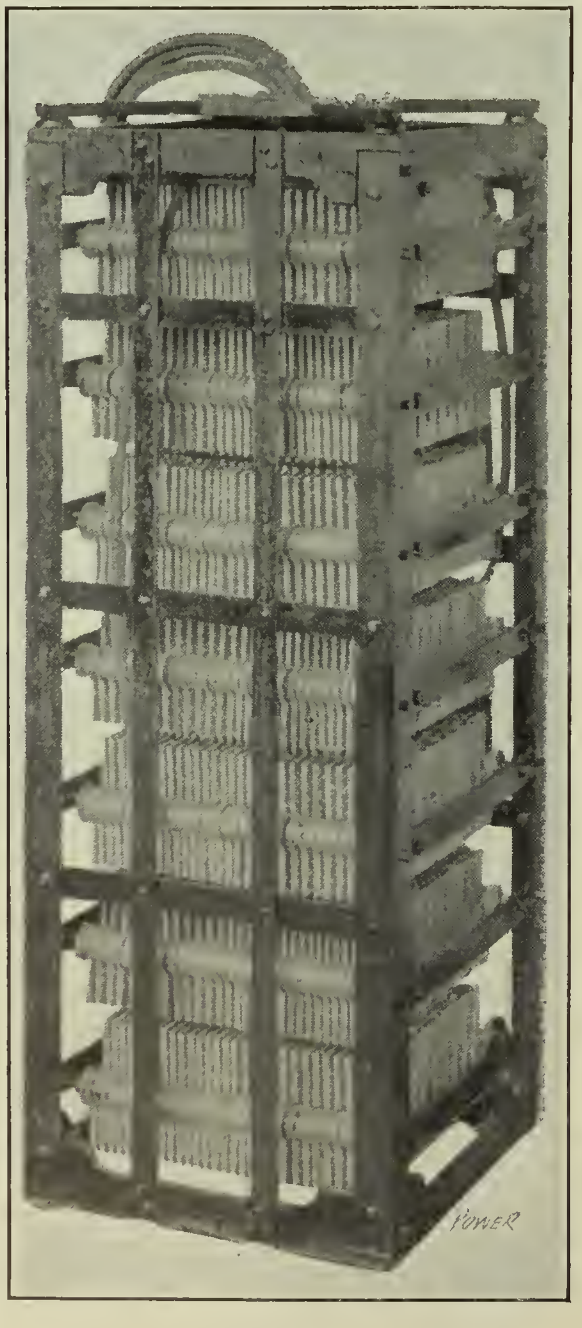


Fig. 2. Resistor Grids in Frame

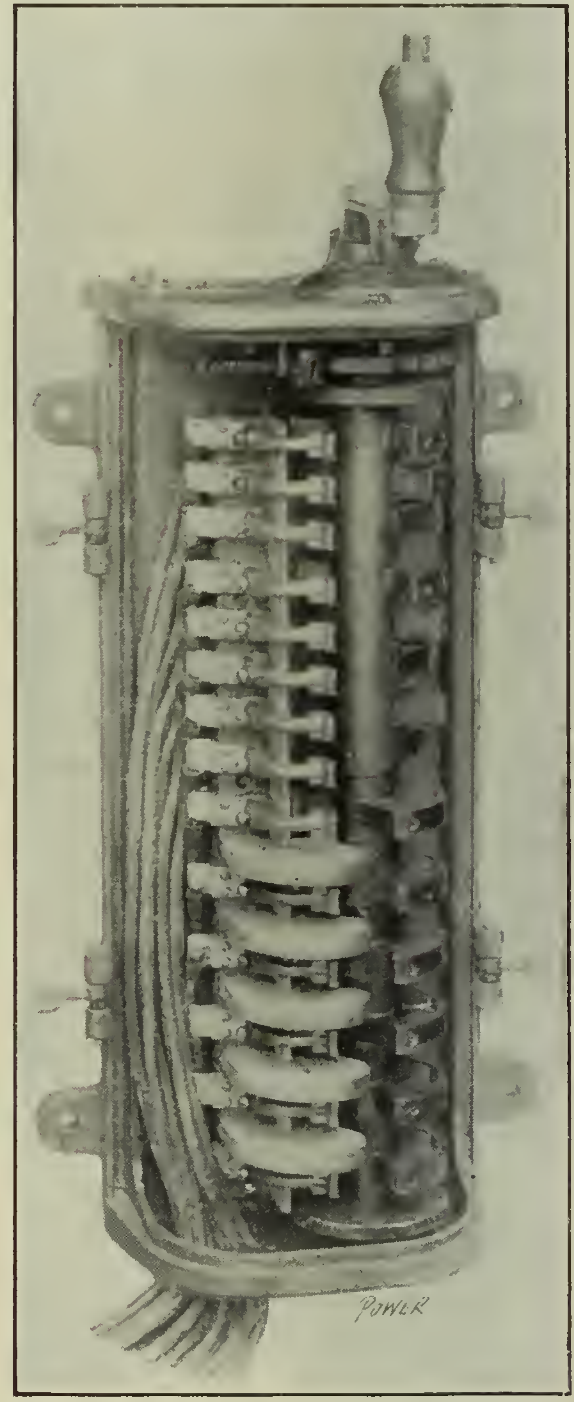


Fig. 3. Stator and Rotor Control on One Spindle

In a previous article attention was called to the fact that wound-rotor motors equipped with independent primary and secondary switches were liable to damage by the line switch being closed by a careless operator when the secondary resistance was cut out. While separate switches are permissible for starting service only, for varying-speed service it is essential that the primary and secondary switches be mechanically interlocked. This is especially necessary where the motor is to be frequently reversed. This mechanical interlocking may be accomplished in several ways. The simplest method is to mount the primary and secondary controlling drums on a common shaft, as shown in Fig. 3, and arrange the connections so that the stator circuit cannot be connected to the line except when all the rotor resistance is in circuit.

The principal objection to this method is the unnecessary wear of the primary switch. After it is closed on the first notch, no further movement is necessary during the various speed changes until the motor is again stopped, but, as the primary and secondary switch drums are mounted on a common shaft, a corresponding movement of the primary switch

FIG. 4. SPEED CONTROLLER WITH CAM-OPERATED STATOR SWITCH

is made for every speed change made with the secondary drum. This not only results in unnecessary wear of the primary contacts, but increases the effort necessary to move the controller, owing to the extra number of fingers bearing on the drum. In large controllers this entails considerable additional exertion on the part of the operator. In order to get rid of these objectionable features, the primary switch is often so arranged that a cam on the operating shaft of the controller closes it for the desired direction of rotation when the controller lever is moved to the first notch and does not again move it until the controller is returned to the "off" position. Such a controller is illustrated in Fig. 4, and a detail of the reversing mechanism is shown in Fig. 5. The primary contacts are submerged in an oil tank to suppress the arc.

It is not desirable to carry high-voltage leads inside the controller case; for high-voltage motors, therefore, the controller is provided with an external oil switch operated by a lever projecting through the rear of the controller case, as shown in Fig. 6. The lever is operated on the

FIG. 5. REVERSING MECHANISM OF CONTROLLER IN FIG. 4

first notch by a cam on the controller shaft similar to that shown in Fig. 5. This arrangement makes it possible to adjust the secondary fingers and drum contacts without danger of a shock from exposed parts of the primary switch.

Controllers are made for both reversing and nonreversing service, the only difference being that on the nonreversing controller the "off" and full-speed positions are at opposite ends of the travel of the handle and the primary switch simply closes and breaks the main-line connections, whereas on the reversing controller the "off" position is in the center of the travel of the handle and the primary switch is arranged to reverse one phase of the primary leads when the controller handle is moved to the "reverse" side of the "off" position.

CONTROLLER REQUIREMENTS

Controllers and resistances are customarily supplied by the motor manufacturer, but in case the motor is an old one, or is bought of some company that does not make its own controlling apparatus, the following information must be supplied to the company furnishing the controller and resistance:

1. Number of phases, voltage, horsepower and frequency.

2. Secondary current per phase of rotor winding.

3. Secondary voltage or ratio of primary to secondary turns.

4. Kind of service. Continuous or intermittent at reduced speeds.

Even when all the apparatus is furnished by one maker it is desirable that the secondary current of the motor be known in order that the leads from the controller to the collector rings may be made of ample size. If this is neglected an objectionable increase in the full-load slip of the motor will result, with evil effects on both the efficiency and speed regulation at normal speed.

The secondary currents vary in motors of different manufacture, but the figures in Table 1 may be considered as fair averages for wound-rotor induction motors. This table also shows the difference in motor ratings for continuous and intermittent service.

As stated in a previous article, the rotors of motors designed for continuous operation at reduced speeds are made of high resistance and the secondary current

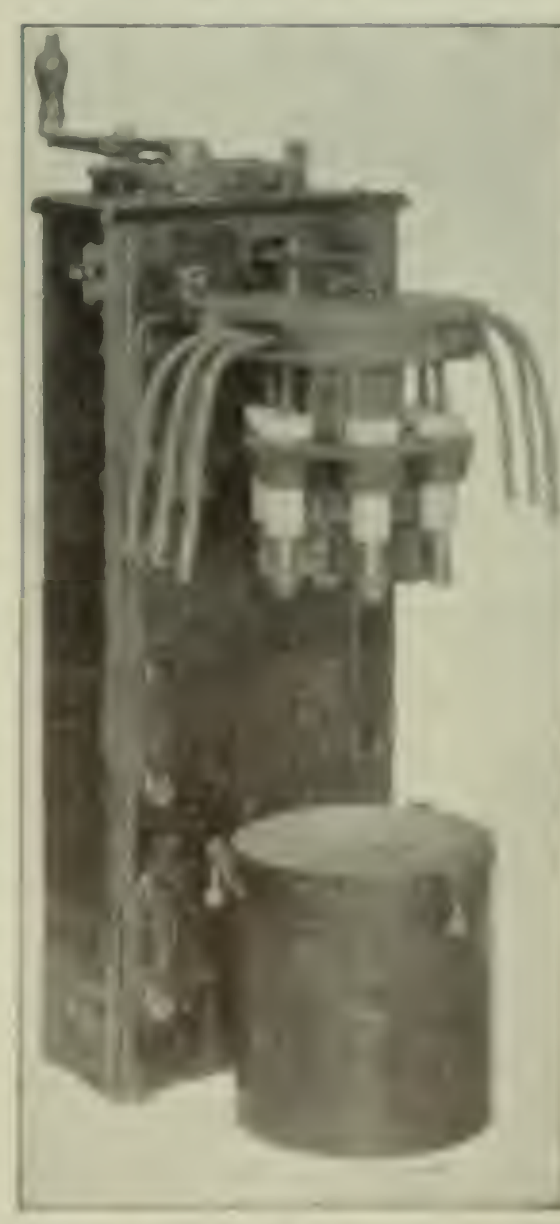


FIG. 6. STATOR SWITCH OPERATED AS LEVER NEAR MAIN CONTROLLER

is small; motors designed to run mostly at full speed and only occasionally at reduced speed are equipped with low-resistance rotors, and the secondary current is relatively large. The resistance grids for the latter type of motor are necessarily quite large and for convenience are usually mounted in two or more frames; one such frame is shown in Fig. 7. The grids designed for the higher resistance motor are smaller and may be mounted all in one frame, as in Fig. 2. In cases where a regular multi-speed controller is used for starting duty only, the resistance grids carry current only for a short time and may be made proportionately smaller.

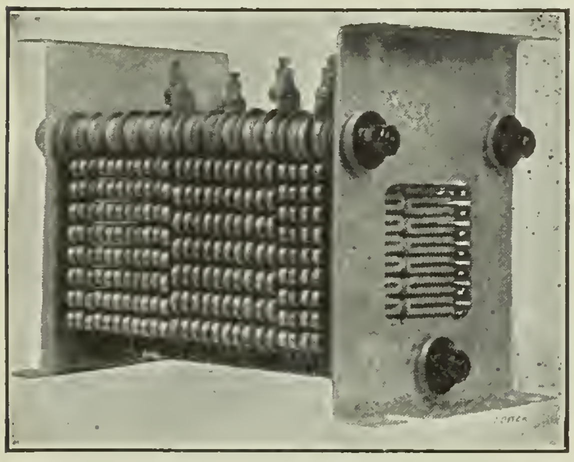


FIG. 7. HEAVY-DUTY RESISTOR GRIDS

There are two methods of varying the resistance in the rotor circuit. In the first method, the connections of which are shown in Fig. 9, resistance is cut out of each phase of the rotor in turn. This method is employed in the controller shown in Fig. 3, and, although it results in the rotor currents being out of balance on two speeds out of each three, this disadvantage is more than offset by the reduction in the number of controller contacts required for a given number of speeds, and the resultant saving in wiring and controller maintenance. In the second method resistance is cut out of all three phases of the rotor circuit simultaneously. This method is used on the controllers shown in Figs. 4 and 10. The connections for this method are illustrated in Fig. 8 and, although the rotor phases are kept in perfect balance, it is apparent from the drawing that the number of drum contacts is considerably greater than is required when the method shown in Fig. 9 is employed.

For elevator service a controller similar to the one shown in Fig. 10 is used. The primary switch is operated by the elevator rope and the secondary switch is operated by a spring which is compressed by the movement of the primary switch. This spring turns the drum against the retarding influence of a dashpot, and by adjustment of the dashpot the rate of movement of the secondary drum, and consequently the acceleration of the motor, may be regulated independently of the will of the operator.

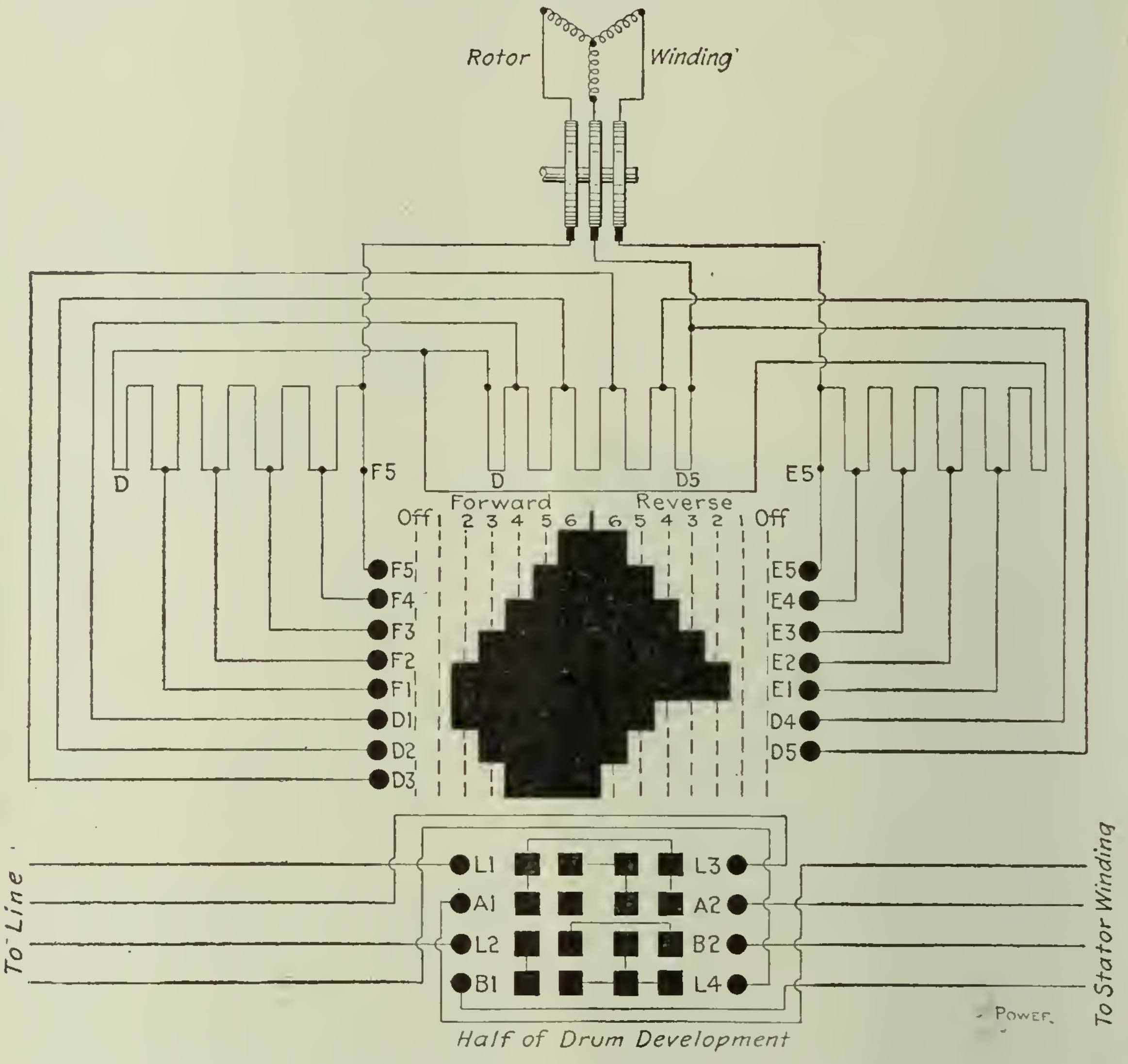


FIG. 8. CONTROLLER FOR CUTTING OUT ALL THREE RESISTORS SIMULTANEOUSLY

TABLE 1. DATA CONCERNING INDUCTION MOTORS OF THE WOUND-ROTOR TYPE FOR VARYING SPEED SERVICE; WITH ROTORS WOUND 3-PHASE FOR 60 CYCLES.

Horsepower.		Speed.		Full-load Amperes per Phase (Stator).				Rotor Amperes.
Continuous Rating.	Intermittent Rating.	Synchronous.	Full Load.	2-phase, 220 Volts.	3-phase, 220 Volts.	2-phase, 440 Volts.	3-phase, 440 Volts.	All Phases and Voltages.
5	7½	1200	1080	11.45	13.25	5.75	6.65	65
7½	11	1200	1080	17.20	19.85	8.60	9.95	71
10	15	1200	1100	22.65	26.20	11.35	13.10	78
15	22	1200	1120	33.20	38.40	16.60	19.20	93
20	30	1200	1105	43.75	50.75	21.85	25.35	155
25	37	1200	1115	54.80	63.40	27.45	31.70	154
35	52	900	830	80.20	92.90	40.15	46.45	175
50	75	900	840	107.15	123.60	53.50	61.80	190
75	112	720	690	164.00	189.50	82.00	94.70	225
75	112	514	495	164.00	189.50	82.00	94.70	180
100	150	720	675	214.05	247.20	107.00	123.00	225
110	165	450	430	235.10	271.30	117.50	135.10	250
150	225	600	575	326.50	377.75	163.25	188.00	286
150	225	450	435	326.50	377.75	163.25	188.00	250
200	300	600	580	427.00	493.00	213.00	225.00	287

"CASCADE" CONNECTION

The greatest disadvantages of the wound-rotor type of induction motor are its inability to maintain constant speed when the load varies, except at full speed, and its poor efficiency when running at reduced speeds. These difficulties cannot be overcome by any commercial control method when one motor is used, but where two motors are connected to the same load, two or more constant and efficient running speeds may be obtained by the use of the so called "cascade" connection. Fig. 11 shows the simplest form of this connection. The rotor circuits of the two motors are connected and the stator of one motor is short-circuited. If the stator of the other motor be connected to the line, both motors will run at a speed corresponding to that of one motor having as many magnetic poles as both of the two motors. The motors shown have equal numbers of poles, so the resultant speed will be one-half that of either one operating alone. This speed will be maintained practically constant under widely varying loads, and the efficiency will be quite high. This control method is similar in principle to the series-parallel method of direct-current control, and, in common with it, requires that both motors be rigidly connected to the load, either by direct coupling or gearing. If this is neglected, one of the motors may run

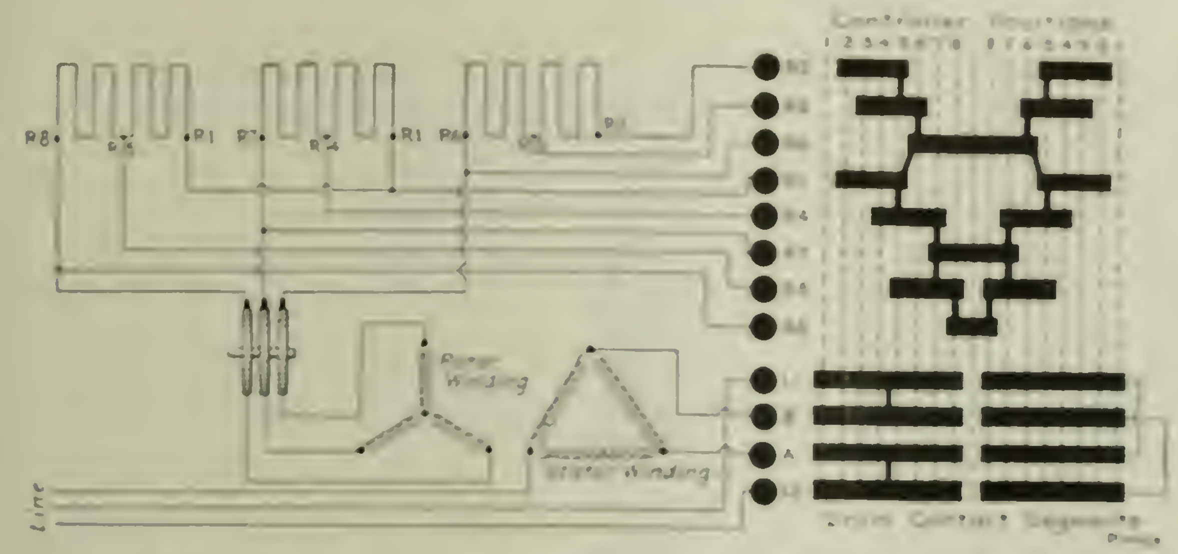


FIG. 9. CONTROLLER FOR CUTTING OUT THE RESISTORS SUCCESSIVELY

up to full speed and the other one stop the first time the division of load between the motors is disturbed.

This method of control may be extended by the use of two motors having a

FIG. 10. HORIZONTAL CONTROLLER FOR ELEVATOR SERVICE

different number of poles, in which case four constant running speeds are obtained. For example, if an 8-pole and a 12-pole motor are installed, the following speeds are obtainable on a 25-cycle circuit:

	Revolutions per Minute
1. Motors in direct "cascade"....	150
2. 12-pole motor alone........	250
3. 8-pole motor alone..........	375
4. Motors in differential "cascade"	750

In differential cascade the motors are connected for opposite directions of rotation and the resultant speed is equal to that of one motor having a number of poles equal to the *difference* between the numbers of poles in the two motors.

The "cascade" method of control is quite expensive to install, as a double motor investment is required owing to the fact that either one motor alone is in use or else the two motors are working at greatly reduced capacity.

For the control of high-resistance squirrel-cage motors in which the speed is regulated by varying the primary voltage, a controller of the type shown in Fig. 12 is used in connection with an autotransformer. There are twice as many contact segments as there are autotransformer taps, and every other segment is connected to a resistance in such a way that the controller brush in passing from one autotransformer connection to the next one, never rests upon two segments connected to different taps at the same time, but always bridges one "live" segment and one resistance segment in such a way that there is always a dead resistance in circuit while taps of different voltage are connected. This obviates the necessity of "killing" the motor while passing from one segment to another.

FIG. 11. CONNECTIONS FOR "CASCADE" CONTROL

LETTERS

Line Disturbance by an Induction Motor

In a recent number, Louis J. Gorilla asks why an induction motor makes the lamps flicker. I will cite an experience that may help him.

I am operating a 150-horsepower induction motor equipped with a starting resistance mounted on the rotor. I was troubled with a brush eating into the short-circuiting ring, and upon taking the bolt out I found that it was loose where it screwed into the rotor; it was also a loose fit in the spool. The bolt was wrapped with shellacked paper to fit the spool and screwed firmly into the rotor, and the machine has been running two years without giving any more trouble.

Tustin, Cal. W. N. GULICK.

FIG. 12. CONTACT PLATE FOR AUTOTRANSFORMER CONTROL

While removing a broken set screw, it was nearly drilled out, when the drill refused to cut. Applying more pressure and sharpening the drill did not help matters. The puzzle was solved when the point of the set screw was found on the end of the drill, with which it was revolving.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Reducing Motion for Gas Engine Indicators

By Robert G. Brown

The attempt to apply to a gas engine of the inclosed type an indicator reducing motion usually develops several difficulties. To convert the rotary motion of the flywheel and shaft into a reciprocating motion corresponding to the movement of the piston and of a length that will give a good indicator diagram, generally requires a crank and connecting rod of a small scale but of the same ratio as those of the main engine. Such an apparatus has several joints which are subject to wear and lost motion; and if the engine is a large one a special arrangement will probably have to be attached to the outside of the flywheel to carry this gear. The custom of using a pin in the end of the shaft to which is attached the indicator cord is inaccurate mechanically and is not easy to connect to when running at 300 revolutions or over.

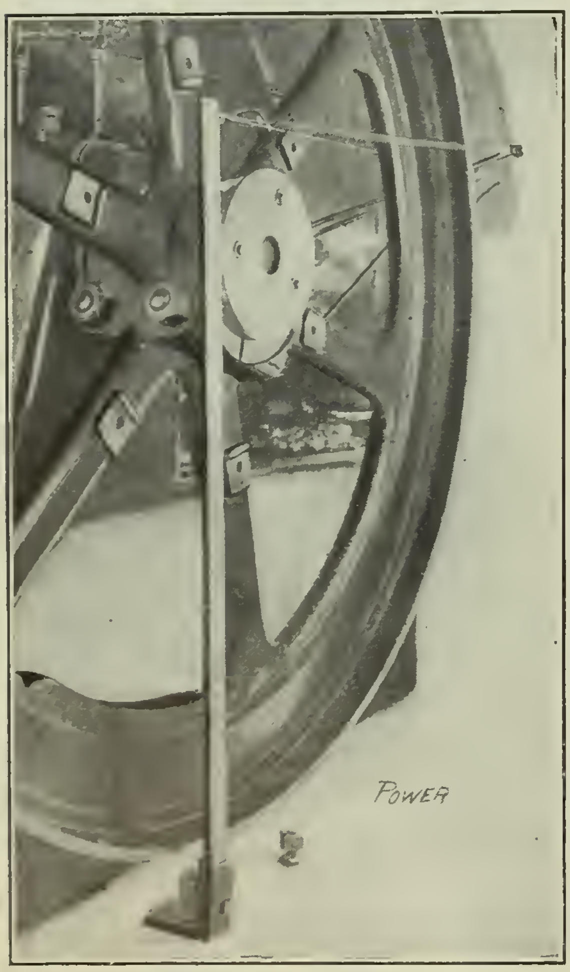


Fig. 1. Eccentric and Oscillating Bar

In the effort to overcome the difficulties mentioned, the cam reducing motion here illustrated was designed. The cam is most simple to make—only requiring a simple turning operation in a lathe. It is attached with two or three cap screws to the end of the shaft or the hub of the flywheel. In some cases it may be necessary to bore it large and slip it over the shaft.

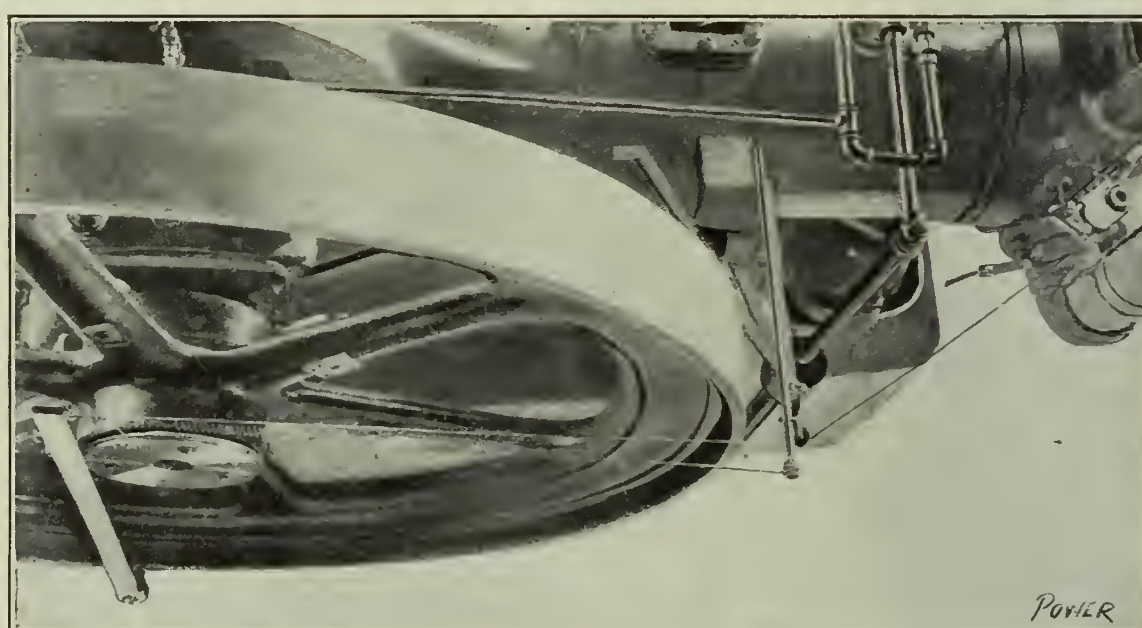


Fig. 2. Looking Down on Engine Equipped with Reducing Motion

Fig. 1 shows a reducing motion of this kind applied to a Fairbanks-Morse Type L producer-gas engine. The flywheel is six feet in diameter. The cam plate bolted to the hub of the flywheel, and a cherrywood bar, hinged to a floor bolt, constitute all the parts. The cam has a V-shaped groove around its edge and a roller on the wooden bar runs in this groove. Unfortunately the indicator could not be shown from the viewpoint of Fig. 1. Fig. 2 is a view looking down on the engine and this shows the location of the indicator at the engine cylinder. The guide pulley for the lead is supported by a tripod of light metal bars.

The indicator lead should be of wire for such a length, and sharp turns should be avoided. The wire should not be carried around the small pulley and drum of the indicator, because it will soon break; a short piece of cord is attached to the end of the wire for this purpose. The wire must run in a direction at right angles to the wooden bar when the latter is midway of its travel. The lead can be hooked and unhooked in any convenient way, to suit the ideas of the operator. The coil spring attached to the end of the bar serves to make the bar follow the cam, thereby relieving the indicator drum spring of this work; on engines which run at less than 200 revolutions per minute, this spring will not be necessary.

A suitable length of diagram can be had by attaching to different places on the bar. The cam itself gives a perfectly accurate motion, but the use of the oscillating bar introduces a slight theoretical error. However, by making it as long and light as possible, the error cannot be detected.

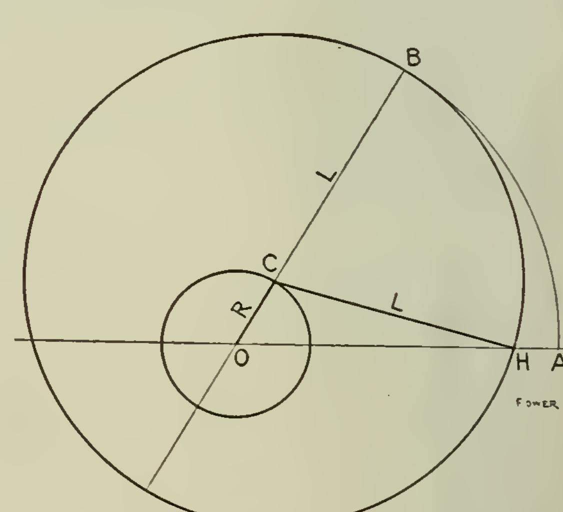


Fig. 3. Graphical Proof

The correctness of the cam motion can be proved mathematically, but the graphical one given in Fig. 3 is sufficient. The lines *R* and *L* represent to scale the lengths and positions of the crank and connecting rod of the engine; L also represents, to a different scale, the radius of the cam circle. The center of the shaft is at O and C is the center of the cam disk, $O\,C$ being the amount the cam is set eccentric. Since C is the center of the cam circle, $C\,H = C\,B$ and $B\,O = O\,A$. Therefore, when the cam and the crank have moved through any angle, such as $B\,O\,H$, the roller has traveled the distance $A\,H$, which is evidently proportional to the motion of the engine piston. The curve $B\,A$ is the path followed by the point B during the travel from B to A.

In laying out the cam for a reducing motion of this kind for a given engine, all that is necessary is to find the ratio of crank to connecting-rod length for that engine. For example, if this is 1 to 5, the cam may be made 5 inches radius and its center set 1 inch off the center of the shaft in line with the crank axis; then it will give the correct motion and the length of the indicator card may be chosen as explained above.

Gas Engine Equipment

By H. W. Jones

As my whole interest in the gas-engine industry is to improve the standing and applicability of the engine, I feel free to discuss the above topic without being accused of "knocking."

I wish to suggest, not alone on the basis of my own experience but on that of others, that it is about time to consider the difference between the cost and the value of the auxiliary equipment of gas engines and, further, to consider what it really should mean when a gas or gasolene engine is installed *complete*. From my price book, which gives the cost of various makes of gas engines, I find that an engine of 20 horsepower can be sold "complete" at a fair profit for $650, and the same engine can also be sold "complete" for $750, keeping the profit exactly the same, the difference in the cost being $100. It all depends on what "complete" means. With some builders the selling price includes a set of engineer's oil cans, also a full set of wrenches, foundation bolts and special washers, an ignition battery, spark coil and switch.

Now, the price of these extras and auxiliaries may be $2.50, or it may be $22.50, and the $22.50 outfit may be the cheaper. The cutoff switch in the ignition circuit may cost $1.80 per dozen or $1.80 each; a set of six battery cells can cost $1.50 or $18; a spark coil for a make-and-break system can cost 50 cents or $3, while the coil of a jump-spark system can be bought for either $2 or $10, or almost any intermediate figure. Some jump-spark coils are very expensive at $4, while others are cheap at $14.

When a man buys a gas engine he seldom considers or knows anything about these points. He may be a master mechanic of the very top grade and yet not realize the value of a switch that changes the direction of current flow across the igniter points. Although he knows full well that experience is valuable, he will not pay cash for it as embodied in gas-engine accessories, but will buy it by shutdowns, engine troubles, experts, repair bills, etc., and probably wind up by damning the gas engine, wholesale. I have seen a three days' shutdown caused by a defective igniter that caused a loss of $300, and the user of the engine utilized all of the modern profanity in abusing gas power when his trouble was due entirely to his efforts to buy *cheap*.

The difference between cost and value is of more far-reaching importance and more promptly manifested in the equipment of a gas engine than in any other thing I know of. Simplicity is very desirable, but do not overdo it.

When you buy a gas engine, insist on having everything on that engine that will add to its effectiveness and reliability of operation, and, further, insist that every attachment, auxiliary and appliance be of the best quality that is obtainable. Do not let anyone try to talk you out of it by the simplicity game; if you do, you lose.

Remedy for Lap Seam Boiler Explosions

By the Oil Drummer

Riley laid down his kit of tools, oiled up the flue expander and asked Kelly, the engineer, if he had read the details of the Pittsfield explosion. Kelly replied he had been so busy keeping track of the lap-seam explosions that he hadn't time to follow the others.

Then Riley remarked that the Pittsfield affair was due to a "lap-seam engineer" screwing down the safety valve, which resulted in killing nineteen men, not counting the engineer himself. The engineer, he said, had got a bath-tub expert to test his steam gage. Kelly retorted by reading the account of nine men being killed by failure of headers on a boiler in the battleship "Delaware" and laid the blame on boilermakers for this and the lap-seam explosions.

Riley grinned, and said, "Even so, the lap-seam engineers have beat the record as agin the lap-seam biler," and mentioned the explosion on the gunboat "Bennington" in 1905, when sixty men were killed. Kelly offset this with the Brockton explosion wherein fifty-eight persons were killed by a lap-seam boiler.

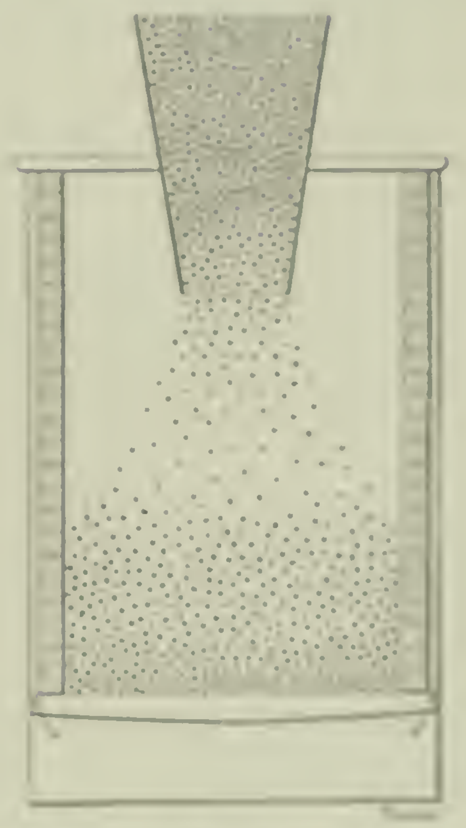
The "old man" blew in at this stage of the argument and settled it by saying that he was figuring on throwing out the steam plant and putting in a gas engine, as he could not take chances on lap-seam boilermakers and lap-seam engineers too.

Honest, do you blame him, the way things are going?

Generator Linings

By C. R. McGahey

A good deal of trouble may be caused by an improperly installed generator lining. If the firebrick is set hard against the metal shell, this is likely to cause trouble because it allows no room for expansion of the brick. Under such conditions it is only a matter of a short time when the brick will begin to crumble and



Air Space behind the Lining

crack, allowing air to pass up through the lining instead of going up through the fire zone. This reduces the capacity and efficiency of the whole equipment. On the other hand, if the brick is not set tightly against the shell, provision must be made to keep the air from passing up between the brick and the shell, as indicated by the arrows in the sketch.

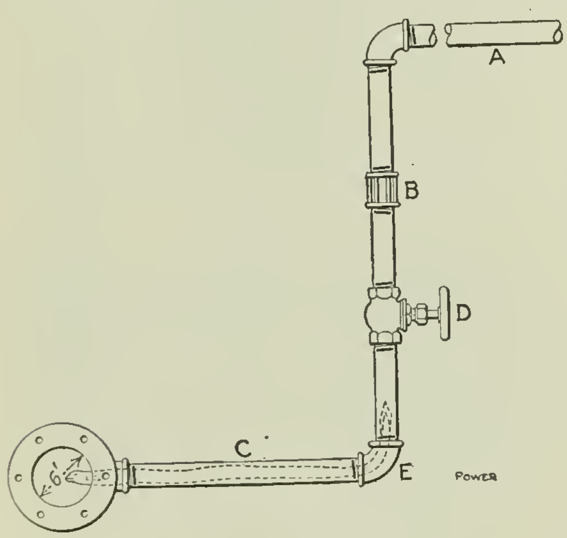
In putting in the lining it is a good plan to allow about 1½ inches of space between the shell and the brick and, as the brick is being put in, to fill this space with asbestos or magnesia. This latter portion should be well tamped in between the brick and the shell. This not only forms a cushion for the expansion of the brick but serves as a packing to prevent the flow of air up behind the brick lining. A lining put in with a backing of this kind will last many times longer than one put in without it, and make the generator more uniform in its operation.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Eel in Water Pipe

One summer evening, about a half hour before it was time to start up and put on the lights, the telephone in the engine room rang. I answered the call and was informed that there was no hot or cold water in the kitchen. This was in an industrial school for boys, and I was the only engineer on duty, as the chief was off and my alternate was home. A relief took my place in the engine room until I could locate the trouble and, if possible, remedy it. I tried all the faucets about the kitchen, and the valves in the cellar, but there was no water. It was evident that there was an obstruction in the pipe somewhere and to locate it was the difficult part of the task.



Eel in Water Pipe

The main 6-inch pipe, which was under the cellar floor, was tapped for a 2-inch pipe to supply the part of the building in which the kitchen was located, and this pipe was fastened to the stringers in the cellar. As this pipe was about 80 feet long, it would be a big job to take it all down to look for the stoppage.

Finally a scheme presented itself to locate the cause of the trouble without taking down the pipe. I got a breast drill, a 1/8-inch drill, some wire nails of a size to fit snugly in the 1/8-inch hole, that was drilled at *A* in the illustration, but there was no water. One of the nails was driven in the hole about one-half inch and cut off with the pliers. This operation was repeated several times, until the stop valve at *D* was reached. It was then plain that the trouble was between the stop valve and the main.

As the chief had arrived, he suggested drilling a hole at *C*; this was done, and when the drill went through the pipe, I felt something soft and springy and said, "It's an eel." The main 6-inch valve that controlled that section of the building was closed and the 2-inch pipe cut at *B* and unscrewed at the ell *E*. The eel's tail stuck out of pipe *C* several inches and, putting a wire through the tail of the eel, it was pulled out.

A union was put in at *B* and the line connected again. A 3-foot eel was brought to the engine room alive in a pail, and when skinned and cleaned made a good breakfast for three men.

James W. Blake.

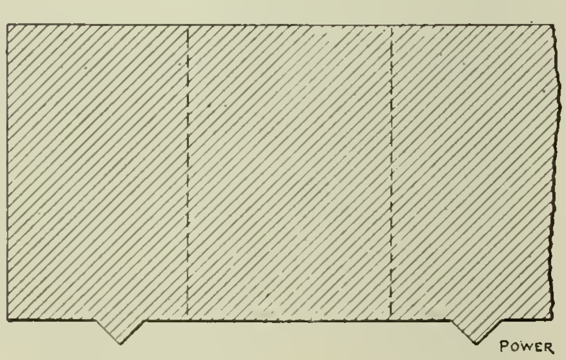
New York City.

Repairing a Pump Seat

This work consisted in reseating the brass delivery deck of a four-valve air pump, of which the cast-iron valve seat had been partially eaten away by the action of salt water.

It was decided to make repairs with lead as the old seat formed a part of the main housing.

First, the delivery-valve deck was put in a lathe and faced up, both on the valve and under side, leaving a 1/4-inch V-shaped ridge on the bearing surface on each side of the stud holes, as shown in the accompanying sketch. The idea was to embed the ridges in the lead seat, this method being considered better calculated to give a proper joint, and also to dispense with the use of a gasket. The lead surfacing was about 3/8 inch thick.



How Valve Seat was Faced

Joseph Hamilton.

Boston, Mass.

Indicator Cord Adjusting Device

Among the many tedious tasks connected with rigging up an indicator none is as bothersome, takes as much time and tries the engineer's patience as much as the adjustment of the length of the indicator cord.

In all cases where the stroke of the piston is longer than the motion of the indicator drum some device is needed to produce a motion within the limits of the indicator drum which is parallel to and in proportion to the travel of the crosshead at all points of the stroke. To accomplish this numerous devices are used and each has its advocates.

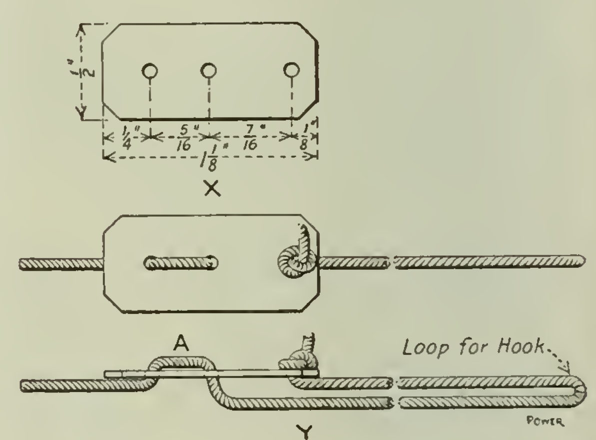


Fig. 1. Sheet Brass Plate

The most common are the pantograph and the reducing wheel, which is considered a part of the indicator outfit. But no matter what device is used the first requirement in taking a card is to see that the drum shall not knock at either end of its stroke. This latter requirement depends entirely upon the length of the indicator cord and demands that it shall be in full tension at all points of the stroke. A cord at its crosshead end is generally fastened to a hook and this hook is simply knotted, a slip knot or bowline being the most satisfactory. In nine cases out of ten when the first adjustment is tried the drum will knock at one end of its motion. Then the knot must be untied and retied a number of times before and during the time of taking a set of cards. All this demands valuable time and in reality is quite unnecessary if the device described herewith is used.

Take a piece of sheet brass not less than 3/64 inch in thickness and cut it to the size shown at *X*, Fig. 1. File off the corners and drill the holes on the center line as indicated. These holes should be just large enough to allow the cord to pass through freely. Be sure to file all around so that no sharp corners or edges are left to cut or scratch the hands. Be sure also to have the holes smooth so that the cord passing through them will not be cut when the string is in tension. This is best done with a very fine strip of emery cloth. Pass the indicator cord through the holes as shown by Y, using a plain knot at the end to prevent it from coming out.

When the cord is disengaged it is an easy matter to slide the plate back and forth by pulling the cord slightly at A in the direction desired, but when the loop and cord are in tension it will not move. If it is desired to move out the end of the loop on which the cord is attached a distance of $\frac{1}{4}$ inch, slacken the cord and move the plate $\frac{1}{8}$ inch toward the hook. If the hook is to be brought further back, slide the plate back twice the required distance in the same manner. In this way it is an easy matter to make a fine adjustment in a few seconds without touching a knot. The size of the plate shown is right for a reducing-wheel cord, but for regular indicator cord increase all dimensions about 50 per cent.

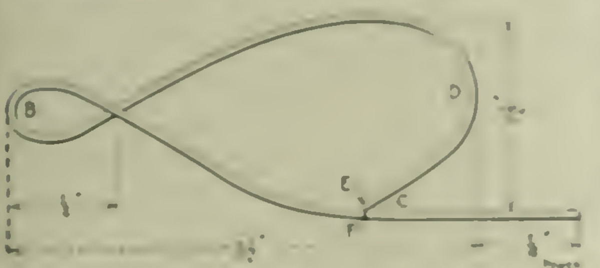


FIG. 2. BRASS-WIRE HOOK

Plates like these are supplied with some indicator outfits and are usually nickel plated, but engineers who do not have them can readily make them in a very short time.

In cases where a reducing wheel is used and the end of the cord is hooked directly to a rod (about $\frac{1}{4}$ inch in diameter and not more than 8 inches long) screwed into the crosshead, and where the stroke is not over 48 inches and the speed not more than 100 revolutions per minute, a very good hook to use at the end of the cord is shown in Fig. 2. It is made out of brass wire of about No. 10 Brown & Sharpe gage and is attached to the loop of the cord at B.

To hook on, hold the hook so that it will be about 2 inches back of the rod when it is at the cylinder end of the stroke, and in line with the travel of the rod; then gradually move it toward the rod until it is in such a position that it will strike the hook at C and then slip in between E and F and rest in D, thus carrying the hook along. To unhook, stand about one foot back of the hook when it is at the cylinder end of the stroke and, facing the crank pin, put the hand nearest the piston rod around the moving cord, but not touching it. Then gradually move the hand toward the crank until the end of the hook is felt at each stroke. Then close the hand around the cord in back of the hook, but do not grip the cord, and with the fingers of the other hand quickly pull the hook off the rod in a direction *away* from the crosshead in a line parallel to the rod. Be sure to do this when the crosshead is as near the cylinder as it is possible to determine. Thus, the second hand will slip the hook off the rod and the first hand will prevent it from flying back and allow the indicator to come back hard with a sudden knock.

Before hooking in it is a simple matter to hold the hook up to the cylinder end of the travel of the rod and then up to the crank end without engaging it to see if the length of the cord is properly adjusted so that the indicator drum will not knock at either end of its motion.

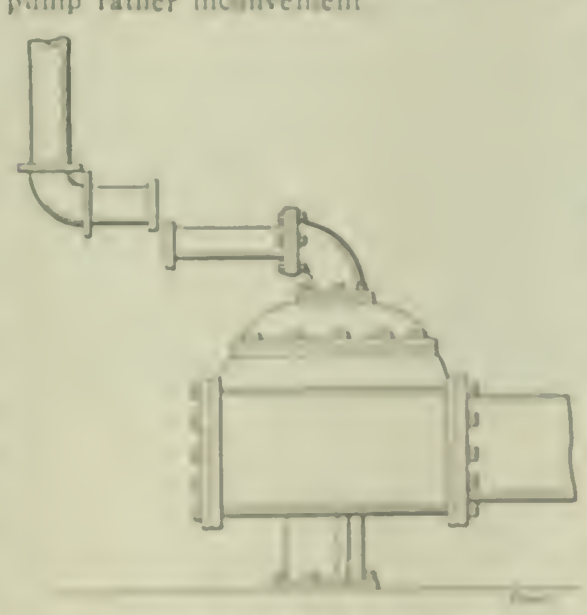
To one who has never tried this method it is advisable to practice when the engine is starting up or stopping, when it is running very slowly, before making experiments when the engine is running at full speed. Three or four trials are quite enough to get the knack of hooking in and out.

H. B. LANGE.

New York City.

Difficult Pipe Fitting

One time when pumping out a mine the manager decided to use a horizontal steam pump that was on hand. The volume of water to be pumped was large and if the pump were shut down for a few minutes the water accumulated very fast, which made the handling of this pump rather inconvenient.



DISCHARGE PIPE OUT OF LINE

Each time the pump was lowered a platform had to be set up on the next landing. Once when the pump was changed the connections on the discharge pipe came together as shown in the accompanying illustration. As the pipe could not be lowered and there was not time to cut a new one, one end of the pump was blocked up and the pipe sprung together.

On moving the pump again, arrangements were made to place the coupling in the vertical pipe. This gave a better chance to make connections in case the pipes did not come together when the pump was moved to a lower level.

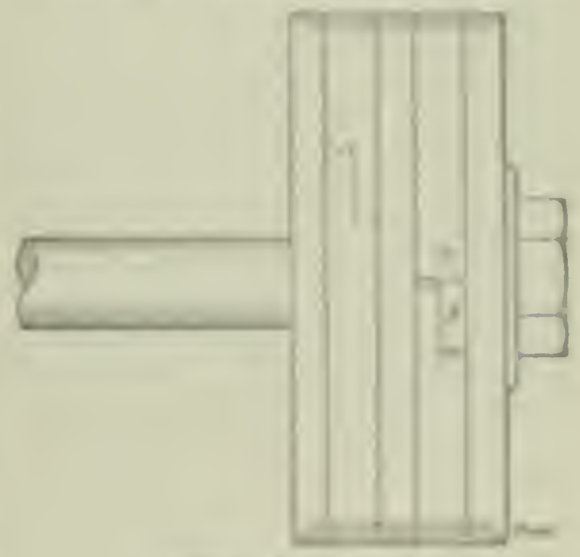
There was never any time to spare when shifting this pump, and on one occasion a new piece of pipe was lowered into the mine with the union on the wrong end. As tools were not at hand to change the union, the pipe had to be sent to the surface to be turned around, and by the time the connection was made the pump was submerged.

EARL E. WEBSTER.

Higley, Ariz.

Broken Piston Ring

One of several large Corliss engines had behaved beautifully for several years, and everything was in good order so far as those interested knew. Then, all at once, the engine began pounding. The braces were sprung and everywhere that anything could possibly budge was strained. An examination indicated that the trouble was internal.



PISTON AND RING

After taking off the cylinder head, an attempt was made to turn the engine over. The piston moved easily through most of the cylinder, but when it approached the head end where the diameter was slightly less, the piston got tighter and tighter until the aid of jacks was necessary to force the piston over to the counterbore. Drawing the piston from the cylinder until the first packing ring showed, the cause of all the trouble came to view.

The accompanying sketch shows the slotted end A of the packing ring, and the line B indicates where this end had broken off. The break was an old one and the continual movement of the small piece of metal, confined in the small cavity, had worn one of its ends wedge-shaped. Finally this wedge slipped under the end of the ring, expanding it at the limit and preventing any contraction. The result was that the piston filled the largest cylinder area and was made a driving fit in the smaller area where less wear had taken place.

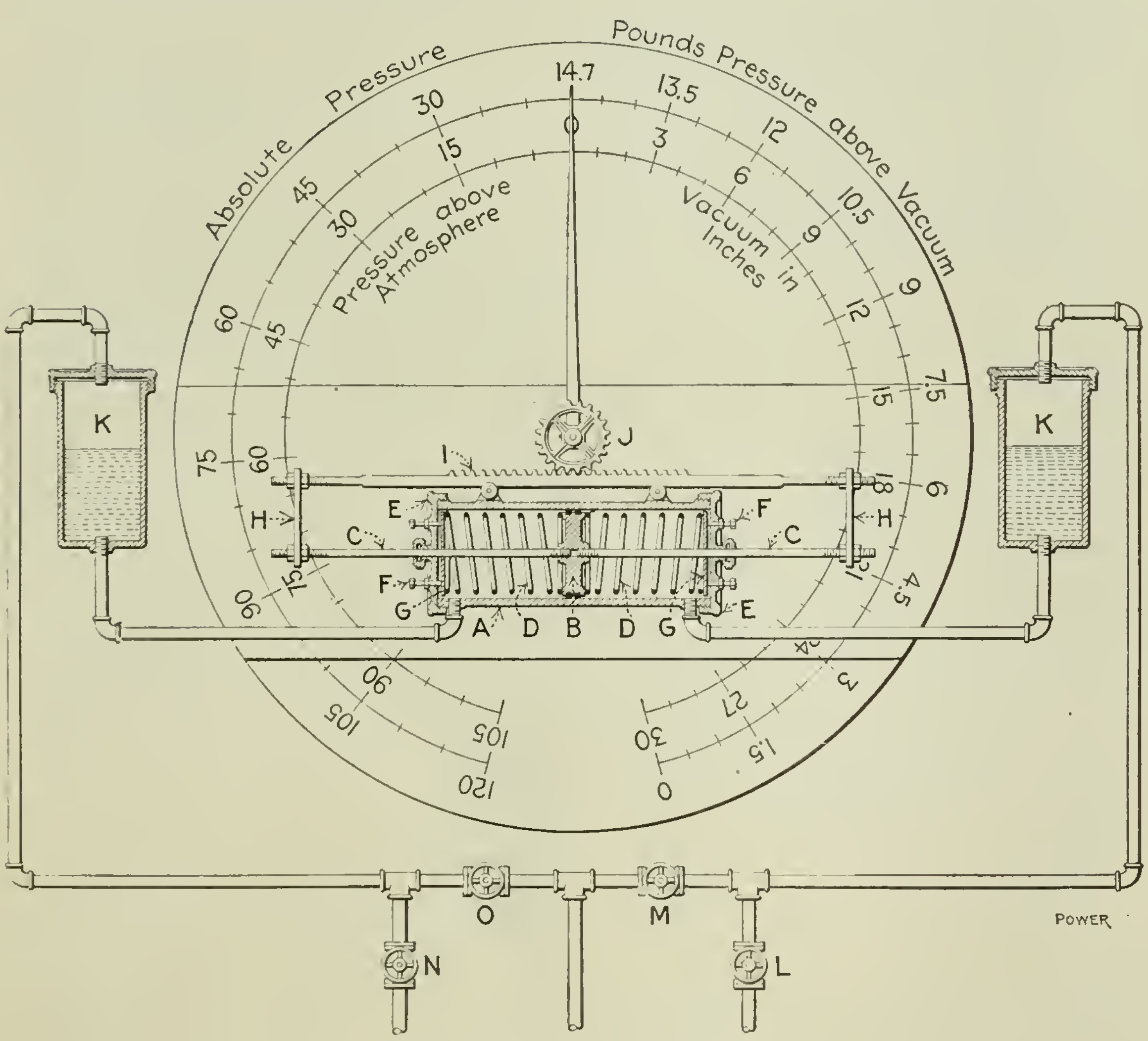
[illegible]

[illegible]

Combination Pressure and Vacuum Gage

Following is a description of a combination pressure and vacuum gage: It consists of a brass cylinder *A*, piston *B*, two piston rods *C*, two spring of different tensions *D* and two cylinder heads *E*. Each cylinder head has four holes for the screws *F* of a very fine thread to prevent leakage which, when screwed in or out, moves the two plates *G* and thus adjusts the tension of the springs. The piston rods are connected by two short rods *H* to a flat, brass gear rack *I*, and the gear engages with the gear wheel *J* to which the pointer is connected. The two drums *K* are to prevent the oil from flowing away.

This gage shows the absolute pressure when connecting the pipe *N* to the live-steam main and the pipe *L* to the exhaust steam. Closing the valve *L* and opening the valve *M* to the atmosphere the gage will register the live-steam pressure, and by closing the valve *N* and opening the valve *O* it will register the exhaust-steam pressure. With condensing engines it is only necessary to connect the pipe *L* to the condenser and the gage will show the mean effective pressure, live-steam pressure and vacuum. If used as a vacuum gage alone, connect the pipe *N* to the vacuum and open the valve *M* to the atmosphere. The pointer will then show the vacuum in inches and pounds pressure above a vacuum.



Details of Combination Gage

VICTOR AZBE.

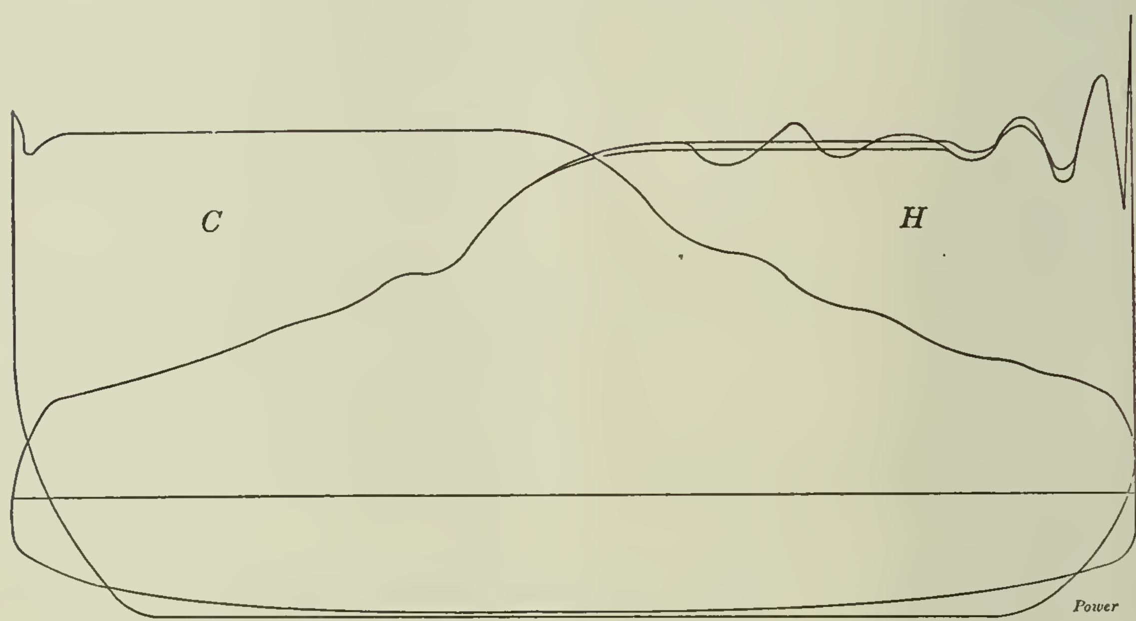
St. Louis, Mo.

Indicator Diagram Defects

The indicator diagram shown herewith was taken from the low-pressure cylinder of a Porter-Allen engine, and diagrams taken from three other engines of the same type show the same lines. These engines are all run compounded in the summer season only. The low-pressure cylinders are disconnected and the engines are run simple for the sake of exhaust-steam heating during cold weather.

The irregularity of the diagram at the point of admission has puzzled the engineer in charge, particularly as several different indicators have been used on these engines.

The speed of each is 157 revolutions per minute and the initial steam pressure in the 24x30-inch low-pressure cylinder is 30 pounds. A vacuum of 21½ inches is maintained. Why do not the same defects show on both ends of the diagrams?



Why Are Not Both Diagrams the Same?

EDWARD T. BINNS.

Philadelphia, Penn.

Disposing of Back Numbers

This seems to be an opportune time to say a few words in regard to disposing of the technical magazines of 1910. Some engineers allow them to accumulate until they are in the way, and then destroy them. Others clip such portions as are of special interest, and destroy the remainder.

These methods are a more or less shameful waste of valuable literature. I have had POWER for 1909 bound in two volumes, by a local bindery, and I am going to have the numbers for 1910 bound in the same way.

To prepare the paper for the bindery, I remove the advertising matter, retaining the editorial page in the front and the page entitled "Moments with the Ad Editor," at the back of the paper, also the pins.

Several engineers with whom I have discussed the subject, and who formerly destroyed their papers, are having them bound. To some this may seem expensive but I think it pays, for in these papers we have accounts of interesting experiments and tests, letters from practical men who give us the benefit of their experience in getting out of difficulty and relate all kinds of stunts and kinks, some one of which may just fit an individual case.

Inquiries of general interest, with answers, are always instructive, also many illustrations of new things for the power plant, and valuable information relating to their construction and operation. This subject as a whole comprises a reference library which can be obtained in no other way, and which, if properly bound, makes a pleasing addition to any engineer's bookcase.

J. A. LEVY.

Greenfield, Mass.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Leakage through a Piston Valve

In the issue of November 29, Mr. Allen's criticism of Mr. Mitchell's article dealing with the matter of leakage through a piston valve is interesting.

For some time it was quite the fashion to discredit this type of valve. But now, thanks to the experiments of Messrs. Callendar and Nicolson, and to the subsequent efforts of designers and makers of this valve, it has quite rehabilitated itself and it is remarkable that the world's records for economy on two different types of engines were obtained with this valve.

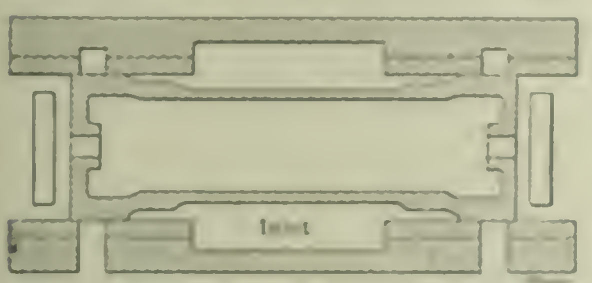


FIG. 1. DIAGRAM OF ORIGINAL VALVE

Mr. Allen's remarks on the advantages of the piston valve are quite in agreement with the experience of makers in England, and, as indicated above, there are some who are prepared to go further than he on the matter of economy if the valve be used with superheated steam.

In Mr. Mitchell's description of his experiments he stated that many schemes have been devised for measuring the amount of the leakage, but in general they are crude and for many reasons the results cannot be regarded as accurate; he then mentions the most important defect common to all of them and straightway embodies it in his scheme.

Had he read the literature on this subject he would have come across Messrs. Callander and Nicolson's experiments and would have seen how inaccurate his statement is, and the study of the subject might have been benefited by his attempting to improve upon the methods of these experimenters.

That there is a great difference between the leakage of a valve or piston when standing and when running seems to be quite understood, yet the first tests were taken with the valve and piston moving, and in order to separate the leakage of the piston from that of the valve the tests were taken with the piston standing.

The fit of the valve when it was tested was stated to be perfect; if this were so, then a great opportunity for taking a valuable test has been neglected; however, what was this fit? Was the clearance measured in ten-thousandths or in thousandths of an inch? Or, was steam turned on and found not to leak past the valve when it was standing?

The fit of the piston was not stated; if it had been an ordinary commercial fit then, when standing, steam would not have leaked past it; the fact that it did leak when standing showed that it was not a good fit. It is improbable that the tests would have been taken had the experimenter considered that this was not a good fit, so possibly his idea of a perfect fit was little better, and the extraordinary amount of leakage is explained.

It is difficult to see why it was decided to have a special valve for these tests;

FIG. 2. SAME VALVE WITH SOLID LINER AT ONE END

the preparations would have been much cheaper and the tests carried out much more accurately and expeditiously if the arrangement shown in the accompanying figures had been adopted.

This arrangement obviates the plugging up of any port, which is a very desirable feature, as it was stated that the plugging up of the cylinder port was not successful and it is probable that the plugging up of the exhaust port from the valve was equally unsuccessful, but in this instance unnoticed.

Fig. 1 shows the original valve and its liners. During the tests this valve was replaced by one which admitted steam to the head end of the cylinder only, and the exhaust port at the crank end was plugged up.

Fig. 2 shows the original valve and one original liner, the other liner being new and without ports so that steam cannot get from it either into the cylinder or into the exhaust pipe; the liner in the head end is easily replaced without dismantling the cylinder and the new liner should be inexpensive.

A pipe can be led from a hole in the head-end valve cover to the condenser and so all the leakage from that end of the valve can be measured; another pipe could be led from the relief-valve hole in the head end of the cylinder to another condenser and so the leakage from the piston measured.

It is seen that with this arrangement it is possible to take very accurate tests of the valve and of the piston leakage separately and simultaneously, and it is hoped that Mr. Mitchell, or anyone who is able to, will use this idea or an improvement on it and repeat the experiments.

If experiments could be made with various types of valves, the results would be most interesting and valuable. When making the tests it should be kept firmly in mind that one assumption vitiates the whole of the test, and that the full data of the tests should be published.

A. VINCENT CLARKE.

Gainsborough, Eng.

Washing Boilers Externally

A correspondent in the December 27 issue inquires as to the advisability of washing the fire surface of the boilers under his charge.

With one battery of boilers I did this for several years with no ill effects. The external washing was done, of course, only when the boiler was down for cleaning and, as the correspondent says, there was heat enough to dry off the surfaces.

I cannot say that I advise external washing, though, for the conditions vary so much; because it proved to be all right in one case does not insure it to be so in all cases.

Filling a boiler with cold water after cleaning is something I much dislike to do, on account of the severe contraction strains set up and the corrosive effect of the oxygen that water gives; the temperature of the water does not need to be high to prevent this; 140 degrees or more will do.

J. O. BENEFIEL.

Anderson, Ind.

Setting Us Straight

Method of Banking Fires

Regarding the question under the above caption in the December 20 issue, M. B. F. makes no explanation as to how thick the grates are covered with fuel or the method employed regarding the fuel on the grates.

Closing all doors and dampers is, of course, right, but in addition the fires should not be left on the grate bars or given an ordinary covering of coal. The proper method of banking fires is to push back the fuel from the front of the grate and then cover the live fuel on the rear of the grate with fresh coal to a depth of not less than 3 inches. Closing all drafts will result in finding the fuel ready for work the following morning, when it can be set into active combustion by simply opening the drafts, pulling the fire over the whole grate and adding a little fresh coal.

I would strongly oppose the suggestion of opening the flue doors to overcome any air leak that may be in the damper, because opening the flue doors means that a current of cold air is being continually drawn through the tubes, causing a chilling of the boiler, which is opposed to engineering practice. Furthermore, flue doors are seldom any too secure or tight and if they are opened at night the chances are that they will leak in the day time. Any plant operating with natural-draft conditions will be subjected to an intake of air at any leaky flue door, greatly to the detriment of the economy of steam production and also to the welfare of the boiler. M. B. F. will do well to leave his flue doors closed both day and night and to see that there are no leaks at that point. On the other hand, he should study the matter of leaving a part of the grate surface exposed, covering the fire a little heavier on the rear end as suggested above.

Steam for Preventing Clinkers

In the December 13 issue the following inquiry and answer are given:

"I have been told that a jet of steam under the grates will prevent the formation of clinkers. Is this true, and is it an economical practice?

"S. P. C.

"Clinkers are caused by the melting and running together of the incombustible in the coal by the heat of the fire. If steam enough is passed through the fire to keep the temperature below the melting point of the ash, clinkers will not form. It is certain that there is no economy in using steam to reduce the temperature of the fire under the boiler which makes the steam."

It is very evident that the answer given was hastily and thoughtlessly furnished, as it is entirely misleading and a very incorrect opinion might be formed by anyone reading it who is not thoroughly conversant with the subject.

What are the facts? Strictly speaking, ash does not melt at all. Clinkers are caused by the fusing of certain elements in the fuel; these elements may be sand, silicate, sulphur, etc.

In coal, the formation of clinker shows different characteristics; in some cases the clinker is very easily broken up and is not in any sense of the word a detriment; in others, it fuses and becomes a part of any firebrick with which it comes in contact and cannot be broken off except at the expense of the firebrick to which it adheres; in still other instances, clinker is so serious a trouble as to compel a cessation of the use of the fuel which produces it.

The detriments of clinker are well known. If the clinker only causes extra labor in the manipulation of the fires, just that excess is a cost. On the other hand, its presence may result in loss of brickwork or loss of active grate surface in the fire.

How, then, is clinker to be prevented? The only successful means of preventing clinker is the use of a steam jet under the grates. In doing this, careful study should be given so that the steam will be uniform under the entire grate surface and yet not of sufficient volume to reduce the temperature of the fire. It is quite unnecessary that the temperature of the fire be materially reduced in order to prevent clinker; in fact, if the temperature were materially reduced by the use of steam jets there would be loss of economy, as the actual steam used and the excess fuel burned would more than offset any cost due to clinker.

How, then, should the steam jet be applied? Its most common and only successful application has been in the form of steam-jet blowers, and it has been the constant aim of the manufacturers of steam-jet blowers to reduce the amount of steam that they use for motive power and reliable manufacturers are now placing on the market blowers which are guaranteed on this particular point.

The use of a steam-jet blower can be for the purpose of increasing the draft or it can be for the purpose of eliminating clinker, or both. I remember very well a certain plant to which my attention was called by an urgent telephone message to the effect that it was impossible to hold steam. On investigating, I found the plant running under natural-draft conditions, although the furnace was equipped with the Parson steam blower. By inserting a slice bar the fuel was shown to be fused together to an extent that rendered the whole one sticky mass, as might be evidenced in a pan of taffy. With the means of a slice bar and a common two-prong hook, I had the fire torn apart and then the steam blower was set in operation. Using the same fuel and with the steam blower in operation, inside of a half hour I had a thoroughly satisfactory fire and the boiler was developing its full requirements of steam and this without objectionable clinker from the fuel.

Such an experience as this, together with hundreds of others of similar conditions which I have personally investigated, would absolutely disprove the statement made in the answer under discussion, that the temperature of the fire must be reduced in order to prevent the formation of clinkers.

By the use of a pyrometer I have found that the amount by which the temperature is reduced when using a proper steam-jet blower is almost negligible, whereas the formation of clinker is eliminated or certainly reduced to a point where it is not objectionable, using fuel which clinkered badly with fan or natural draft.

Again referring to the item under discussion, the statement therein made that "It is certain that there is no economy in using steam to reduce the temperature of the fire under the boiler which makes the steam" is one that would suggest the conclusion that there is no economy in using steam jets or steam blowers.

I can cite hundreds of cases where the use of a steam jet has not materially reduced the temperature of the fire, although it successfully eliminated objectionable clinker; therefore, it is quite unnecessary to say that "There is no economy in using steam to reduce the temperature," because steam is not used in sufficient volume to reduce the temperature nor does it materially reduce the temperature of the fire; in many cases it positively improves it.

Using jets made of ordinary pipe has been common practice, but I would suggest that the steam jet used be supplied by means of a proper form of blower as being the most economical and best method of accomplishing two purposes.

Horsepower and Boilers

Another inquiry in the December 13 issue requested the rating of horizontal tubular boilers with respect to the amount of heating surface. The reply given was to the effect that horizontal tubular boilers were rated on a basis of 10 square feet of heating surface per horsepower.

While it is quite true that makers of horizontal tubular boilers at the present time base their rating on 10 square feet of heating surface per horsepower, claiming this type to be fully as efficient as the water-tube type, it is not true that this is a common rule, and for years back manufacturers of horizontal tubular boilers have established rating on a basis of one to fifteen; then, later, they established a basis of one to twelve.

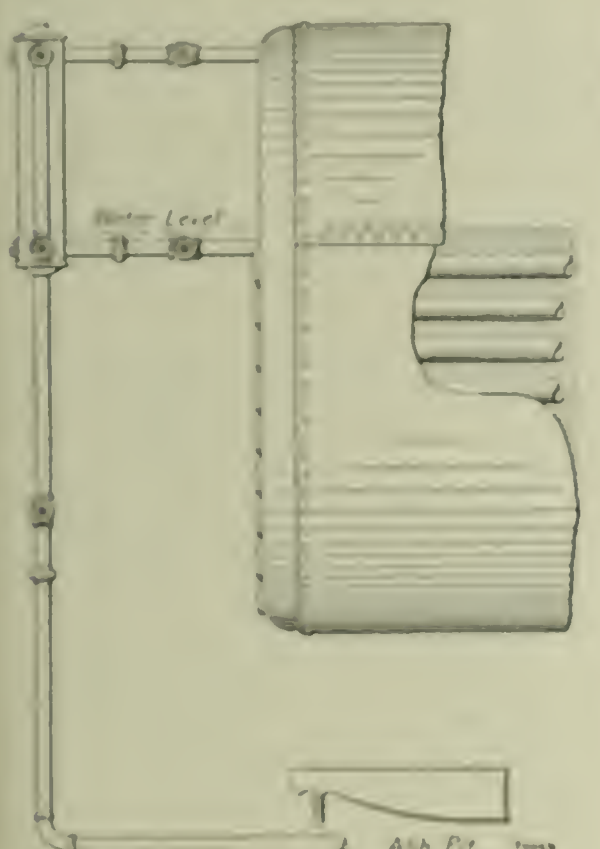
While it is true that horizontal tubular boilers are capable of high overrate, the inquiry was directed by an engineer who had a boiler already produced and not a boiler which was being made at the present time; I therefore suggest the development of this subject so that the engineer asking the information may be in full possession of the subject rather than being given an answer which he would find flatly contradicated by a very large percentage of operating or professional engineers. The real difference between the efficiency of a water-tube boiler and that of a horizontal tubular boiler lies in the difference in the settings.

CHARLES H. PARSON.

New York City.

Water Gages

In the December 13 number of POWER Mr. McGahey favors valves in the water-column connections. I think he is right on that point, but his sketch shows a poor way of connecting the column. Also the column is in a bad position in re-



IMPROVED ARRANGEMENT OF WATER-COLUMN PIPING

gard to the water level. I submit the accompanying sketch as showing an improved layout. The sketch is self-explanatory. With the blowoff piping arranged as shown, the column can be blown down with even greater convenience than in the case where the column is arranged as per Mr. McGahey's sketch.

L. JOHNSON.

Exeter, N. H.

If there is anything worse than no water column on a steam boiler, it certainly is one arranged as shown by C. R. McGahey in the December 13 issue of POWER. No doubt a good many readers would like to have Mr. McGahey lay out a front view of his column arrangement, as it probably would enrich their conceptions of the fourth dimension. I have always been under the impression that a gage glass should show the hight of the water *above* the tubes and not *below*. Another thing I consider to be poor engineering is the use of gate valves on columns, where impurities are liable to clog the pipes.

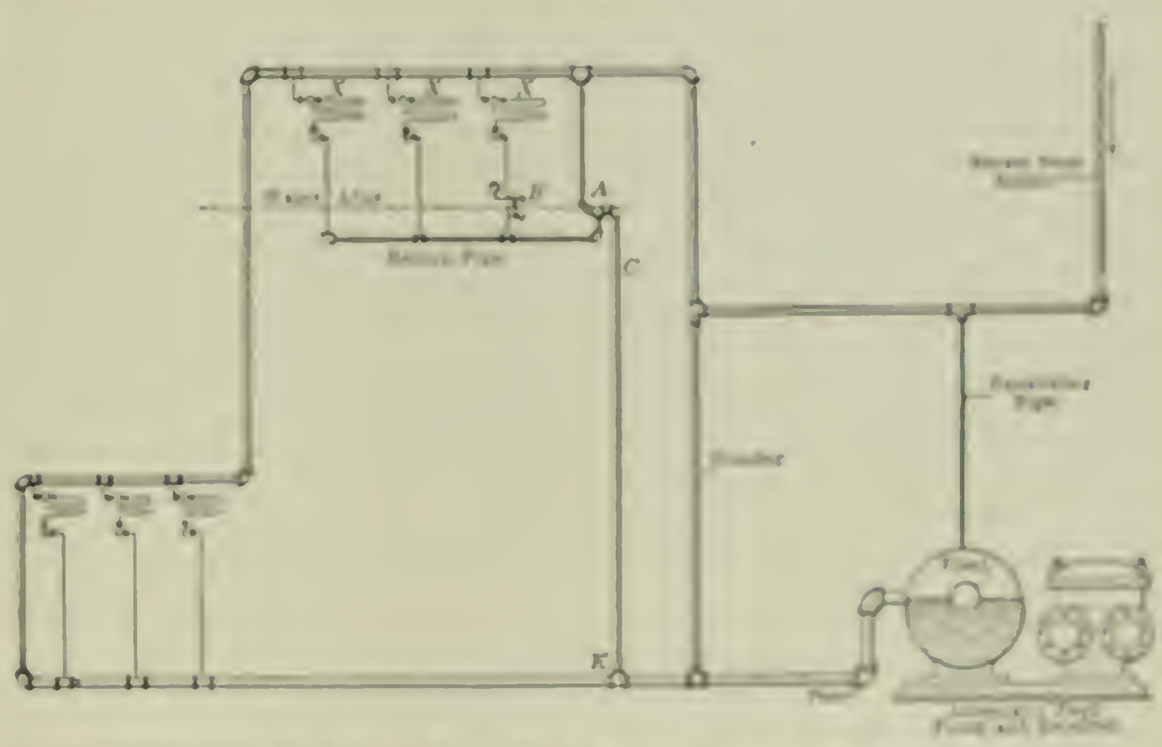
H. F. HAYSOM.

Bridgeport, Conn.

Trouble with a Heating Plant

In regard to Mr. De Saussure's problem, as described under the above heading in the January 10 number, in my opinion the equalizing pipe on top of the receiver tank, if properly connected, serves mainly to facilitate the work of the pump and guard the tank against a vacuum; hence, this equalizing pipe has no effect on the distant group of radiators.

Since he has a seal at *A*, the water line in the returns must be about where the dotted line is; but what causes the seesaw is the steam pipe at *A* running from the main to the seal trap, which "buck"



REPRODUCTION OF FIG. 1, SHOWING ARRANGEMENT OF HEATING SYSTEM

against the regular flow of water from the horizontal return until the water line *A B* is high enough and the pressure in the radiators sufficiently equalized to start a sudden rush of steam and water down *C*, the arrangement at *A* acting as an injector for the time being.

I am not of the opinion that the pressure in *C* ever drops; further, I do not think that the gage is at the proper point to indicate any variations in the pressure in pipe *C*. As soon as the siphon-like action ceases on account of lack of water, the pressure at *B* will be at its lowest, and it will gradually increase as the seal *A* becomes full of water.

I should say that the elimination of pipe *A* from the main to the seal would stop the trouble. Then pipe *C* would have the steady drop in pressure necessary to allow a regular steady flow to the receiver.

ALEX DOLPHIN.

Jamaica, N. Y.

Boiler Explosions

In many of the accounts of boiler explosions I see this statement, "The boiler was being limbered up after being idle for some time" or, "The boiler had not been used for some time." I believe that many boiler explosions have been caused by getting the boilers under pressure too rapidly after they had been idle for a longer or shorter period.

When a boiler has been standing cold for some time, the steam gage is more likely to become stuck than at other times. The spring may not throw the needle accurately.

I noticed in the account of the Pittsfield explosion the statement that the steam gage showed only 35 pounds pressure, while there probably was a pressure of 125 pounds or more on the shell of the boiler.

Once, while running a battery of boilers in a plant in New England, I was getting up steam in Nos. 1, 2 and 3, when I noticed that the gages on Nos. 1 and 3 showed 40 pounds while that on No. 2 showed only 10 pounds pressure. I knew by the fires, water, etc., that the No. 2 gage ought to have shown as much pressure as the others. I gently tapped and shook the gage and the needle came right up to the proper mark.

I believe that in every plant that has only one boiler, the boiler should have two steam gages. Then if one happens to stick there is not one chance in a hundred that the other would register wrong also.

W. J. STEARNS.

West Cummington, Mass.

Boiler Explosions in Germany

The editorial under the heading "Boiler Explosions in Germany," in POWER for December 20, should make one sit up and think. Why have we so many explosions in this country? There must be something radically wrong. Perhaps there may be a few reasons.

Germany has no coroner handy with the whitewash. The officials whose business it is to investigate such accidents are installed and shielded by the government and all stand on their honor, which is worth more to them than mere dollars and cents. They never bow to the dollar sign. They do their duty no matter whom their action hits. They are sticklers in upholding the law; try to bribe one and see how quick the briber goes to jail. When a boiler explodes, killing one or more persons, the district attorney with a circuit judge goes to the scene.

The attorney and the judge conduct the inquest. Experts are summoned, only such men as hold master certificates and are well qualified, also the inspector who last examined the boiler being eligible.

These men sift the evidence and no one dares to block their efforts. They need fear no political wrath, for all hold their jobs for life, unless promoted, and promotion comes according to ability in enforcing the law. If, in their investigation, they find someone negligent, the blame is placed; it makes no difference who the party is or whether he is of high or low rank. And the blame is often found to be with someone "higher up" that is living (not a dead man or a dying engineer; remember Brockton, Mass.).

The man responsible is then placed under arrest immediately. At the trial he is charged with such a crime as the inquest seems to indicate. He must clear himself if he can; nine times out of ten he cannot. Sentence is pronounced if he is found guilty; the penalty usually is not a fine because this only hurts the pocketbook; generally it is a jail sentence.

If we had some of this in our great and glorious United States, what a blessing it would be! Look through the list of explosions and one cannot help but shudder. How many dead men there are with blame resting on them of which they are innocent! But, dead men tell no tales.

A. RATHMAN.

Chicago, Ill.

Metallic Packing

In answer to the question by W. D. Marquest in the December 13 number concerning metallic packing, I would say that if he will indicate his engine he will probably find there is back pressure at the end of the crank-end stroke which is so high as to produce a pressure on the packing greater than that due to the boiler pressure.

If there were back pressure at the other end of the stroke it would not have any effect on the packing or rod, as the piston would be between the pressure and the packing. I still have the first rod that was used in my engine; it is worn tapered at the crosshead end.

The tension of the springs causes but very slight wear.

W. H. PHELPS.

Ellwood City, Penn.

Does the Crosshead Stop?

I have been reading the arguments on Mr. Fryant's question, "Does the Crosshead Stop?" My opinion was that it did. I wanted to know for sure so I made a wooden cylinder and mounted it beside the engine with its axle parallel with the crosshead. I kept it in motion by a string running around the shaft of the engine, around two spools and then around the cylinder. Then, by placing a piece of paper on the cylinder, fastening a pencil to the crosshead so that the point just touched the paper, I was ready to take a diagram. I turned the engine over once by hand and secured the diagram shown in Fig. 1. This diagram proved beyond a doubt that the crosshead does not stop for, if it did, there would be a straight line at *A* and *B*, Fig. 1. As the ends of the diagram are curves, the crosshead did not stop. I took this diagram from a high-speed automatic engine with a 14-inch stroke.

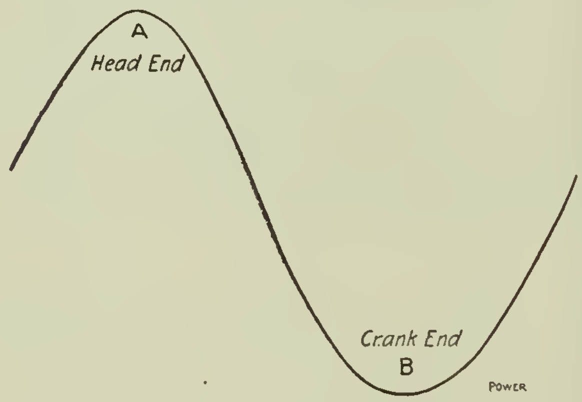


FIG. 1. DIAGRAM OF CROSSHEAD TRAVEL

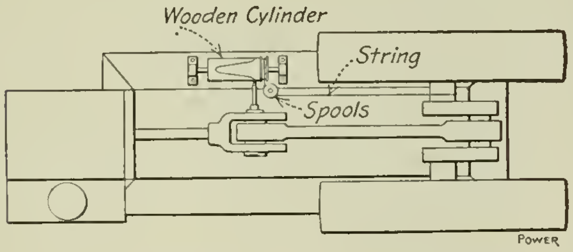


FIG. 2. ARRANGEMENT FOR DRAWING DIAGRAM

The curve at the head end of the diagram is somewhat sharper than that at the crank end on account of the crosshead having a quicker motion during the head-end half of the stroke.

WILLIAM T. KINGSLEY.

Boise, Idaho.

Fusing Temperature of Ash

The discussion by J. V. Hunter in the issue of December 27 of the article on "Fusing Temperature of Ash," which appeared in an earlier issue, is very interesting, and bears out conclusively the contention that the clinkering property of coal bears no relation whatever to the percentage of sulphur in the coal.

All other usual determinations, such as the percentage of iron in the ash, percentage of lime, etc., apparently fail in indicating this characteristic, and the only test which we have found to be consistent is that of determining the fusing temperature of the ash.

Mr. Hunter says that few people are in a position to obtain these data and it is reasonable to suppose that sole reliance must be based upon actual tests conducted in the plant. This is true to a certain extent, for even the proximate analysis of the coal, the B.t.u. determination, the percentage of CO_2 in the flue gas, etc., are only of value when properly interpreted in connection with actual operating conditions. The purpose and value of such tests, however, are that they serve as definite and reliable indications of the suitability of various fuels or conditions for securing the best results in practice.

In the past, the only method of determining the clinkering property of coal has been to burn it, and while it is true that the "proof of the pudding is in the eating thereof," yet it is often very desirable to learn before the pudding is eaten, or the coal burned, whether or not the act is going to result disastrously in either case.

In many of the larger power plants today, capacity is of primary importance. The greatest enemy of capacity, as well as efficiency, is the formation of clinker, and it is certainly very desirable in every possible case to prevent the disastrous procedure of trying out in practice all of the various kinds of coal which may be shipped upon a contract, by providing limitations of the fusing temperature of the ash in the specifications with suitable penalties and premiums, just as are imposed upon variations in the B.t.u., percentage of ash, etc., in many cases today. In other words, the fusing temperature of ash is a short cut to determining before a coal is placed in the furnace, or even before it is delivered to the plant, whether or not it will be suitable, without having to wait until the plant is shut down for lack of steam, due to lack of air with which to burn the coal.

We hear a great deal today about the heat value of coal, and the percentage of CO_2 in the flue gas, but neither can the maximum B.t.u. be developed, nor the best percentage of CO_2 be obtained if the ash forms a clinker which slags over the grate and prevents the flow of air through the fuel bed.

It is true that there is a great variation in the amount of clinker formed in different furnaces, due to the method of handling the fire, and every engineer and fireman should remember that any ash should be kept as cold as possible, thereby preventing undue risk from heating it up to, or far beyond, its fusing temperature. However, under similar conditions, whether they are good or bad, the fusing temperature holds a relation which indicates the comparative values of different coals, and it is comparative quantities that are of value in engineering practice more than absolute or theoretical figures.

Mr. Hunter referred to the practice of mixing coals, and its effect upon the formation of clinker. His conclusions on this are in general correct; in some cases it may be helpful to the more troublesome coal, while, on the other hand, the mixing may cause serious trouble, while either coal burned separately might give satisfactory results.

Mr. Hunter also mentioned the possibility of adding ingredients, such as lime and silica to the ash, in order to eliminate this trouble. This point has already been taken up by W. N. Wing in the November 22 issue of Power and discussed by E. Dixon in the December 27 number. In the case under discussion, Mr. Wing spoke of using oyster shells to remove clinkers from a boiler furnace, and there is no question but that he might have received some benefit from the use of lime in this form, but as to the action of lime, I differ with Mr. Dixon in this connection and do not believe that the lime added lowered the fusing temperature of the ash by fluxing it, but that it increased the fusing temperature of the ash. With a certain composition of ash, lime added, up to a certain percentage, may act as a flux, but as lime itself cannot be fused much below the temperature of the electric arc, it would certainly increase the fusing temperature of any ash if used in sufficient quantity, and this is probably what Mr. Wing did. I have known of other cases where oyster shells have been used in lessening the trouble from clinker. I have also learned that from some mines, coal with a higher percentage of ash due to the admixture of certain kinds of clay and slate which were high in alumina increased the fusing temperature of the ash and lessened the trouble from clinker, and there is a possibility that in the future coal may be treated in order to prevent clinker as feed water is now treated in order to prevent scale. This, however, can only be done by adding other material, the composition of which will depend upon the nature of ash which is already inherent in the coal, and while it may be feasible in the case of coal which has a low percentage of ash, yet where a high percentage of ash exists in the coal a greatly increased percentage of the added material would probably offset any advantage gained thereby.

E. G. Bailey.

Boston, Mass.

Why the Feed Pipes Clog

In regard to Mr. Piper's letter in the January 3 issue under the title, "Why Did the Feed Pipes Clog?" it is my opinion that the trouble is due to iron in the water.

I have had the same trouble. If Mr. Piper will have the water analyzed, he will probably find that it contains iron. This forms a reddish scale.

Peter Elseth.

Crookston, Minn.

Faulty Design and Economic Engineering

In Power for November 22, R. L. Rayburn speaks of the engineers in charge of plants, knowing the plant as no others do, as a reason for not securing the services of a competent consulting engineer. As the general run of chief engineers are usually busily engaged in making necessary repairs and changes, they are left but little time to spend in convincing the management of the necessity of making needed changes or improvement in equipment; while the consulting engineer has little else to do. Moreover, it is well known that a man's personal appearance and standing or reputation has much to do with the consideration given his propositions. Very frequently it is the case that the management does not like to have the engineer become the advisory board. In such cases the consulting engineer can and does play a very useful part, as the engineer can have his plans carried out through the consulting engineer.

A chief engineer in charge of a plant cannot reach the management for an audience until he has risen in their esteem and subsequently in the ranks of men, through his everyday efforts and achievements.

Of course there are consulting engineers and consulting engineers, those of good repute and otherwise. No man would commend the practice of employing a man as chief engineer in charge of plant just because said man had made a failure in some particular plant. I have been wondering what Mr. Rayburn's impressions are of what a consulting engineer really should be capable of; we may call a man a consulting engineer or he himself may assert that he is capable of performing the duties of a consulting engineer, but that does not make it so. To become a successful consulting engineer, it is necessary first to apply the theories, and one's own hypotheses to everyday practice. A man rises to such a position by a gradual process. Perhaps he should first be the chief engineer in charge of a plant before he should consider himself eligible for the duties and responsibilities of the consulting engineer.

There are different types of consulting engineers. Unquestionably, a man should specialize along some particular line of work.

It is only natural to find men terming themselves "consulting engineers" who in reality are entirely unfit to design or lay out a power or heating plant. I have known college graduates to establish offices in cities and term themselves consulting engineers; certainly we would not expect such persons, just out of college, to be capable of laying out a power plant, neither would we expect a good business man to employ such engineers.

I say that the consulting engineer will play a more important part in the operation of light, heat and power plants each succeeding year, as a man of caliber, high standing and achievements will be necessary to make the final determinations and to display sufficient tact in presenting a new layout or proposed change to the management.

Perhaps a great many of the changes, etc., were the ideas of the engineer in charge, but the changes often never would be made if they were presented to the management by the engineer. This is an age of salesmanship, an accomplishment which the engineer does not frequently possess to any marked degree.

In concluding, I assert that the isolated plants cannot expect to withstand the onslaught of the central stations unless they, too, are organized in a concrete body as the central stations are. Also, they are ultimately doomed unless the same high standard of salesmanship is resorted to, in order that the management may be convinced that it would be cheaper and better to operate its own plant. This high-grade salesmanship must be one of the attainments of the consulting engineer, as he is in such standing with the management that the engineer in charge can never attain.

Waldo Weaver.

Middletown, O.

When cutting pipe threads in a lathe it is sometimes difficult to get the exact diameter necessary. When a mistake is made and the threads on a [illegible] pipe are cut a trifle too small, so that it screws right up to the shoulder, then it remains for the workman to get out of the trouble the best way he can. A very good way is to use wire cloth of the brass variety, about 50 or 60 meshes to the inch, similar to that used by the farmer for screening his [illegible]. Wrap a bit of wire cloth around the pipe, daub it with litharge or red lead and screw the pipe home with the wire cloth in the joint. This joint will never leak or come loose.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

To Make Pipe Covering Stick

How can asbestos be made to stick to steam pipes and cylinder heads?

P. C. S.

Give the surface a coat of silicate of soda, sometimes called liquid glass, and before it has time to dry apply dry asbestos as thick as possible by handfuls. The silicate will stick to the surface and hold enough asbestos to serve as an anchor for the following coats to be applied in the usual manner.

Reasons for Compression

What reasons are there for giving compression when setting engine valves?

R. F. C.

Compression reverses the direction of pressure on the pins and main bearing of an engine gradually, takes up the lost motion without shock and allows the crank to pass the centers quietly. It also fills the clearance space with exhaust steam instead of with steam from the boiler.

Safety Valve and Steam Gage

If with a safety valve set to blow at 80 pounds the steam gage should show a pressure of 120 pounds, what should be done?

S. S. G.

The pressure should be reduced, the boiler cooled and both gage and valve tested by a competent man.

Reducing Size of Eccentric

If 1/8 inch is turned off the outside of an eccentric, how will it affect the valves and the speed of the engine?

R. S. E.

In no way whatever.

Capacity of Duplex Pump

How many gallons of water will be delivered by a duplex pump making 30 strokes per minute with 4x6-inch water cylinders?

C. D. P.

The area of the 4-inch piston is 12.56 square inches and 75.36 cubic inches of water will be delivered per stroke. Both pistons will, together, make 3600 single strokes in one hour and the quantity of water pumped will be

$$\frac{75.36 \times 3600}{231} = 1174.44 \text{ gallons}$$

Cutoff with Lapless Valve

If a slide valve has neither lap nor lead, at what point in the stroke will the cutoff take place?

C. L. V.

At the end.

Badly Scaled Boiler

In case a boiler is found to be badly scaled, what should be done?

R. S. B.

It should be thoroughly cleaned at once.

Thickness of Strap Plates

Why are the cover plates or straps of a butt and strap joint made thicker than the shell plates, and why can they not be made thinner?

T. S. P.

They are never made thicker than the shell, but on the contrary are frequently thinner. They should never be less than five-eighths of the thickness of the shell plate.

Center of Shaft

Does the center of a shaft revolve?

C. O. S.

It does not.

Diameter of Steam Pipe

What diameter of pipe 1000 feet long will be required to deliver 200 pounds of steam per minute at a velocity of flow of 100 feet per second with a drop in pressure of only 5 pounds; from 100 to 95?

D. S. P.

No diameter of pipe will fit all the conditions. A 6-inch pipe will deliver 200 pounds per minute with a drop in pressure of only 4½ pounds, but the velocity flow will be only 4000 feet per minute. A 5-inch pipe will give a velocity of flow of 6000 feet per minute for 200 pounds delivery, but the pressure drop will be 11 pounds per square inch.

Increasing Speed of Fan

I have a 7-foot fan running 187 revolutions per minute and I wish to increase the speed to 400 revolutions per minute. The fan is driven by an 8x8-inch engine running 153 revolutions per minute with a steam pressure of 100 pounds. How can I make the change?

I. S. F.

You cannot do it. The power required to drive a fan is approximately as the cube of the speed. A 7-foot fan at 187 revolutions per minute takes about 20 horsepower, which is about the limit of your engine at its present rate of speed at 60 pounds mean effective pressure in the cylinder. To drive the fan at 400 revolutions will take over 90 horsepower, which means an increase in piston speed or mean effective pressure beyond what is possible. The safe speed for the fan will fall below 275 revolutions per minute. These and other reasons, any one of which is sufficient without the others, will show why it cannot be done.

Weight of Boilers

What is the weight of a 60-inch and a 72-inch return-tubular boiler?

W. O. B.

The weight of a 60-inch return-tubular boiler without front or fittings varies according to length, etc., from 10,000 to 13,000 pounds; complete from 17,000 to 18,500 pounds. The weight of a 72-inch boiler will range from 14,500 to 26,000 pounds, depending on length and equipment.

Horsepower of Boiler

What is the horsepower of a horizontal return-tubular boiler, 6x18 feet, containing sixty 4-inch tubes, allowing 12 square feet of heating surface per horsepower?

H. O. B.

The heating surface of a horizontal tubular boiler is the total area of one-half the shell, the inside area of all the tubes and the area of one head less twice the cross-sectional area of all the tubes. One-half the area of the shell equals,

$$3 \times 3.14 \times 18 = 169.56 \text{ square feet}$$

The inside tube area is equivalent to

$$\frac{11.72 \times 18 \times 60}{12} = 1054.8 \text{ square feet}$$

The heating surface in the head would be

$$28.27 - \left(\frac{12.56 \times 2 \times 60}{144}\right) = 17.42 \text{ sq.ft.}$$

The total heating surface in the shell, tubes and heads would then be

$$169.56 + 1054.8 + 17.42 = 1241.78$$

square feet which would give a horsepower rating of

$$\frac{1241.78}{12} = 103.48$$

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POWER

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Reliability of Test Figures

Tests, such as those of engines and boilers, are so flexible that it is an easy matter to deceive oneself as to the results that are obtained. No wonder, then, we are startled now and then by the published reports of such phenomena as a boiler efficiency of eighty-five per cent. and the like. Not infrequently such reports are given out over the signatures of men whose integrity is above the slightest suspicion, in which event the figures are quite startling.

When men whose ability is beyond question and who have absolutely no motive in deceiving themselves about the performance of a given piece of apparatus can induce themselves, by virtue of their faith in the results obtained, to sign reports which indicate performance considerably beyond the ordinary, it is small wonder that a manufacturer or his chief engineer, can persuade himself to believe that his observations are reliable even when they indicate results that border on the impossible.

Results apparently secured are shown by the observations made by the persons conducting the test. These observations depend for their accuracy upon the calibration, precision and manipulation of the instrument used in making the observations. Even after an instrument has been found to be accurate, unless it is used carefully and intelligently, the indications which it makes may be far from the truth, as the following tends to show:

The man in charge of the Orsat apparatus during a certain boiler trial found that the percentage of carbon dioxide as indicated by the apparatus was too high. It would go as high as from seventeen to nineteen and the percentage of oxygen indicated would be nine or ten. Obviously, something was wrong, as the total of the quantities of carbon dioxide and oxygen amounted to from twenty-six to twenty-nine per cent., which is from five to eight per cent. in excess of what is theoretically possible.

For some time the operator was wholly unable to discover where the trouble was. After some searching, he discovered that the time taken in manipulating the apparatus had much to do with the percentage of carbon dioxide indicated. Strange to relate, however, the more rapidly the flue gas was passed back and forth between the measuring burette and the absorption pipette the higher would be the indicated percentage of carbon dioxide. Next he noticed that the rubber gas bag attached to the back leg of the absorption pipette remained distended after the liquid had run back to its normal level, and lo, the "mystery" was solved! In passing the gas rapidly from the burette to the pipette, too much pressure was put upon it and some of the gas was forced down through the glass capillary tubes in the front leg of the pipette, bubbled up through the liquid in the back leg and escaped into the gas bag. When the operation was reversed, the pressure in the gas bag was not great enough to force the gas back into the front leg so that it could be drawn back into the burette again. Hence, the water level in the burette seemed to indicate that more carbon dioxide had been absorbed than really was the case. By varying the speed of the manipulation the operator could obtain any indication for carbon dioxide that he desired.

The moral to be drawn from this incident is that unusual results should be viewed with caution even by the man who has obtained them. Before making them public the methods employed and the deductions made should be subjected to careful investigation and analysis.

"It's better to be sure than sorry."

Professor Nicolson's Experiments

Professor Nicolson's experiments with high gas speeds in boilers, an account of which is given elsewhere in this issue, demonstrate that an enormously high rate of heat transfer through the tubes can be attained if the velocity of the gases is great enough. Beyond establishing this fact, however, they add nothing which would seem likely to revolutionize present boiler practice.

In order to prevent the passages around the economizer tubes from becoming choked with soot, it was found necessary to respace the tubes, and after this had been done, the temperature of the gases leaving the economizer rose to two hundred and forty degrees. This is no better than the results attained in everyday operation in well designed plants equipped with economizers; in fact, it is not uncommon in some plants to have the temperature of the gases fall to two hundred degrees. Another significant fact is that Professor Nicolson's experimental boiler did not show any extraordinary efficiency, such as might be expected from the high rate of heat transmission. True, an efficiency of seventy-nine per cent. was attained on one run, but when the steam required to operate the fan at its high rate of speed, was deducted, the net efficiency fell to sixty-nine per cent.; which is considerably below the results obtained with the best boiler practice.

When it is considered that the goal aimed at in the design of all boilers is to deliver to the water the greatest possible percentage of the heat in the coal, it would seem that the further solution of the problem lies within the furnace.

Gas Poisoning

The narrow escape of an engineer, a few weeks ago, from death by carbon monoxide gas in a producer-gas power plant and the more recent death of a young man and woman in Maryland due to the same gas from a defective stove, bring the subject of gas poisoning strongly to the front. In every producer-gas power plant there is constant danger of fatal "gassing," as our British cousins call it, unless proper precautions have been taken to prevent the escape of carbon monoxide into the building.

The simple suction producer plant is less likely to give trouble in this respect than any other, because the entire system is below atmospheric pressure right up to the engine. But the simple suction plant develops bad operating features as soon as two or more producers are operated in a battery, especially if two or more engines are supplied simultaneously. The induced-draft type of plant comes next in point of freedom from leakage possibilities. The generators, scrubbers and all of the many connections between the generators and the fans are under suction, only the piping between the fans and the engines being under pressure. Moreover, the pressure in this part of the equipment is only a few ounces per square inch and all joints are or should be in plain sight and easily accessible. In such a plant there is much less excuse for gas leakage than there would be for steam leakage throughout the piping of a steam plant.

Even where straight pressure producers are used because of their well known meritorious features, there should not be any great difficulty in preventing the leakage of gas into the building. Of course, there are more points to be protected, but that is merely a routine part of the designing engineer's work.

No matter what the system or the operating conditions, it is just as incumbent upon the builders and erectors to prevent gas leakage as it is upon boilermakers to eschew low-grade steel and lap seams.

Plant or Unit Efficiency

There is a tendency among engineers to judge the economical operation of their plants by the performance of the main engines and boilers. At one plant where the boilers show an efficiency of seventy-two per cent. and the engines a water rate of fourteen and a half pounds per horsepower-hour, it is believed that power is being produced about as cheaply as possible for the size and type of installation; whereas a neighboring plant of similar equipment, in which the boilers show an efficiency of only seventy per cent. and the engines a water rate of fifteen and a half pounds, may, in reality, be producing power much cheaper than the first plant.

Although a determination of the individual efficiencies of the boilers and engines is useful for comparison with other engines and boilers they cannot be taken as a criterion upon which to base the economy of the whole plant. One engine may attain a lower water rate as a result of a half inch higher vacuum, yet the extra power required to produce this additional half inch may more than offset the economy due to the lower water rate. Similarly the other auxiliaries have a direct bearing upon the cost of generating power as do also the labor and fixed charges, and these must be included in the plant efficiency.

The prominence given to the main units is no doubt due largely to the fact that competition among the builders has kept their performances continually in the limelight, and also, in a lesser degree, to the fact that tests of individual units are more common than plant tests.

Concealing the Facts

Accidents are frequently the results of mistakes the careful and intelligent analysis of which will usually bring much to light that will be of great value in showing how the repetition of the mistakes may be avoided.

Refusing to give information and denying access to such information to those whose business it is to search for and find the cause, if possible, is to deliberately seal a source of knowledge to which the public has an unquestionable right, even down to the smallest detail; every factor in an accident which has endangered or destroyed life or property is vitally important to those interested in related lines of work, and they have a moral right to such information. That which is a menace in one situation is also a menace in another, if the conditions are similar, and an error in construction or operation of machinery in one case may be repeated over and over in other localities if detailed information be refused in the first case. Full publicity in every case of accident, therefore, will do much to reduce the number that occur.

Dissatisfaction and even resentment are often if not always shown by all who are in any way connected with an accident if the investigation indicates that it was caused by ignorance or carelessness. This attitude, while perfectly explained on the ground of selfishness and absence of consideration for the safety of others, is wholly inexcusable. That the public has a right to protect itself from polluted water, adulterated food or contagious disease is unquestioned. Power-plant owners and operators do not seem to realize that it has the same right to protect itself from the danger of an accident that ignorance or carelessness may cause.

There is another side of the question that seems to have escaped due attention also. That is the fact that the refusal to give out information concerning an accident will always arouse a natural suspicion that there is a foundation for the uncharitable criticism and gossip which are so general concerning matters of the kind under discussion. It is a good deal better to tell the full truth about an accident than to encourage sinister suspicions and possibly the publication of a garbled story based on partial information and guesswork by a reporter, against which the editor of a periodical is almost always defenseless.

We are hearing so much of late regarding the conservation of our national resources. What about the conservation of time? The average man would be surprised if he realized the amount of time he wastes annually through lack of a systematic way of doing things. System is one of the greatest of time savers.

Balzac said that "Cruelty and fear shake hands together." In steam engineering, ignorance and death walk hand in hand.

A California man who tickled a lion under the chin is now minus three fingers.

A Massachusetts engineer who screwed down a safety valve burst a boiler, killed himself and nineteen others. One act was just as foolhardy as the other.

A certain type of engine runner is disappearing. He is in a class with the old tiddle-de-winks and ping-pong outfits—out of date.

While a man was thawing out a frozen oil pipe, gas, which had accumulated in a receiving tank, was exploded by the torch that was used. The man was blown 150 feet and killed. It pays to be careful.

The man who rigs up an appliance from material on the scrap heap, and makes it work, is a genius compared to the man who makes a nice working drawing of an appliance that will not work.

The majority of explosions occur, not while the boiler is in regular service but while it is being started up. The Pittsfield catastrophe is a case in point.

Flywheel Explosion at Lowell, Mass.

By Joseph King

> *The 25-ft. flywheel of a twin simple condensing Corliss engine explodes with disastrous results to mill and machinery. The regular speed of the engine was 58 revolutions per minute and the wheel was evidently safe at 80.*

Shortly after 7 o'clock Thursday morning, January 26, the 25-foot flywheel of the twin 32x60-inch condensing engine at the No. 7 Boott mill, Lowell, Mass., burst with disastrous results to the engine, machinery and building, but without seriously injuring any of the 150 operatives. The wheel, which weighed approximately 56 tons, was eight feet wide and carried three belts.

As no examination of the engine can be made until the tons of wreckage under which it is buried can be removed, it is not possible to give the initial cause of the accident. That the rupture of the wheel was due to excessive speed is well known, as for some minutes before the final crash the looms on the floors above automatically stopped when the speed increased, and pulleys in various parts of the mill burst from the effects of the high speed.

In the light of the little that is known it is thought that perhaps one of the large belts broke and piled itself up on the floor back of the wheel, either breaking the governor belt or forcing it off the pulley.

The governor, not being furnished with safety devices, allowed the engine to take steam nearly full stroke, which soon drove it to a speed so far above the normal that the wheel exploded.

FIG. 1. THE ENGINE LIES BURIED BENEATH THE WRECKAGE

The three belts ran vertically upward quite near the wall and were made to cover a large proportion of the circumference of the flywheel by the use of an idler. As the engine ran "under," it is quite within the limits of the possible that a broken belt following the direction of rotation of the wheel would catch on the floor and pile up between the engine frames and render the governor inoperative.

The engine ran at 58 revolutions per minute, which was only about two-thirds of the safe speed for the comparatively modern design of this wheel.

The fragments of the rim tore through four floors and the wall of the building, making an opening about 50 feet wide, around and over the edges of which hung the ends of machines and shafting supported by the remaining belts and lag bolts. One section of the wheel, weighing nearly 900 pounds, was thrown through the roof and landed on the top of the building where it remained, while another piece went up through the second floor and lay close to the edge of the hole.

Although it is true that probably nothing is certainly known of the cause of the accident, a great deal of street talk and the newspaper reports give the impression that from the time the increase in speed was noticed to the final crash, several minutes elapsed, and that the engine might have been stopped, as the operatives had plenty of time to escape from danger.

FIG. 2. PIECE OF WHEEL ON ROOF AND HOLE THROUGH WHICH IT CAME

During this time, it is reported that the engineer, a new man, was seeking the master mechanic to get permission to stop the engine.

It is estimated that the damage will exceed $50,000, $30,000 of which is covered by insurance. Only one operative, a young Greek girl, was hurt in any way, and she only slightly by running against one of the machines.

Heating and Ventilating Convention

The seventeenth annual meeting of the American Society of Heating and Ventilating Engineers was held on January 24, 25 and 26 at the Engineering Societies building, New York City.

The following papers were presented: "Pipe Line Design for Central Station Heating," by B. T. Gifford; "The Value of Good Ventilation," by Prof. Severance Burrage, Lafayette, Ind.; "Standards of Ventilation," by Dr. W. A. Evans, Chicago; "Ventilation of the Capitol, Washington, D. C.," by Nelson S. Thompson. In addition to these papers a report was submitted by the committee on "Effect of Air Leakage and Wind Velocities on Heating Guarantees." A report was also submitted by the committee on "The Rating of Heating Boilers."

Mr. Gifford's paper on "Pipe Line Design for Central Station Heating" will be printed in abstract in next week's issue.

Value of Good Ventilation

Professor Burrage indicated in his paper on the above topic that the value of good ventilation was found in the good health and high efficiency of the people occupying well ventilated buildings. One of the most important predisposing factors in the spread of tuberculosis and pneumonia is bad air. Not only is health greatly improved and the power of resistance of the body against disease greatly increased by breathing pure air. but much more efficient work can be done by those who study and work in well ventilated rooms.

Standards of Ventilation

Doctor Evans showed that the standard of ventilation must be complex because it must depend on many factors such as the different qualities of air and the different methods of handling air. If a building is so located that it gets lots of sunshine in its interior the standard of ventilation may, possibly, be lowered 20 per cent. while that for a basement or cellar where sunshine seldom enters must be raised 20 per cent. In a hospital the standard must be high because the general degree of health is low. Thus, the standard is influenced by the physical character of the building, the use to which it is put, the class of people occupying it, etc.

After all such factors have been taken into account, the standard of ventilation must provide restrictions as to the dust content in the air, the humidity, the temperature, the carbon dioxide content, odors, the frequency of air change, air current and bacterial conditions.

Ventilation of the Capitol, Washington, D. C.

The paper on this topic consisted mainly of a description of the methods employed and the results obtained during tests to ascertain the quantities of the various constituents, chiefly carbon dioxide, of the air in the Capitol building.

The system of ventilation used in the Senate chamber and that of the House of Representatives is of the up-draft type. Air is admitted by numerous floor openings, and is drawn out through ducts in the ceiling by exhaust fans. The conclusion drawn from the tests is that while the quantities of air circulated are sufficient for excellent ventilation, the distribution of the air is poor and that the system employed is, consequently, unsuitable.

Effect of Air Leakage and Wind Velocities on Heating Guarantees

The report of the committee on the above consisted of a few specific examples in the form of test results obtained at the Harvard Medical College buildings and at the gymnasium buildings at Michigan University.

Due to the dirth of data available to the committee it was impossible to draw any definite conclusions. The committee urged that a future, larger committee be created to acquire more data on these important factors in heating requirements.

Rating of Heating Boilers

The committee on the above recommended that a square foot of direct heating surface be used as the unit of rating, based upon the assumption that a square foot of direct steam heating surface gives off 250 B.t.u. per hour, and that a square foot of direct water heating surface gives off 150 B.t.u. per hour. It was recommended that the rating of heating boilers be based on the number of square feet of steam radiation or water radiation surface having heat radiating values as before stated and that the statement of rating be accompanied by a statement of the rate of combustion and the efficiency of the boiler.

The following were elected to office for 1911: R. P. Bolton, President; J. R. Allen, first vice-president; A. B. Franklin, second vice-president; W. W. Macon, secretary and W. G. Scollay, treasurer, reëlected.

Industrial Accidents

Industrial accidents in the United States take an annual toll of life and limb far exceeding the killed and wounded of several great military campaigns. The statistics given by the *Bulletin* of the Bureau of Labor for 1908, which must be regarded as incomplete because of the failure to report fully these accidents, show a yearly mortality of between 30,000 and 35,000 adult wage earners alone, and the nonfatal injuries inflicted will roll up the total by at least an additional 2,000,000. These and other arresting statements are made by John Calder, manager of the Remington Typewriter Works, Ilion, N. Y., who will, at the New York monthly meeting of the American Society of Mechanical Engineers, 29 West Thirty-ninth street, New York, Tuesday evening, February 14, present a brief for the mechanical engineer and the prevention of accidents. Much, Mr. Calder believes, can be accomplished by a movement on the part of the profession which has to deal so largely with the planning and working of industrial machinery. Prevention, not cure, is the theme of the paper, which analyzes the causes of those accidents regarded as preventable and describes various devices for guarding equipment and processes, drawn chiefly from the writer's experience in plant management. Mr. Calder considers that one-third of the present rate of mortality can and should be eliminated by such devices. The National Civic Federation and the Industrial Safety Association, which have already done much to arouse public sentiment along this same line, will be represented at the meeting and engage in the open discussion which will follow the presentation of the paper. Both before and after the meeting the American Museum of Safety, also located in the Engineering Societies building, will open its exhibit to the public.

Under the head of safeguarding, the author has many interesting views of equipment and machinery, showing the use of such devices on gears, steam turbines, lathes, cotton carders, rolling-mill engines, transmission tubes, belts, etc. He also takes up in detail especially dangerous machines and processes which present difficult safeguarding problems for the engineer.

Advance copies of the paper may be secured for review upon application to the secretary, Calvin W. Rice.

Water Power in British Columbia

According to Consul Frank C. Denison, in the *Daily Consular and Trade Reports,* a plant for the generation of electrical power by water has been successfully inaugurated by a company of Americans at the Bull river falls, 13 miles due west of Fernie. At this point a fall of 273 feet has been obtained by the construction of a flume 9000 feet long, which takes water from the river above the falls and returns it below. A head of 273 feet with a flow of 462 cubic feet of water per second has been obtained. The flume, constructed of wood and built upon a rock foundation, is 30 feet wide by 7½ feet deep at the intake. The width is reduced to 16 feet within the first thousand feet, this width being kept to the end of the flume. The estimated horsepower that can be utilized is 12,600.

The company is now preparing to install the penstock, which is to be of steel, 9 feet in diameter, and will rest upon bed rock the whole length, at an angle of 30 degrees. The foot of the stock will rest upon a natural bed rock, and a tee-shaped cross pipe will be placed at the end of the stock in which the wheels will be placed; three wheels of 4200 horsepower each will be utilized as the demand for power develops.

Within a radius of 30 miles there are now in operation steam plants with an aggregate of 23,650 horsepower. Some of this power is used by sawmills, which will continue to employ steam on account of the cheapness of the mill waste used as fuel, but it is expected that many mining and smelting plants within reach of this new plant will discard steam for electrical power.

Within this radius there is available undeveloped water power to the extent of 30,000 horsepower, the greatest single power being at Elko, on the Elk river, 20 miles south of Fernie. This estimate does not include the possible power to be developed by damming the different mountain streams in their courses, but is confined to the power available at the various natural falls on larger streams.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

The Merrick Conveyer Weightometer

This device is for the purpose of recording the weight of coal transported on a belt or bucket conveyer.

It consists of a pair of weighing levers *L*, Fig. 1, a steelyard or beam *B*, similar in principle to those of the usual platform scale, but of special design so that a short section or portion of the conveyer can be suspended from the weighing levers.

The weight of the load on this suspended portion of the conveyer, regardless of its distribution, is at any instant automatically counterbalanced by the buoyancy of a cylindrical iron float suspended from near the long end of the weighing beam and partially immersed in a bath of mercury. Any increase or decrease of load on the levers will either raise or lower the float in the mercury until the loss or gain in buoyancy compensates for the variation in load. Fig. 2 shows how the weightometer is placed over a belt conveyer.

The function of this float is to insure that the movement of the beam from its zero position, or position when the conveyer is empty, be proportional to the weight of material at any instant on the suspended portion of the conveyer.

At the extreme end of the weighing beam is connected a totalizing mechanical integrator, which derives its other factor from the travel of the conveyer by means of suitable gearing from a band pulley on the return belt or a sprocket wheel if on a bucket conveyer.

This integrator continuously totalizes the product of two quantities, one proportional to the weight of material suspended and the other to the travel of this material. The result therefore represents the total weight of material and is plainly indicated by a register in units and tenths of units of either a short ton, long ton or metric ton.

For cases where the material handled adheres to the conveyer in a varying amount, an attachment is added that automatically counterbalances the variable weight of the empty conveyer. This avoids frequent adjustment to meet the changes in the weight of the empty conveyer and material that may adhere thereto.

This integrator consists of an aluminum disk, Fig. 3, around the periphery of which are mounted rollers that are free to revolve, and have their axes tangential to the edge of the disk, and form practically a continuous annular roller which cannot move around the disk which is fixed on a shaft that revolves in bearings on the frame. This frame is mounted with a bearing at either end so that it can rotate about an axis coincident with the plane of the disk and at right angles to the axis of the disk. On one end of this frame is an arm the extremity of which is connected by a link

Fig. 1. View of Weightometer on Belt Conveyer

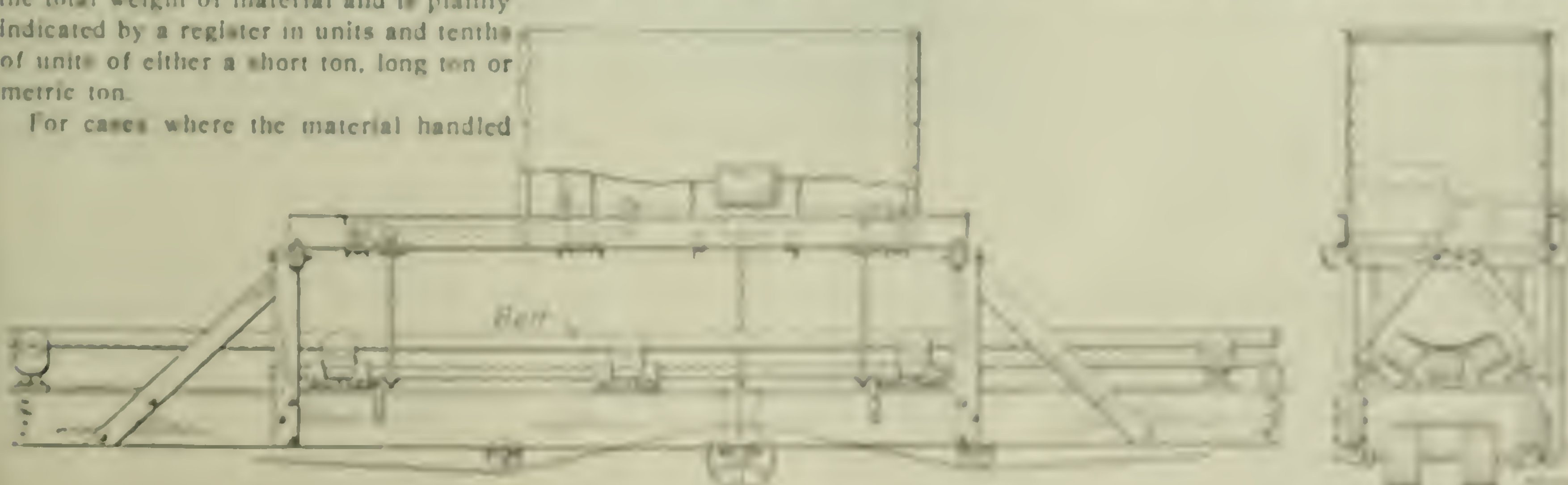


Fig. 2. Side and End Elevation of Weightometer

to the long end of the beam. Thus any movement of the beam, caused by an increase of the load on the belt, tilts the frame through an angle whose sine is proportional to the vertical movement of the float, and again proportional to the load on the suspended portion of the conveyer.

As the rollers cannot slide on the disk they will rotate it around its axis. Consequently the speed of rotation of the disk is proportional to the deflection of the beam, the movement of the float or the load on the conveyer. The amount of its motion is thus a measure of the weight of material carried by the conveyer during the period of observation. Thus the revolution counter mounted on the disk shaft will record and totalize the weight carried in any units for which the mechanism is designed.

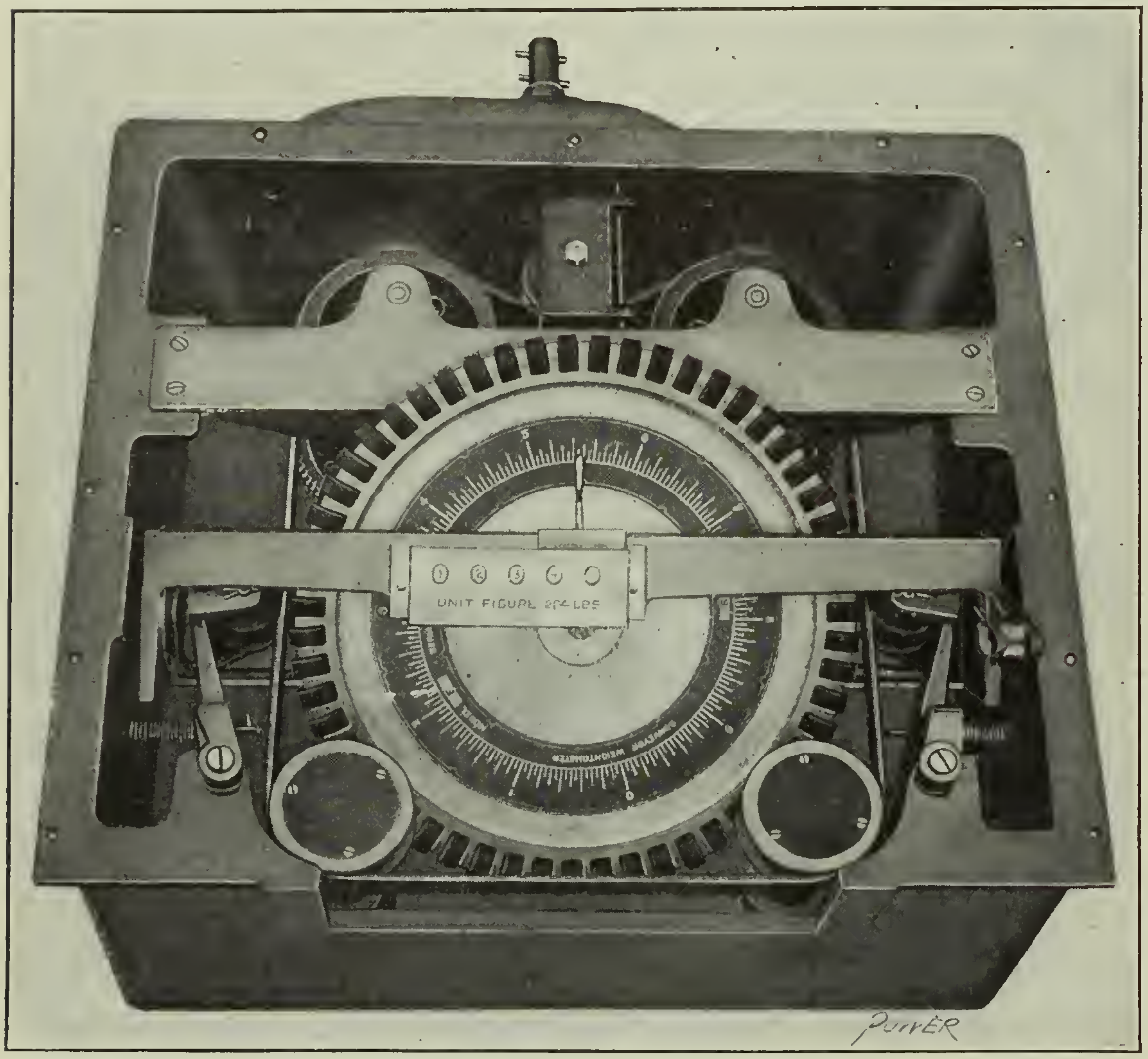


Fig. 3. Details of the Integrator

Four pulleys guide a small endless belt around the disk and touching the rollers thereon at two points diametrically opposite and on the axis of the frame.

Pressure rollers behind the belt keep the belt and disk rollers in contact. A weighted take-up pulley assures an even tension in the belt and takes care of any stretch. The two upper pulleys are geared together and are driven by means of miter gears from a band pulley under the return belt as shown in Fig. 2. The integrator belt thus travels at a speed proportional to that of the conveyer.

So long as the plane of rotation of the roller on the recording disk is parallel to the direction of the integrator belt, the motion of the latter will only affect it to the extent of revolving the roller on its own axis. This condition corresponds with the zero position of the beam or when there is no load on the conveyer. If, however, the beam is deflected by the loading of the belt, the frame and recording disk will be correspondingly tilted. This will incline the axes of the roller with respect to the integrator belt. Then, besides rotating them, the belt will push the rollers sideways across its face at a rate proportional to their inclination.

A glance at the dial when the conveyer is running empty will determine whether the dead weight of the idlers, etc., plus the weight of the belt or buckets is correctly balanced so that the net weight of the material is recorded. Should the dial remain stationary or move back and forth between two constant limits of travel the adjustment is correct. Should the dial make a plus or minus gain the proper balancing is done by means of a weight on the steelyard. This weight is carried on a screw and is similar to that on the ordinary platform scale, as turning the screw moves the balance weight.

A magnetic counter is furnished, if desired, that will duplicate the reading of the scale register in the engineer's office or at any other point distant from the scale itself and present the record right at hand. This is accomplished by a pin on the recording dial closing a circuit, thereby causing an electrical current to pass through a set of coil magnets, the armature of which is attached to a link connecting to the counting device which is located in the engineer's office.

All of the shafts within the casing and integrator turn either in ball bearings or special self-lubricating bushings, but no matter how much looseness there may be in the latter due to wear, the accuracy is not impaired as the travel of the small belt is not reduced. The speed of the integrator belt is only about 30 feet per minute and therefore the pulleys and rollers on the disk rotate slowly, resulting in but very slight wear after long service. Because of the large diameter of the disk, the wear of the rollers on their pins causes only an almost inappreciable error.

As all parts are inclosed in a removable sheet-iron casing, Fig. 4, unauthorized persons are prevented from having free access to the apparatus, and the dust and dirt always present around conveyers, which would quickly impair the efficiency of any exposed mechanism, is thus kept away from the working parts of the device.

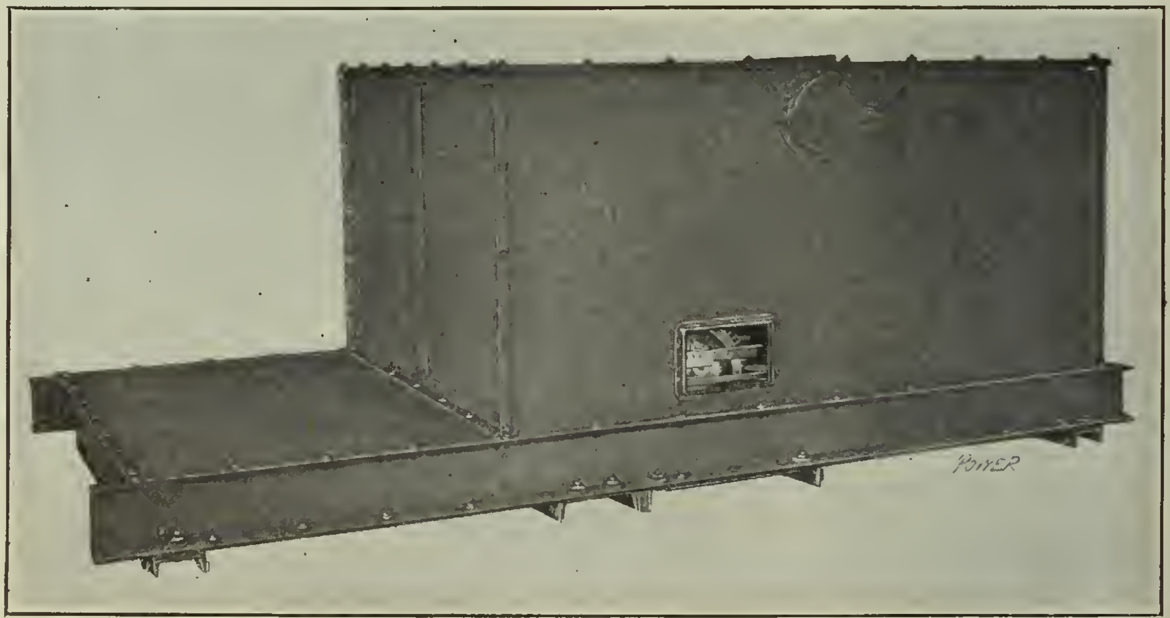


Fig. 4. Weightometer with Casing in Place

This weightometer is manufactured by Herbert L. Merrick, Passaic, N. J.

Correction Note

In the issue of December 20, mention was made of the flow past the seat of the Nelson blowoff valve. One of the special features of this valve is that it has no seat, as may be readily seen from the cut which accompanied the description. In the same article an older form of the Powell blowoff was shown. The latest or "cyclone" self-cleaning valve will be described in the near future.

Mechanical Engineers Give Reception to Captain of "Celtic"

An informal committee of the 1910 transatlantic party of the American Society of Mechanical Engineers entertained Capt. A. E. S. Hambelton, of the "Celtic," at luncheon on January 17 at the Engineers' Club, New York City.

The "Celtic" was the ship upon which the mechanical engineers went to England last summer at the time of their joint meeting with the Institute of Mechanical Engineers at Manchester, Eng.

The luncheon to Captain Hambelton was given as a token of the high esteem in which he is held by the members of the party.

Prof. F. R. Hutton, as director of ceremonies, extended the felicitations of the members to the captain in the shape of a wish that he may continue to meet with the success he so well deserves.

Those who attended are: F. R. Hutton, Capt. A. E. S. Hambelton, Jesse M. Smith, Leonard Waldo, F. B. Gilbreth, John Platt, C. E. Davis, S. L. Moore, G. M. Bond, L. C. Marburg, Augustus Smith, G. A. Orrok, C. W. Rice, E. D. Meier, C. H. Corbett and H. B. McCreery.

Boiler Flue Blows Out

Another boiler accident in Missouri emphasizes the necessity of rigid boiler-inspection laws in that State. It is reported by Albert Dedrick that on January 20, several flues in an old boiler in a flour mill at Union Star, Mo., failed. The engineer had a narrow escape from death, having only a few minutes previous stepped to the rear of the boiler to make some minor repairs. One flue went out through the front flue sheet and landed several hundred feet away. As luck would have it, no one was hurt. An examination showed that the boiler was old and the flues were in such condition that they should have been replaced long ago.

Pabst Brewing Company Wins Boiler Explosion Suit

In the case of the Pabst Brewing Company versus the Hartford Steam Boiler Insurance and Inspection Company, just tried in Milwaukee before Judge A. T. Sanborn, of the western district of Wisconsin, the jury brought a verdict in favor of the plaintiff for $98,400 with interest from December 1, 1909. The case was immediately appealed. Full particulars will be given in a later issue.

BOOKS RECEIVED

AUTOMOBILE MECHANICIANS CATECHISM. Published by Frederick J. Drake & Co., Chicago, Ill. Leather cover; 110 pages, 4[illegible]x6[illegible] inches; illustrated plates; indexed. Price, $1.25.

THE MECHANICAL WORLD ELECTRICAL POCKETBOOK FOR 1911. Published by Emmott & Co., Ltd., Manchester, Eng. Cloth; 208 pages, 3[illegible]x6 inches; 68 illustrations; tables. Price, sixpence.

Valuable Reference to Technical Press

The International Institute of Technical Bibliography is publishing a monthly index to the world's technical press, covering technical periodicals, new books and the proceedings of learned societies. The first volume has now been completed. To create an English and American center, the institute has recently founded a special branch in London, 57 Chancery lane, whence the English and American editions are sent out. The value of the publications may be best explained by reprinting an appreciation of them by E. Wyndham Hulme, chief librarian of the English patent office, which appeared in the *Library Association Record*.

"By some freak of fortune practical England has for the last half century stood out as the champion of the indexing of the periodical literature of pure science, while to philosophic Germany belongs the credit of having maintained for the same period an annual index of the corresponding literature of the applied sciences. Not many years ago the Royal Society's *Catalogue of Scientific Papers* was handed over to the control of an International Council with regional bureaus, and today we have to chronicle a similar reorganization of the "Poole" of technical periodical literature, viz., the *Repertorium* of the imperial patent office of Berlin. This hardy annual has in its turn been transferred to an International Institute of Technical Bibliography, organized on lines similar to those of the International Council. The first step taken has been to transform the publication into a monthly, and to extend it by the inclusion of book notices. From the beginning of the past year the index has been published in six sections dealing respectively with 1, mechanical; 2, civil; 3, electrical engineering; 4, mining and metallurgy; 5, applied chemistry; 6, matter not included in the preceding sections. A further section dealing with the naval, military and aëronautical sciences has also appeared recently. These monthly sectional indexes or *Abstracts*, as they are termed, will be consolidated at the end of each year in one general alphabet. The first of these annual publications for the year 1909 has just appeared in two volumes. The classification of the deceased *Repertorium* was on dictionary principles, the titles, headings and index being in German, English and French, while the entries were compiled in the language of the articles indexed. The new publication follows closely on the old lines, except that the monthly sections have their headings arranged in class order, with a synopsis of the classification prefixed to each number.

"The life of the German edition is practically guaranteed by subscriptions from the state department, professional societies and manufacturing firms of Germany. But the fate of the English edition must be regarded as conditional upon the support received in these countries."

SOCIETY NOTES

The ninth annual reception and banquet of the combined associations of the National Association of Stationary Engineers of Greater Pittsburg was held on Thursday evening, January 26. Over 400 of the members and guests, including both sexes, gathered about the tables in the large dining hall of the Monongahela house and enjoyed an appetizing dinner.

After the banquet was served, an entertainment was given by the Duquesne quartet; J. C. Usher, Crandall Packing Company; Billy Murray, Jenkins Brothers; Frank Corbett, Consolidated Valve Company, and Jack Armour, of POWER. Dancing followed and concluded a most enjoyable and successful occasion.

With the new year the National Electric Light Association has taken another leap forward in membership and on January 21 crossed the 6500 line. This is a gross gain of over 1500 since the St. Louis convention and a net gain of about 1250. The Canadian Electrical Association voted recently to affiliate with this body and this will also bring a large accession; while new company sections are being formed in Pittsburg, Allegheny City, Scranton, Connellsville, Penn., and other cities. H. H. Scott, the chairman of the membership committee, estimated that 7000 members will be enrolled by the end of January and that the number may easily be 8000 by the next annual convention in June. Fifteen months ago the membership was slightly over 3000. A number of smaller central stations are included in the new membership.

Tom Blowoff takes a "leap" with [illegible]. His boss told him that they [illegible] [illegible] [illegible] in a [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

Cleveland No. 5 Honors Past President William Powell

It has been the practice of the National Association of Stationary Engineers in recent years to present the retiring national past president with a past officer's jewel. At the last convention it was voted to present such badges to the living past presidents of the association who had not thus been honored.

On Saturday evening, January 28, Cleveland Association No. 5, of which Past National President William Powell is an old and honored member, held a special meeting for the formal presentation of this jewel.

There were present Past National Presidents John W. Lane and Robert E. Ingleson, many State and subordinate officers and State examiner of engineers Haswell. There were large delegations from the two other Cleveland associations, as well as a big representation from the other Ohio associations, justifying the claim of Chairman J. E. Radigan that this was the largest and most important gathering of Ohio engineers that has been held outside of a State convention.

After the adjournment of the regular meeting, the company proceeded to the dining hall, where Mr. Powell was seated at the head of the table and presented with the jewel of past president of local association No. 5, and then with the national emblem. Mr. Powell was visibly affected by this expression of appreciation of his past services, and in his speech of acceptance reviewed in an interesting way the conditions of the engineer before the organization of the National Association of Stationary Engineers, and some of the earlier activities of the association.

Brief remarks from many others in attendance enlivened the proceedings and extended the program well into the night.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

BOILERS, FURNACES AND GAS PRODUCERS

FURNACE FOR WATER-TUBE BOILERS. Alfred Smallwood, London, Eng. 981,699.

WATER-GAS PRODUCER. Bernhard Spitzer, Frankfort-on-the-Main, Germany, assignor to the Corporation of Dellwik-Fleischer Wassergas-Gesellschaft, m.b.h., Frankfort-on the-Main, Germany. 981,708.

WATER-TUBE BOILER. Darwin Almy, Providence, R. I. 982,198.

STEAM GENERATOR. Jean Van Oosterwyck, Liege, Belgium. 981,722.

POWER PLANT AUXILIARIES AND APPLIANCES

COMBINED FEED WATER HEATER AND GRATE. Gustav Beyer, Fort Sill, Okla. 981,609.

BOILER-CLEANING DEVICE. Laurence Smith and George D. Mullihan, Webb City, Mo. 981,701.

CRUDE-OIL BURNER. John A. Scott, Joseph F. Grubbs, and John E. Goss, Oklahoma, Okla. 981,801.

HOSE COUPLING. Samuel R. Lockhart, Buna, Tex., assignor of one-half to Stephen E. Milsted, Buna, Tex. 981,866.

FEED-WATER HEATER. Edward T. Turner, Dayton, Ohio. 981,901.

METALLIC PACKING. William M. Brooks, New York, N. Y., assignor, by mesne assignments, to Premier Engineering and Manufacturing Company, New York, N. Y., a Corporation of Delaware. 981,912.

PIPE UNION. Josiah Boone Austin, San Diego, Cal. 982,028.

GATE VALVE. Adoniram J. Collar, Yreka, Cal. 982,036.

VALVE. George Wilkinson, Philadelphia, Penn. 982,108.

VALVE. Henry R. Adams, Bridgeport, Conn. 982,109.

OIL CAN. Madel T. Axelton and William C. Axelton, Graettinger, Iowa. 982,114.

PRESSURE REGULATOR. Tom William Brown, London, England, assignor of one-half to Frederick Charles Tilley, London, England. 982,123.

OIL BURNER. Henry N. Kellar, Kiefer, Okla. 982,141.

OIL BURNER. Charles W. Wright, Hobart, Okla. 982,167.

ROD PACKING. Thomas A. Johnston, Chadron, Neb., assignor of one-fourth to Thomas L. Finley, Long Pine, Neb. 982,182.

PRIME MOVERS

INTERNAL COMBUSTION ENGINE. Eldridge W. Stevens, Baltimore, Md. 981,811.

ROTARY ENGINE. Robert Ford Courtenay Keats, Portsmouth, Eng. 981,862.

OSCILLATING WATER MOTOR. Robert C. Smith, Oak Park, Ill. 981,889.

INTERNAL COMBUSTION ENGINE. Clark Sintz, New Orleans, La., assignor of fifty-one one-hundredths to William A. Gordon, New Orleans, La. 981,952.

INTERNAL COMBUSTION MOTOR. Clyde J. Coleman, New York, N. Y., assignor to Rockaway Automobile Company, Rockaway, N. J., a Corporation of New Jersey. 981,978.

MOTOR. Charles E. Godlove and James L. Van Nort, St. Louis, Mo.; said Van Nort assignor, by mesne assignments, to said Charles E. Godlove, St. Louis, Mo. 981,995.

ROTARY ENGINE. Clarence E. Clapp, Buffalo, N. Y. 982,035.

ROTARY ENGINE. Edward Hager, Buffalo, N. Y. 982,054.

WATERWHEEL MECHANISM. Thomas A. Macdonald, Clifton, N. J., assignor, by direct and mesne assignments, to Macdonald Hydraulic Power Company, a Corporation of New Jersey. 982,079.

CURRENT MOTOR. James H. Martin, Springfield, Mo. 982,154.

ELECTRICAL INVENTIONS AND APPLICATIONS

ELECTRIC SWITCH. Howard R. Sargent, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 981,692.

ELECTRIC LOCOMOTIVE. Wm. Schaake, Pittsburg, Penn., assignor, by mesne assignments, to Westinghouse Electric and Manufacturing Company, East Pittsburg, Penn., a Corporation of Pennsylvania. 981,799.

ELECTRIC CONTROLLER. Arthur C. Eastwood, Cleveland, Ohio, assignor to the Electric Controller and Manufacturing Company, Cleveland, Ohio, a Corporation of Ohio. 981,847.

ALTERNATING-CURRENT POTENTIAL SWITCH. David Larson, Yonkers, N. Y., assignor to Otis Elevator Company, Jersey City, N. J., a Corporation of New Jersey. 981,930.

MOTOR CONTROL. William N. Dickinson, Jr., New York, N. Y., assignor to Otis Elevator Company, Jersey City, N. J., a Corporation of New Jersey. 982,041.

ELECTRICAL SYSTEM FOR THE SUPERVISION OF WATCHMEN. Albert Goldstein, New York, N. Y., assignor to International Electric Protection Company, a Corporation of New York. 982,052.

ALTERNATING-CURRENT MOTOR CONTROL. John D. Ihlder, New York, N. Y., assignor to Otis Elevator Company, Jersey City, N. J., a Corporation of New Jersey. 982,067.

SOLENOID-OPERATED SWITCH. Henry L. Smith, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 982,100.

POWER PLANT TOOLS

WRENCH. Harry Horsman, Jamestown, Cal. 982,064.

RATCHET WRENCH. Walter Gartze, Solingen-Mangenberg, Germany. 980,626.

WRENCH. Charles Andrew Hartvigsen, Salinas, Cal. 980,632.

WRENCH. Joseph T. Humphries, Oakville, Tex. 980,786.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York. Next meeting in New York City, May 29 to June 3.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., Prof. J. D. Hoffman; sec., William M. Mackay, P. O. Box 1818, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting at Detroit, Mich., January, 1912.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION.

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

POWER

NEW YORK, FEBRUARY 14, 1911

FOR over a year this page has been a feature of the paper. It was designed to bear a message to the man who is doing things or, at least, trying to do them.

Endeavor is made to make the language as near "human" as possible, and to point a moral or illustrate a truth in a way calculated to be emphatic as well as entertaining.

We are receiving regularly ample, unsolicited testimony that our efforts have met with approval. As soon as this ceases to be apparent this editorial leader will be dragged off to Barren island as a "dead one" and the space which it occupies will be given over to something more desirable to the readers. For, is not this the reader's paper?

Although the editor might get a wealth of comfort and enjoyment out of writing this weekly "whirl," yet would he have to forego it at the instant that the spectators turned down their thumbs on his handiwork.

And don't you know that what is true of the editor's work is just as true of your own, no matter what your work may be? The instant that you stop "delivering the goods" you're on the greased slide and a swift slip to the discard is imminent.

A certain successful member of the race which is noted for business shrewdness was in the wholesale clothing business. One of his salesmen seemed to feel that every time he came in from a trip it was necessary to make elaborate explanations why the orders he had received were not more numerous.

So he would take up an hour or two of his employer's time telling how this man was all stocked up, and wouldn't buy; how that one was putting in a line of cheaper goods, and so on. Always the lack of orders was no fault of the salesman. Finally, toward the end of one of these sad seances, the manufacturer stopped the flow of excuses with the terse remark, "Well, Mr. Lowen, what we want is orders."

He might have said "results" and meant the same thing. Everywhere, in power-plant operation as well as in any other line of work, RESULTS are the things upon which a man's worth is based.

It makes no difference what you might, could, would or should have done, it is what you actually did do that tells.

In the long run you are weighed by your work—not by your words.

Modern Boiler Plant, Holyoke, Mass.

By Warren O. Rogers

A central station, replacing three smaller boiler plants, reduced the operating expenses $75 a day. In the new plant the engineer can read the temperature of the flue gases, of return water from the mills and of the feed water, also the percentage of CO_2 in the flue gases without stepping from his office. The coal consumed is automatically weighed as it is conveyed to coal bunkers, and the weight is registered in engineer's office.

Present tendencies are to centralize the boilers and engines of manufacturing plants and use electric drive, especially where the buildings are scattered over a large area.

To secure the economies available through consolidation, the American Writing Paper Company, Holyoke, Mass., decided to erect a central steam-generating plant, of sufficient capacity to supply all the steam necessary to operate three separate paper mills, which were equipped with separate steam plants of from 600 to 1200 horsepower capacity.

This work was designed and installed by the company's engineering department under the direction of Edward P. Butts, chief engineer of the company. As a result, although aiming to keep the first cost down to a minimum, the plant stands a model for simplicity of design and ease of operation.

By means of this new plant the cost of operation, including labor, fuel and supplies, has been reduced $75 per day, or from $20,000 to $25,000 per year.

The boiler plant consists of six 400-horsepower Babcock & Wilcox boilers, based on 10 square feet of heating surface per horsepower. These boilers do the work formerly done by nineteen small boilers in the old plants. The boilers are operated constantly at 25 per cent. above their rating in order to obtain the best efficiency from them.

Murphy stokers are used, the grate area being 80 square feet, with a ratio of fifty to one. There has been no trouble in burning 30 pounds of coal per hour per square foot of grate surface and the plant operates practically with no smoke.

These boilers are set in three batteries, of two each, as shown in Fig. 1. A permanent iron stairway and rail has been placed at one end of the boilers and, as a platform extends the length of the boiler settings, the firemen can easily get at the coal chutes or fixtures on the front of the boilers.

In order to eliminate air leakage into the furnaces through the brick settings, the side walls of each battery have been lined with a magnesia covering. The tube blow-hole plates are fitted with a sheet-iron cover which prevents air leakage at these points. These features are shown in Fig. 2.

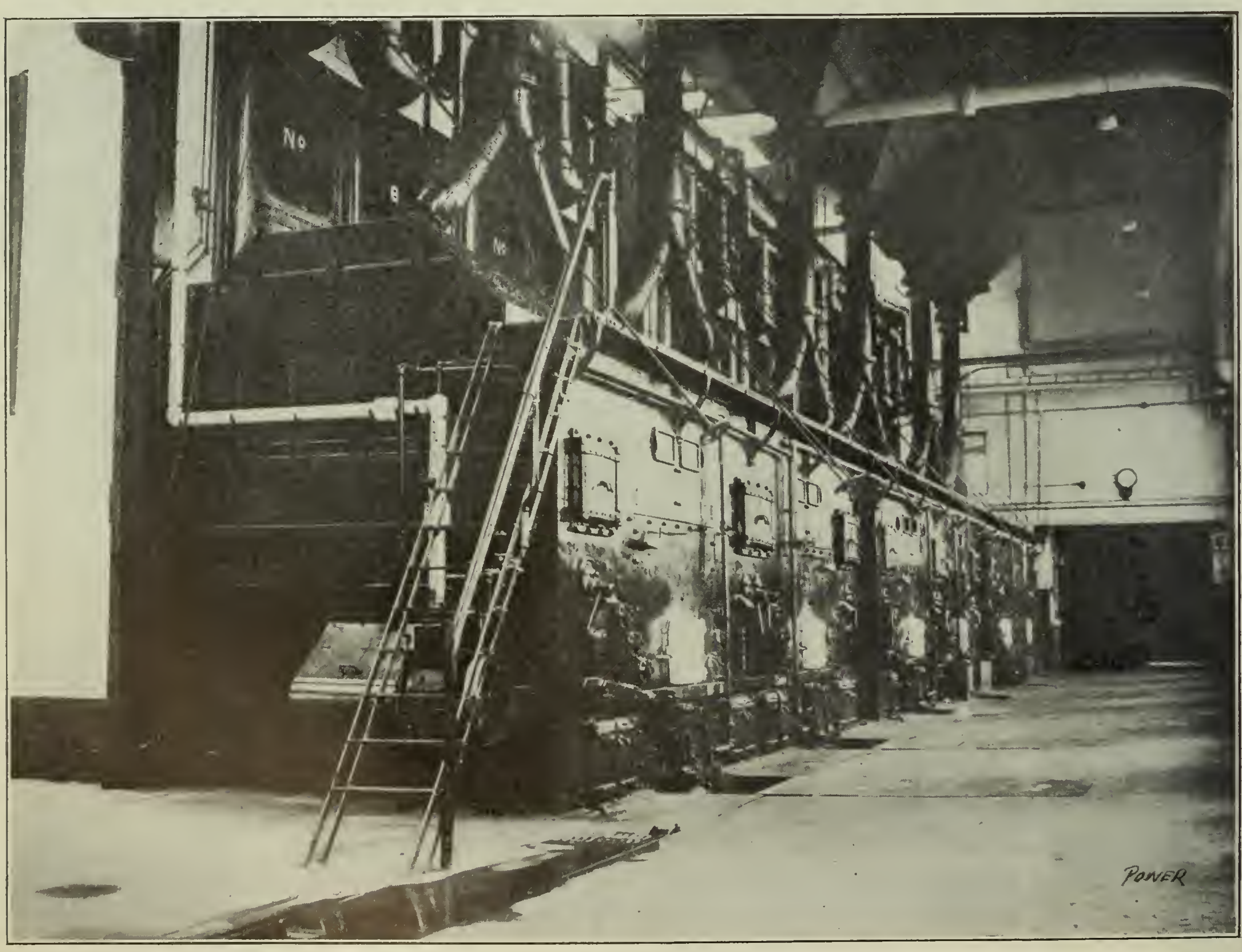


Fig. 1. New Boiler Room of the American Writing Paper Company

Each boiler smoke flue is fitted with a damper, but the draft is controlled by a main damper placed in the main smoke flue, between the stack and the junction of the individual smoke flues. This damper arrangement is peculiar, but effective. Instead of having a bearing on both sides of the smoke flue, the damper is suspended by means of an iron beam, placed crosswise over the top of the flue, an eyebolt, three large iron links and a short length of chain. The details are shown in Fig. 3.

FIG. 2. SHOWING MAGNESIA COVERING ON BOILER SETTING

The damper is connected to the damper regulator by means of a rod, as shown. Suspending the heavy damper on rings and chain has the advantage of allowing it to turn on a very small bearing point, thus eliminating friction and permitting free operation. In order to prevent the damper sticking to the side and top of the smoke flue, a clearance of 1½ inches at the top and bottom has been allowed.

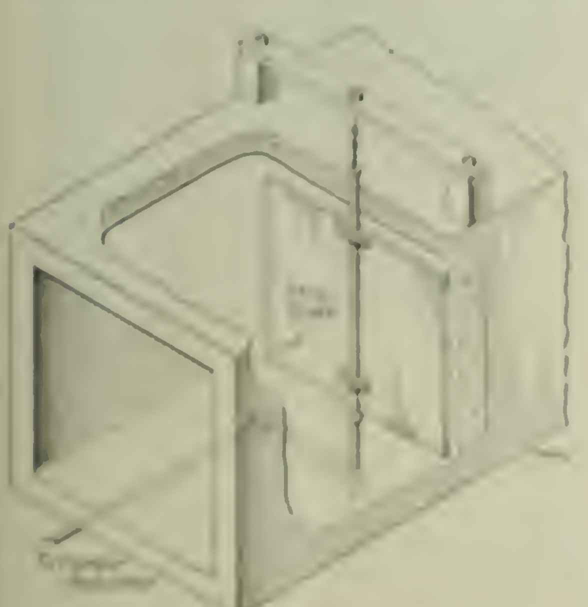


FIG. 3. DETAIL OF DAMPER ARRANGEMENT

FIG. 4. VIEW BACK OF THE BOILERS

An iron stop is secured to the side of the smoke flue, and so placed that the damper rests against it before it is entirely closed. These precautions prevent any possibility of the damper sticking when closed and shutting down the entire plant.

Fig. 4 presents a view of the alley back of the boilers, showing the arrangement of the smoke flue, damper regulator on the wall and blowoff pipes, of which there are two lines for each boiler; double blowoff valves are used. An iron spiral stairway gives easy access to the top of the boilers.

These boilers generate saturated steam at 150 pounds pressure per square inch, although designed for 200 pounds with provision for using superheaters at some future time, should it be deemed advisable. Considerable thought was given to the subject of superheating the steam, which is carried to the mills several hundred feet distant, but as the steam was to be reduced to 100 pounds pressure for factory uses there was but little benefit, if any, to be derived from superheating at the boilers, and it was decided that the steam in passing through the reducing valves into receivers would be superheated to some extent. As it is, the steam goes to the factory in a dry state.

The ashpit of each boiler is made with a semi V-shaped bottom. This enables the fireman to hoe the ashes out into the 6-inch inlet pipe of the Darley vacuum ash-conveying system. The main ash tube, which is 5 inches in diameter and 170 feet long, empties into an ash tank located at one end of the building and above the top level of the boilers. A 14-ounce [illegible] carried on the system is maintained by a fan direct coupled to a Curtis steam turbine.

As the 6-inch inlet ash pipe is placed under an iron section of flooring outside of the furnace fronts, it is necessary for the men to hoe the ash from the ashpit into the cement opening over the ash pipe. This pipe could have been placed under the ashpit, but it would have added to the cost of installing the system and also loss of draft when the system was in operation, and with no additional saving in labor. This system was put in on a guarantee to handle 300 pounds of ash per minute, and it will handle anything that will go through a 6-inch pipe.

Figs. 2 and 5 give a good idea of the piping layout over the boilers. The flanges are screwed onto the pipe; the ends of the pipe are then peened over and faced. A walkway at the rear of the boiler extends the length of the boiler settings, and there are steps leading to the top of the steam drums.

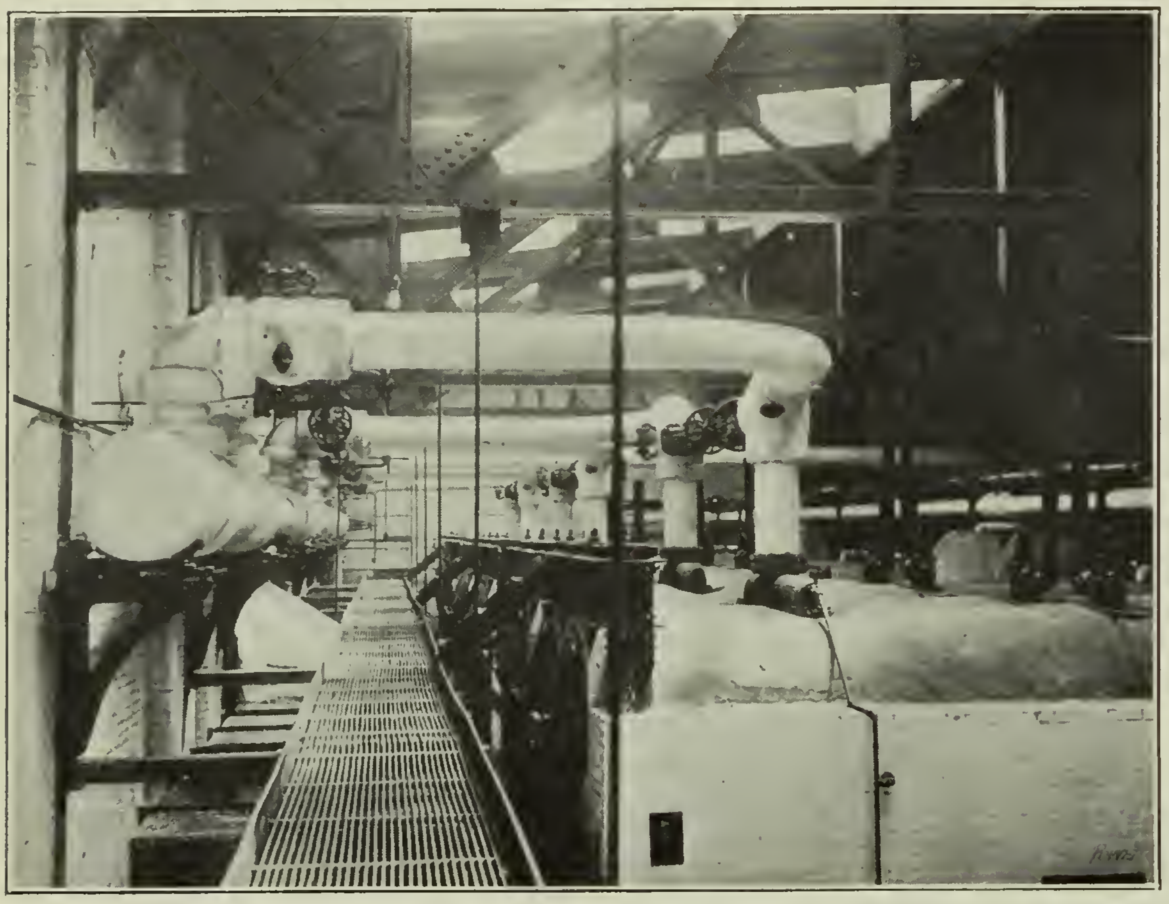


Fig. 5. Layout of Piping Over the Boilers

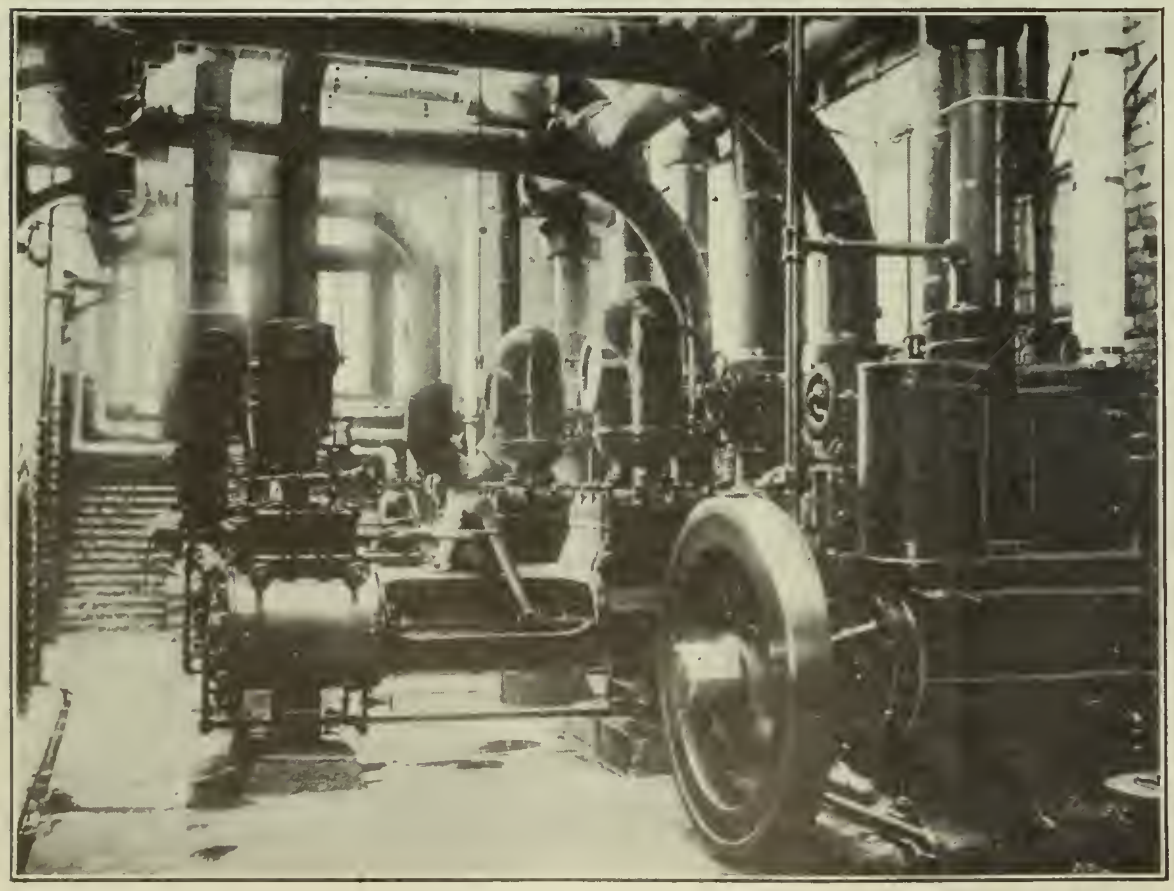


Fig. 6. Auxiliary Units

Water may be fed to the boilers by means of either one of the two Deane 12 and 7 by 12-inch duplex pumps. Each is fitted with an air chamber to prevent pulsation in the Venturi meters. There is also a Worthington four-stage centrifugal pump, direct coupled to a Terry steam turbine, which runs at a speed of 2000 revolutions per minute. The turbine-driven pump is used 24 hours a day with an occasional shutdown while the duplex pumps are being tried out to be sure they are in running condition; they are kept as emergency units. A Westinghouse engine furnishes power to operate the coal-conveying system. These auxiliary units are shown in Fig. 6.

There are six concrete-lined steel coal bins over the boilers, each having a capacity of 20 tons. The construction of the lining of these bins is rather interesting. Owing to the deteriorating action of moisture and sulphur on steel, these bins are lined with cement. Channel irons are placed on the inside of the steel casing and held in place by bolts and nuts, as shown in Fig. 7. On the outside of the channel iron is placed a layer of wire lathing which is held in place by nuts. Over this iron lathing, and filling up the space between it and the outside steel casing of the bin, is a thick coating of concrete made of a one to three mixture of cement and sand, worked hard in order to get a smooth surface.

Fig. 7. Construction of Coal Bunker

Coal is delivered to these bins from either coal cars or from the reserve supply in the yard by means of a Robins belt conveyer. Fig. 8 illustrates the method of handling the coal. This belt conveyer is 250 feet long and is driven by means of a shaft which is belted to the 60-horsepower Westinghouse engine located in the pump room. The shaft is placed underground and also supplies power for the coal-crushing rolls. Fig. 8 also shows a coal car in position over the chute and hopper leading to the crushing rolls. After the coal is crushed it is elevated to the top of the conveyer tower and is either carried to the coal bins over the boilers or is discharged onto the reserve pile in the yard, where about 2000 to 3000 tons are kept on hand for emergency. The coal flowing from the bins to the stokers through iron chutes regulates itself, as the supply banks up in the spouts as soon as sufficient coal has run down.

When it is desirable to discharge the coal into the yard, the *A* frame controlled from the yard level and shown in Fig. 8, is placed above the point where it is desired to dump the coal, and the unloading device on the conveyer set so that the coal will be discharged on both sides of the belt. Under the conveyer shed is a line of hoppers leading to an underground conveyer so that the supply in the yard can be elevated and carried to the boiler room. When the coal in the immediate vicinity of the opening has been used the outlying coal must be shoveled into the underground hopper or moved in some other way.

To reduce this labor to a minimum a portable conveyer, made something as shown in Fig. 9, is used. It consists of a long framework set on a pair of iron wheels. A 3-horsepower motor is suspended and boxed in under the frame. The belt conveyer and supporting rolls are placed on top of the framework, the belt running over rollers placed at each end of the frame. One roll shaft is fitted with a sprocket wheel which is belted to a similar wheel on the motor shaft. A stationary hopper is fixed at one end of the frame into which the coal is shoveled.

When in use, the hopper end is placed farthest from the underground conveyer and the portable conveyer set in a horizontal position. Six men can shovel into the hopper and the belt will take care of the coal without trouble. This device saves considerable labor in case coal from the outer edge of the coal pile must be used. The belt runs at a speed of about 300 feet per minute.

The coal is weighed on a Merrick scale or weightometer and a Merrick coal-weight recorder is placed in the operating engineer's office, each dial representing 200 pounds, 2 tons or 10 tons. A record is made by a pin on a revolving disk on the scale, closing a circuit and causing an electrical current to pass through a magnet coil which draws an armature down and revolves the first unit of the counter, and for every contact made the register is advanced one number, as in the case of a revolution-counting recorder. The accuracy of this combination scale and record is apparent when it is stated that a difference of only ½ of 1 per cent was found in weighing thirteen million pounds of coal as invoiced by the shipper. An average of 15,000 tons of Clearfield coal, containing 14,000 B.t.u. per pound, 9 per cent. ash and 1½ per cent. sulphur, are burned per year.

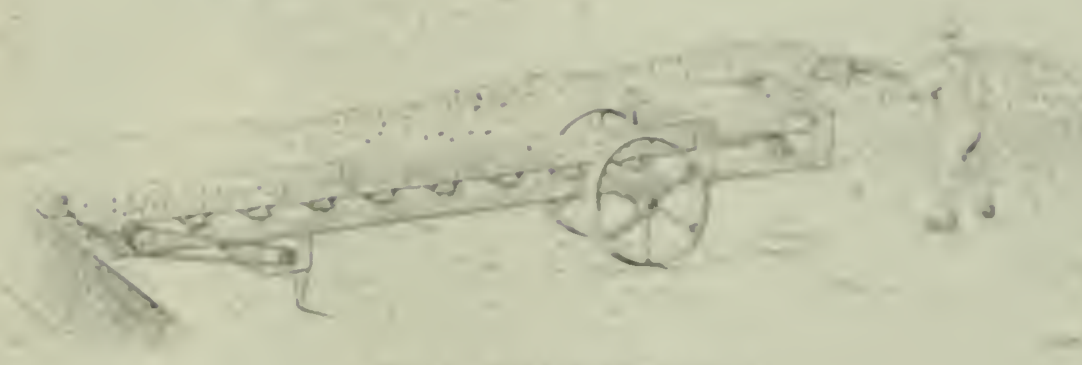


Fig. 9. Portable Conveyer

Above the boiler and overlooking the firing alley is the operating engineer's office. Here are placed the recording instruments which enable him to tell at a glance the temperature of the flue gases from each boiler and also of the gases in the main flue, temperature of the return water from the coils through the various pipe lines, the steam pressure carried and the amount of water being used.

Fig. 10 shows one corner of the office and the board on which the temperature-recording instruments are mounted.

The top central dial is the clock; the two small gages at each side are the feed-line pressure gage and vacuum gage on the ash vacuum system. At the left is shown a combination steam and recording gage, and at the right of the board is shown the draft-recording gage. The switch arrangement at the bottom of the board represents an arrangement that is unique in every detail. The switches are for the purpose of closing a circuit between the electric couples on the return hot-water line, feed-water lines, uptake for each boiler and the main smoke flue. These switches are of the double-throw type because it is the intention to install continuous recording instruments at some future date.

The Wilson-Maculen Company designed the present system. It consists of two Wilson electric indicating instruments, shown just below the two larger recording gages. One terminal of each instrument is connected to a line leading to the electric couple, the other terminal of each instrument is connected to the upper contact jaw of the switch of the couple to be tested. The center or pivot post of the switch is connected to the grounded end of the electric couple.

All that is necessary in order to ascertain the temperature of any return line or uptake temperature is to throw the switch corresponding to the right electric couple so as to form an electric circuit through the indicating instrument. No two couples can be connected to the instrument at one time, so the chances of error are entirely eliminated in case two or more switches should be thrown at the same time. The couples on the water lines are of the compound type; the temperature of the flue gases is obtained by simple couples. There are three return water lines from the coils and two feed lines to the boilers, one being used as an alternative line. The thermo-couples for the flue gases are located in the smoke flue at the rear of each boiler. The average temperature of the main-flue gases is 500 degrees Fahrenheit.

A feed-water temperature of 190 degrees is obtained after passing the feed through a heater. With a temperature of 80 degrees on the grounded end of the thermocouple the readings for the various boilers vary but 25 degrees the

Fig. 8. Coal Conveyer and Coal-storage Yard

all seasons of the year, but simple adjustments for season change reduce the variations in the readings to 5 degrees.

The water consumption for the six boilers runs as high as 100,000 pounds per hour, this volume fluctuating with the stage of water supplied to the water-wheels, with which the three mills are equipped.

The amount of water consumed in the plant is recorded by a Venturi water meter that is located in the office. The chart scale is graduated into thousands of pounds per hour, and the total amount is measured by a planimeter on daily charts. Each feed line is equipped with a Venturi meter and a third meter is connected to a bypass feed line, as shown in Fig. 11. This allows running any one boiler on a test, and the amount of water used is metered without interfering with the total amount of water passing through the meter in the main feed line. For instance, suppose all of the water being used by the boilers is being passed through the meter on feed line No. 1. If a test is to be made on a single boiler, the valve on feed line No. 1 between the meter and the boiler to be tested is closed and the regulating valve on feed pipe No. 2 opened. The valves *A*, *B*, *C* and *D* are open and valves *E*, *F* and *G* closed. The flow of water to the boiler being tested would be through the main feed line No. 1, the meter *M* and valves *A* and *B*, meter *N* and valves *C* and *D*

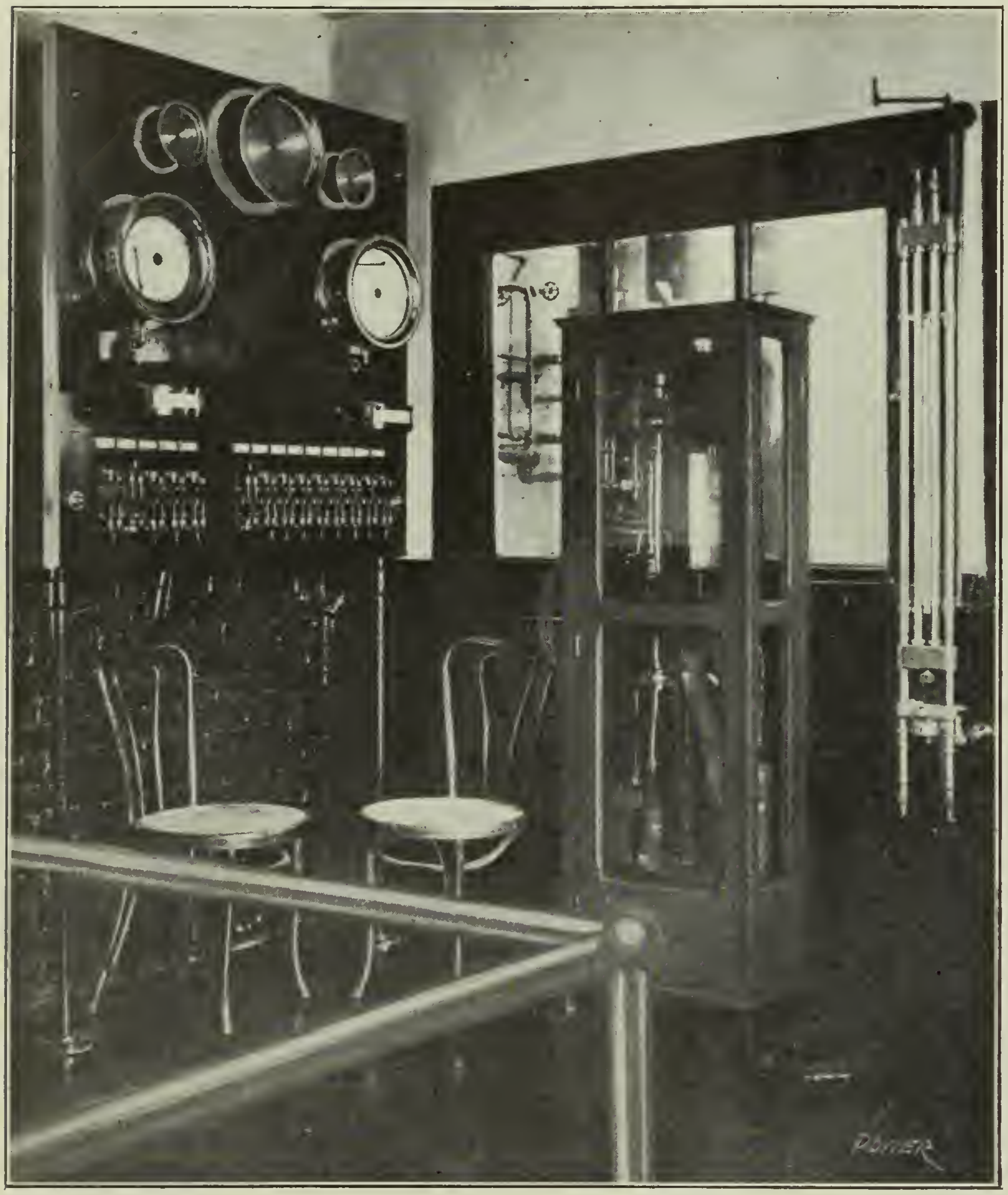


Fig. 10. Partial View of Engineer's Office

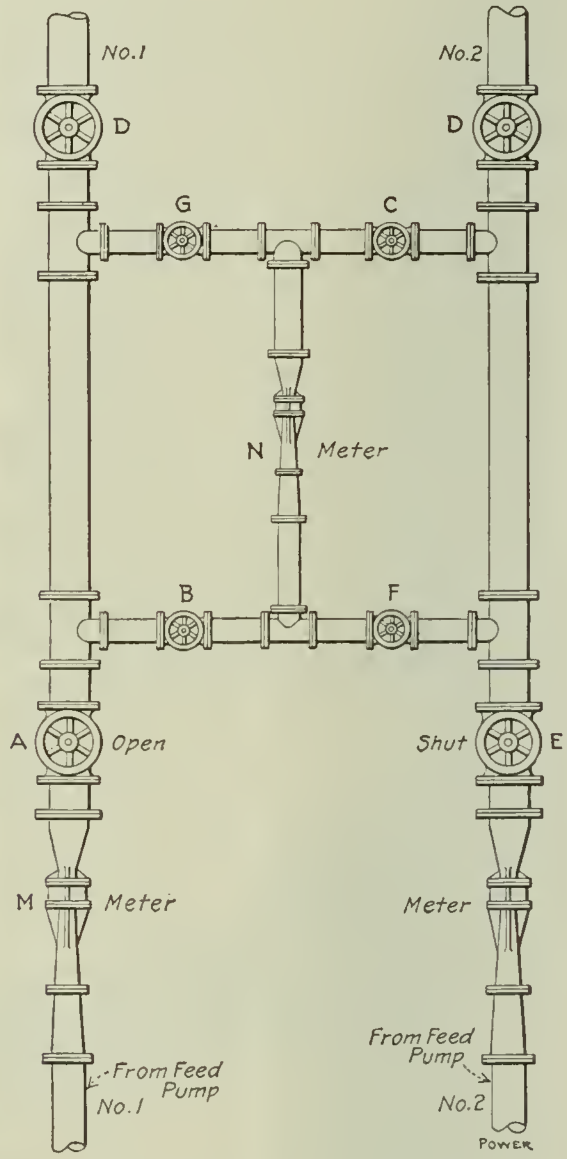


Fig. 11. Arrangement of Meters and Feed Pipes in Pump Room

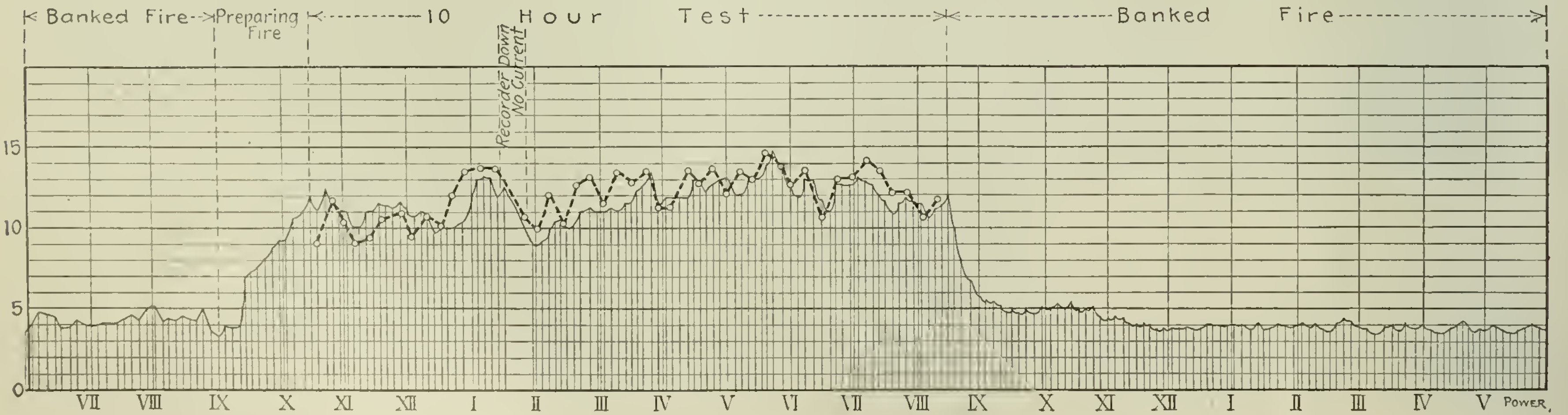


Fig. 12. Comparative Records of CO_2 Content in Flue Gases

BOILER TEST.

AMERICAN WRITING PAPER COMPANY,

DEPARTMENT OF MANUFACTURING AND MAINTENANCE

HOLYOKE, MASS.

Date June 21, 1910

Made by	E.L. Small & J. R. Fortune		
At	Central Boiler Plant "A"		
On boiler No.	2 - B & W. 196 - 4" tubes 18'-0" long, 3 drums 42" dia x 20'-4" lg.		
To determine	Efficiency of Murphy Furnace.		
Kind of fuel	(Empire) Bituminous Coal		
Kind of furnace	Murphy Stoker.		
Method of starting and stopping		Alternate	
Grate surface	sq. ft.	64 or 80	
Water heating surface		4000	
TOTAL QUANTITIES			
Date of trial		6-21-10	
Duration of trial	hrs.	10	
Weight of coal as fired	lbs.	20220	
Percentage of moisture in coal	%	7	
Total weight of dry coal	lbs.	18804	
Total ash and refuse	lbs.	1694	
Percentage of ash and refuse in dry coal	%	9	
Total weight of water evaporated	lbs.	198893	
Factor of evaporation		1.0968	
Equivalent evaporation from and at 212 degrees	lbs.	218145	
HOURLY QUANTITIES			
[illegible]	lbs.	1880	
[illegible]	lbs.	23.5 or	29.38
[illegible]	lbs.	21814.5	
[illegible]	lbs.	5.45	
AVERAGE PRESSURE, TEMPERATURE, ETC.			
[illegible]	lbs.	144	
[illegible]	deg.	165	
[illegible]	deg.	570	
[illegible] .568			
[illegible] Inside of back	%	12.1	Average of 45 samples
[illegible] nipples	%	0.3	" " 21 "
[illegible]	%	7.2	" " 21 "
HORSE POWER			
[illegible]	H.P.	631.	
[illegible]	H.P.	400	
[illegible]	%	157	
ECONOMIC RESULTS			
[illegible]	lbs.	11.60	
[illegible]	lbs.	12.75	
COST OF EVAPORATION			
[illegible]	$		
[illegible]	$		

REMARKS:

to the feed line No. 2 and into the boiler. This allows the entire amount of water used in all boilers to pass through the meter M, but the water used in the boiler being tested passes through meter N, so that its water consumption can be accurately measured. The mercury gage for the small Venturi meter used on this test is located in the office, as shown in Fig. 10.

A Wonsever CO_2 recorder, placed in the office, registers the performances of the furnaces. Fig. 12 shows a performance worthy of notice, and represents a ten-hour test that was run to determine the CO_2 content of the flue gases. The continuous lines denote the record obtained from the Wonsever recorder and the heavy line on which the circles appear represents the time of taking and the percentage of CO_2 obtained from a hand Orsat recorder. Forty-five samples of gas were taken just inside of the back nipples of the boiler, during the ten-hour test. The average of the CO_2 record of the Wonsever recorder shows 11.73 per cent. and that of the hand Orsat 12.10 per cent.

The accompanying boiler test gives a good average of the boiler performance at the time of the test.

A reproduction of the boiler-room daily report sheet is shown below. These sheets are bound in book form with two bullard sheets, one for filing with the chief engineer, the other a carbon copy to be filed by the operating engineer. The daily report sheet is 13x24½ inches.

It is so ruled and tabulated that scarcely any explanation is necessary for the reader to understand. The spaces devoted to coal under columns I, II, and III enable the engineers to determine the amount of coal on hand at the end of each day's run. Under column I, record is made of the coal consigned from the coal car to the yard; column II is a record of the coal taken from the car and conveyed to the coal bins over the boilers, and column III is a record of the coal taken from the yard to the bunkers. By


AMERICAN WRITING PAPER CO.

BOILER ROOM DAILY REPORT

AMERICAN WRITING PAPER CO

BOILER ROOM WEEKLY REPORT

CENTRAL STATION "A"

WEEK ENDING____________19___

BOILERS, ETC.	SERVICE HOURS	CLEANING	REPAIRS	SUPPLIES USED	REMARKS
Boiler No. 1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
Total for Week					
Pump No. 1					
2					
3					
Conveyor Engine					
Ash System					

Feed Water Temperature Average for Week	
Steam Pressure " " "	
Factor of Evaporation	
Water Evaporated Total " " Pounds	
Equivalent Evaporation F. & A. 212° "	
" " " " per lb. coal as fired	
Boiler H. P. Maximum load developed	
" " Minimum " "	
" " per boiler max. " "	
" " " " average load developed	

COAL	2000 POUND TONS	MOISTURE	ASH
Coal on Hand from previous week			
" received present week			
" on hand in Yard Storage			
" " " " Bunkers			
Coal Burned present Week			

SIGNED____________________

adding the amount of coal taken from the cars and that taken from the yard the total amount consumed during the day is determined, and deducting the amount of coal taken from the yard, the total amount in the yard as indicated from the previous report is ascertained, which is carried on for each day's report to the next and shows the total amount of coal in storage. Therefore, there is no guess work as to the amount of coal in the yard at the end of any day's run.

The weekly report is a condensation of the daily report, and is made on 8½x19-inch sheets. In case any particular item is in question, it is easily checked by referring to the daily report sheets of the same dates given on the weekly report sheets. These report sheets are perforated at one end, making it easy to tear out of the book. They are also punched for placing in a binder so that the sheets may be readily filed.

The foregoing information and illustrations were obtained through the courtesy of Edward P. Butts, chief engineer of the company.

Central Station vs. Factory Plant

By Henry D. Jackson

Two instances in which the conditions were such that although the tentative figures submitted by the central-station management were in their favor, the actual results proved that a greater saving would have been effected by the installation of individual plants.

For the past few years, central-station men have been making a considerable stir regarding the possibilities of economy in the operation of factory plants through purchased power, the argument being that the central station—owing to the character of its load, type of machinery and the location of its plant—could produce and deliver power to the manufacturing plant at a lower price than a manufacturing plant could generate it.

The central-station men take the stand that the use of exhaust steam for heating, or for any other purpose, has no material bearing upon the cost of power. They usually contend that the back pressure necessitated by the heating system is so great that the increased steam consumption by the engine more than neutralizes the gain which might be obtained through the use of this steam for heating purposes; in other words, they claim that it is fully as cheap, and in some cases cheaper, to heat by steam direct from the boiler than by exhaust steam from the engine. Although this may be true under certain conditions, it is by no means true in many cases, particularly in those plants requiring the use of steam in any considerable quantity for heating and other purposes, where low-pressure steam can do the work.

A properly arranged heating system will not put back pressure on the engine, and where a plant is operating condensing, it is sometimes possible to operate a vacuum system of heating, utilizing the exhaust steam from the engine and reducing the vacuum of the condenser to a point which will allow sufficient steam to flow through the heating system. This, however, is available in comparatively few plants, as the gain thereby is not sufficient to warrant it.

An example of central-station engineering recently came to the writer's attention in a plant requiring considerable power for operating its machinery and for lighting. The central station made the claim and apparently substantiated it with figures of its own making, to prove that it would be more economical to operate with electric drive—the power to be furnished by the lighting company—than with the original belt drive. The owners were convinced of the advisability of the change and installed the electrical equipment, apparently under the engineering advice of the central station. To the great astonishment of the owners, after the installation was complete, the cost of operating the factory, instead of decreasing, increased to a very marked extent. It was at first supposed that increased production was the cause of the increased cost, but a comparison of the output soon showed this to be untrue; the production was less but the cost greater.

Numerous attempts were made to locate the trouble but without success until a few carefully made tests throughout the factory and a thorough examination of the conditions existing about the installation, showed that while a large amount of heavy shafting and countershafting had been removed with its attendant friction, the actual friction power was still far in excess of what it should have been in a properly laid out electric drive. The rooms were low studded and the shafting was quite close to the ceiling, so that the permissible diameters of the pulleys were restricted. The motors were of the highest speed obtainable, in most cases, to reduce first cost. The ratio of pulley diameters was far too great for the economical transmission of power, and the exceedingly small motor pulleys and short centers required a very heavy belt tension which deflected the shafting itself; this deflection naturally caused a heavy friction loss throughout the entire line shafting.

It was further found that much of the machinery, which was intermittent in operation, would not operate satisfactorily, owing to the excessive slip on the small motor pulleys when the machines were put into service. In other cases where the shafting was run along the floor, motors were hung on the ceiling underneath, the belts running through the floor to the shafting. The ratio of pulley diameters was about 5 to 1, the motor pulleys being approximately 3 inches in diameter and the distance between centers about 3 feet. The friction loss on these particular shafts was about 98 per cent. of the total power required to operate when the machinery was in service. In many cases throughout the factory, the friction power required to drive motors and shafting was over 75 per cent. of the average power required. A careful study of all the conditions showed that the power required to operate the shafting and motors alone was considerably over 50 per cent. of the total power required to operate the factory under full-load conditions.

Further study showed that had the electric company agreed to furnish power for one-half of its regular charge, the total cost of operating the plant, including heat, would have been practically the same as that which existed with the original belt drive; also, that a change in the methods of drive would result in a marked decrease in the friction loss; and as steam was required for heating purposes practically the year round, the plant could generate its own power for approximately one-half that which the lighting company could furnish it. Hence, under the conditions of decreased friction, the plant could generate its own power and utilize it throughout the factory with a considerable saving over the old belted installation. The figures included all of the fixed charges on the plant, as well as all of the operating charges.

A few instances of waste power were discovered, which could readily be remedied, among them being one place where forced circulation of air was used for drying purposes. A comparatively inexpensive change in the arrangement of the drying outfit would do away entirely with the use of power. It was also found that certain pieces of apparatus which were used all day were connected across the lighting circuits and might readily be put on the power circuits. There was, however, a difference in the charge for light and power of approximately two to one, so that it was to the advantage of the central station to have these pieces of apparatus on the lighting circuit.

Another instance which came to the writer's attention was in a comparatively large establishment, to which power was offered for approximately $40 a horsepower-year of 3080 hours, and an attempt was made to show that power was costing the owners considerably more than this figure. A study of this plant showed, to the contrary, that power was costing them far less than $40 a horsepower-year. This surprised the owners and also the lighting company. The reason for it, however, was plain enough; in the first place, at least double the amount of steam was required for various purposes throughout the plant that was required for power production. The temperatures required were such that exhaust steam or low-pressure steam was effective, so that the engines used did not need to be bought for steam economy and were not, and this heat was required the year round. Furthermore, waste material from the plant which could be sold for practically nothing could, to a large extent, be utilized for fuel; in fact, for many days out of the year little or no coal was used, so that the fuel bill was exceedingly small. The cost of the installation itself was low, the attendance was small compared to the size of the plant, and as a result the total power bill per horsepower-year was considerably under that which could be offered by the electric company.

In their figures, the electric company took the stand that the coal required was approximately four pounds per horsepower-hour, that the steam plant cost in the neighborhood of $100 per horsepower, and that the attendance on the basis of a plant operating twenty-four hours a day, also interest, maintenance and depreciation, were figured at excessive rates.

These are two of the most glaring instances the writer has yet come across, but there are numerous other instances where the management of a central-station plant has made use of figures which were hardly reliable and made claims of being able to furnish power at prices which the owners could, if they but knew how, readily prove to be exorbitant.

There are many plants which can profitably buy power from a central station, but there are also many plants where the central station cannot afford to make a price which the owner should listen to. These are due very largely to local conditions, but they exist in practically every locality where power is sold. No manufacturer can afford to neglect the cost of heating, either for the buildings or for special processes of manufacturing as a part of the operating cost of his plant; and when a central station offers power at what seems to be an exceedingly low rate, he should take into account when making a comparison, what it costs him to purchase power and supply all of the heat required, as compared to what it will cost him to operate his own plant, supplying all the heat required. If he is not capable of making this comparison in a thoroughly accurate manner, he should employ someone who can. It should be noted particularly that in making these comparisons, it is absolutely essential that every item entering into the cost be figured, such as labor, coal, water, oil, taxes, interest, maintenance, depreciation, etc.

Loaded Safety Valve

By M. [illegible]

Michigan has been responsible for a great many interesting engineering combinations, and the one illustrated herewith is another of which she will have to take the responsibility.

Anyone interested can figure out at

Weighted Safety Valve

what pressure the safety valve, shown in the accompanying illustration, will blow, with 123½ pounds weight on the lever that has a length of 3 feet 10 inches, a fulcrum of 2½ inches, and a valve diameter of 2½ inches. In making the calculations it will, of course, be necessary to neglect the possible effect of corrosion resulting from long continued inaction.

John Brown & Co., Ltd., of Clyde Bank, the builders of the "Lusitania," the "Carmania" and the "Caronia," have received an order from the Cunard company for a new Atlantic liner exceeding in power and dimensions the "Olympic" and "Titanic," being built by Harland & Wolff, of the White Star Line. The design has not yet been finally settled but Engineering gives the probable dimensions at about 900 feet over all, about 50,000 tons gross tonnage, and 70,000 to 80,000 shaft horsepower, which is expected to give a sea speed of 25 knots in service. The machinery will be of the turbine type, driving four shafts and screws.

Piping Layout of Closed Heaters

By W. H. Wakeman

The exhaust steam for heating the feed water is led into the main heater and the surplus steam then carried over to an auxiliary heater supplying water for manufacturing purposes.

In Fig. 1 are shown two closed heaters located in a shop where considerable steam is used for heating water for manufacturing purposes, in addition to the boiler supply. It is necessary to use more or less live steam for this purpose, but inasmuch as it takes only about one-sixth of the exhaust steam from an engine to heat the feed water, there is a large surplus which can be used for other purposes. No special advantage is gained by the use of two heaters, as the same results may be secured with one if large enough to do the work. However, it should be fitted with two independent coils so that it will be impossible for employees of the shop to use water which the engineer needs for the boilers.

Where two heaters are in service it is often because of the fact that only one was formerly used, and that the demands for hot water had increased until this was no longer sufficient for the purpose, resulting in its being taken out and a larger one substituted and the old one connected up afterward in order to use all of the exhaust steam. In the present case, exhaust steam passes through the larger heater, and what is left is prevented from going directly to the atmosphere by the back-pressure valve. Therefore, it passes to the right, through a pipe which projects through a brick wall, beyond which there is a tee connecting with a smaller heater; this has no outlet on the bottom except a drip for removing water of condensation. Steam passes readily into a heater piped in this way, because water passing through the coil condenses some of the steam and creates a partial vacuum; more steam rushes in to fill this space and the supply is maintained as long as there is any steam passing through the horizontal pipe. If any is left it passes on to be used for other purposes.

There are at least two ways for connecting the water pipes of such a system, the better of which is here shown. Water from the pump passes to the bottom of the large heater and coming out at the top is conducted through the upper pipe to the boilers. This insures hot water for the boilers as long as the engine sends enough exhaust steam through the first heater. Entering near the bottom of the smaller heater, the water for manufacturing purposes passes upward and out near the top, then enters the right-hand side of the larger heater. A separate coil is provided for this water and the outlet is on the same side near the top, whence it passes to the shop as indicated.

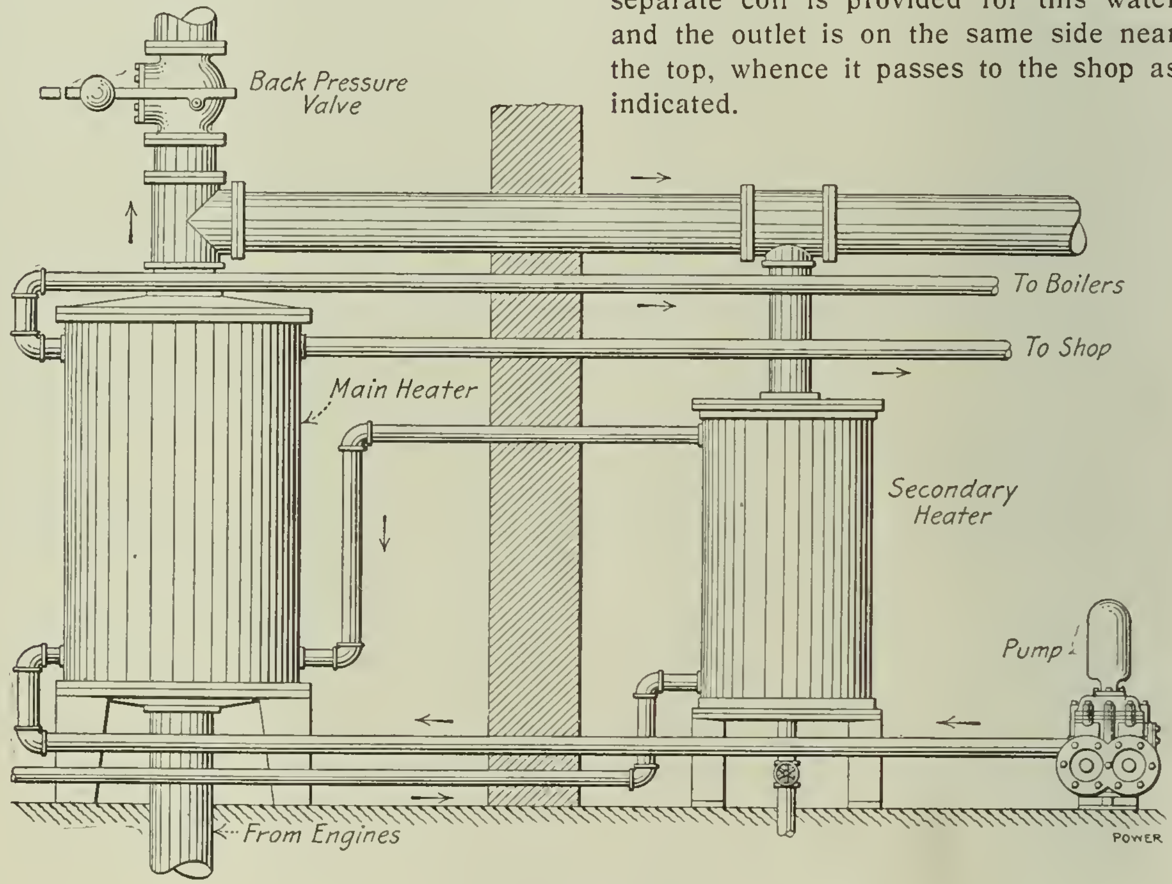


Fig. 1. Main and Secondary Heaters

The engineer of the plant laid out this arrangement of piping, and insisted upon its adoption, although it was not favored by the superintendent; the latter wished to have water for the shop service go into the larger heater before it went into the smaller one. The reason for this difference of opinion is evident. The engineer's plan insures hot water for the boilers, and if there is not sufficient exhaust steam to supply everything, the shop service fails to obtain the required heat. The superintendent's plan would insure hot water for the shop service, and lack of exhaust steam to fill all demands would result in sending comparatively cold water into the boilers. As a rule, it is better to introduce the cold water into a heater near the point at which the exhaust steam escapes, but this is ignored where it would necessitate the use of extra piping and fittings.

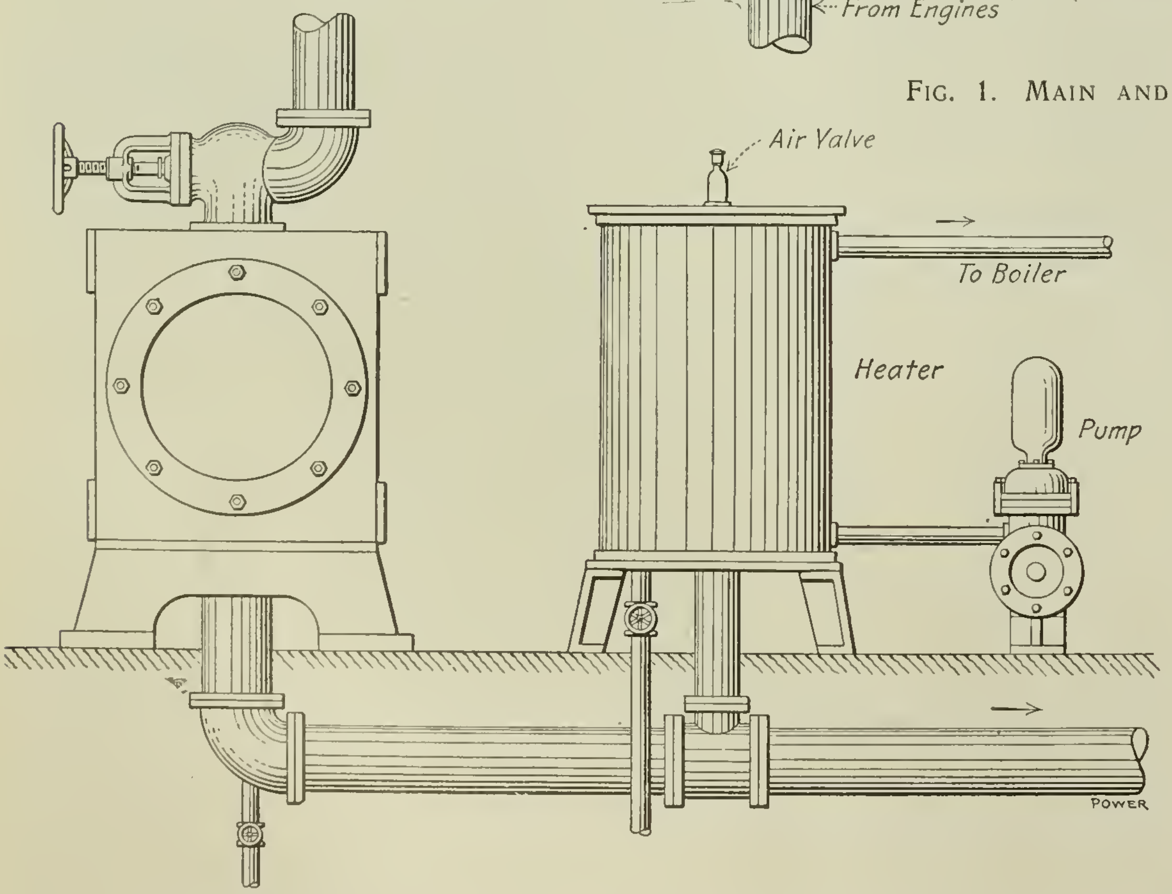


Fig. 2. A Common Arrangement of Piping Heater to Engine

Fig. 2 illustrates a neat arrangement for a heater which is used for the boiler-feed water only. The exhaust pipe is carried under the floor as usual, but it contains a tee the outlet of which projects upward, the pipe from it entering the heater. No outlet is required, but an air valve is provided to release the air which is trapped in the heater when the engine is started. A drip pipe is provided to let out the water of condensation, which, if allowed to flow back through the exhaust pipe, would interfere with the free circulation of the steam.

Exhaust Steam Turbines in England

By James A. Seager

The exhaust steam from the blast-furnace engines is superheated and used at atmospheric pressure in two turbo-generators which supply power to the surrounding districts.

An interesting development in the use of exhaust steam is to be found at the iron works of B. Samuelson & Co., of Middlesborough, England. Here the exhaust steam from the blast-furnace engines is collected and after being superheated is utilized in low-pressure turbo-generators which supply power to consumers as far north as the Tyne. The turbines are of the double-flow Parsons type with water-sealed glands arranged for operating with steam in the event of the water supply failing, and also for use when starting. A view of the turbines and generators is shown in Fig. 1. The governors are of the centrifugal type, driven direct through a worm gear and shaft from the turbine spindle, and control the valve which admits steam to the turbines. Two methods are provided for shutting down the turbines in case the speed should tend to increase above 10 per cent. over normal: one closes the governor valve and the other opens a large air connection to the condenser, thus destroying the vacuum without which the turbine cannot operate.

Fig. 1. General View of Low-pressure Turbines

The surface condensers are placed directly beneath the turbines, Fig. 2 showing one end of a condenser together with the other auxiliaries. A striking feature is that there is no reciprocating apparatus in the whole installation, the dry-air pumps being of the Leblanc type and wet-vacuum pumps of the two-stage centrifugal type. Elaborate arrangements are made to keep the condenser and pumps free from mud or foreign matter which may be deposited from the circulating water drawn from the river.

On regular full-load service the condensers maintain a vacuum of 29 to 29½ inches with the barometer at 30 inches. In order to keep a continuous check on the steam consumption of the turbine the wet-vacuum pump delivers into a special measuring tank in the basement, from which the water is returned to be used over again.

The generators are of the three-phase, two-pole, revolving field type each capable of delivering 1250 kilowatts at a voltage of 6600. The guaranteed steam consumption of the unit was 27 pounds per kilowatt-hour with steam at atmospheric pressure superheated 50 degrees Fahrenheit and exhausting into a vacuum of 28.8 inches, referred to a 30-inch barometric pressure. These figures were easily attained on the recent official tests.

Fig. 2. Condenser and Pumps

According to a note in the *Electrical Review*, the total available horsepower of the rivers of Canada is stated to be 25,982,907 on the basis of minimum flow development. Of this total only about 2 per cent.—516,887 horsepower—is now developed. The distribution of the water powers in the various provinces is as follows, the figures representing horsepower: Yukon, 470,000; British Columbia, 2,065,500; Alberta, 1,144,000; Saskatchewan, 500,000; Manitoba, 504,000; North-West Territories, 600,000; Ontario, 3,129,168; Quebec, 17,075,000; New Brunswick, 150,000; Nova Scotia, 54,300.

Firing Boilers with Pulverized Coal

By W. S. Worth

A 300-horsepower boiler at the Henry Phipps plant in Pittsburg has been fitted with the Blake system of pulverizing coal, and during a period of two hundred days' operation has shown a high degree of economy. With this system the proper mixture of air and fuel is attained in the pulverizer, hence complete combustion takes place in the furnace. By using a set of nozzles the flame does not come in direct contact with the tubes.

About a year ago, a 300-horsepower boiler at the Henry Phipps power plant, Pittsburg, Penn., was fitted with a device for burning pulverized coal. This has been in operation about 200 days and has proved very satisfactory. Several tests and the records of the plant show that it has a high efficiency and that there is a considerable saving of fuel as compared with the other boilers of the same type fitted with mechanical stokers. The system is the invention of J. E. Blake, of New York, who spent 14 years in its development.

Principle of Operation

Referring to Figs. 1 and 2, the coal is crushed by an ordinary commercial crusher into small lumps about the size of cherries, and placed in the feed hopper of the pulverizer and blower, from which it is fed into the machine by an endless screw. The pulverizer is of the rotary type driven by a 12-horsepower motor. From Fig. 2 it will be seen that the coal, upon entering the chamber, is struck by the revolving paddles which break up the lumps into smaller fragments. The centrifugal force produced by the rotary motion given to the larger-sized lumps causes them to revolve near the surface of the cylinder and the baffles prevent them from passing to the second chamber. The air is drawn into the first chamber with the coal through passage *A* and also through the opening *B* around the shaft. After being given a whirling motion by the rotor, it passes to the second chamber and thence through the successive chambers, receiving in each a whirling motion before passing to the next. The smaller and lighter particles of coal in the first chamber are caught in the whirl of air and carried to the second chamber where the pulverization becomes finer, and so on throughout the successive stages until in the fourth chamber it is reduced to a fine powder suitable for burning. After entering the fan chamber, the mixture of coal dust and air receives an additional supply of air which is drawn into the fan chamber through the opening *C* and is discharged in an intimate mixture into two pipes conducting the mixture to the furnace. The air entering through openings *A*, *B* and *C* prevents the escape of coal dust.

Each pipe branches into a distributer, from which cylindrical nozzles discharge the mixture into the furnace, where it burns with a long flame closely resembling that of natural gas, except for the luminous particles heated to incandescence. The flame, which is directed downward at an angle of about 20 degrees to the vertical, impinges upon the bottom of the furnace, forming eddy currents, and the minute particles of coal dust burn completely while in suspension, the gases then passing over the heating surfaces of the boiler.

As the refractory lining of the furnace is heated to a high temperature, it assists in producing complete combustion. The furnace is of the reverberatory type, its action being the reverse of the ordinary industrial type.

Crusher

The crusher is of the ordinary vertical "coffee-mill" type and is belted to a one-horsepower motor. Low-grade slack coal is fed into the crusher by hand and is crushed into small lumps suitable for feeding into the pulverizer. The crushed coal is transported and charged into the pulverizer by hand. As the capacity of the crusher is greater than that of the pulverizer, it is not run continuously, the supply being crushed at suitable intervals.

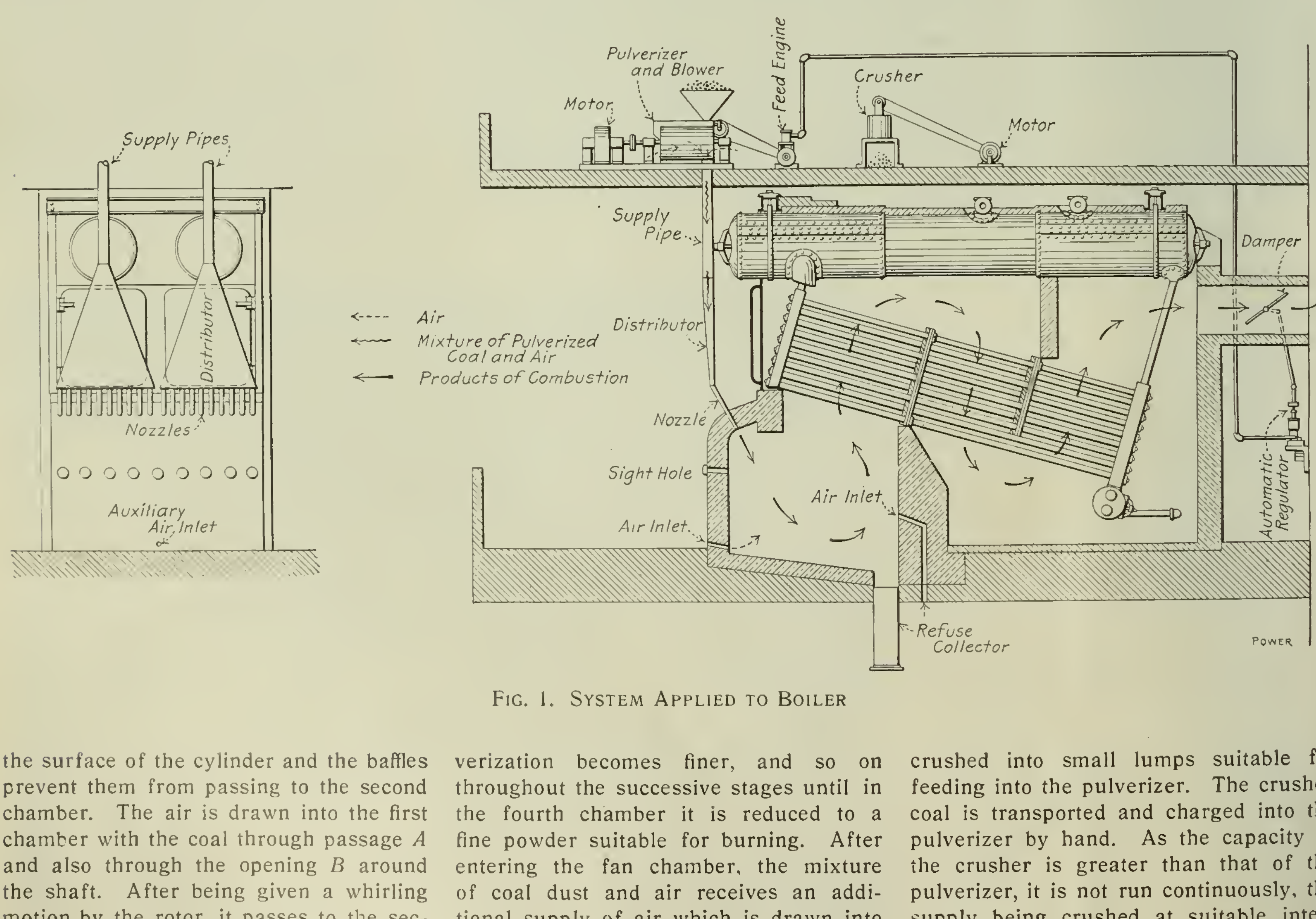


Fig. 1. System Applied to Boiler

Pulverizer and Blower

The pulverizer and blower are driven at a speed of 1200 revolutions per minute by a 12-horsepower motor direct connected to the rotor of the pulverizer. A small simple engine is belted to the feeding screw of the pulverizer. The casing of the present pulverizer and blower is made of boiler plate, but it is intended in the future to make this of cast iron divided horizontally on the center line as shown. The rotor consists of a steel shaft, carried in ring-lubricated bearings, to which are keyed the forged-steel rotors. To the arms of the rotor are bolted the paddles, which consist of hard tempered-steel plates.

The fineness to which the coal is pulverized depends upon the character of the coal and the required length of flame—the powder usually being from 80 to 120 mesh fine—and is regulated by the velocity of the air passing through with the coal; if the velocity is high, the powder will be coarse, and *vice versa*. The areas of the openings *B* and *C* can be adjusted to give the desired flow of air. The discharge pressure of the mixture is from $\frac{1}{2}$ to $\frac{3}{4}$ inch of water.

It is planned to improve future machines of this kind by mounting the crusher on the pulverizer and operating it from the driving motor. A small model, about the size of a derby hat, in which these improvements were incorporated, was used successfully in firing a 12-horsepower boiler. In future designs, provision will also be made for varying the speed to suit the conditions.

Supply Pipes, Distributors and Nozzles

As shown in Fig. 1, the pulverizer discharges into a header from which the coal passes to the supply pipes, distributors and nozzles, all of which are made of No. 24-gage sheet iron. As no valves or cutouts are fitted, all nozzles are used regardless of the rate of combustion, there being eleven 2-inch cylindrical nozzles leading from each distributor: twenty-two in all.

Furnace

The furnace is lined with ordinary firebrick and has a refuse collector in the back, as shown in Fig. 1. It is about 5 feet long, 7 feet high (from the bottom to the boiler tubes) and 6 feet wide. The interior can be observed through peep holes in the front and one in a door at the side. A small supply of air, about 5 per cent. of the total supply, may be admitted to suit conditions through one opening in front and another in the back. The refuse collector extends through the floor and has an opening through which the refuse is run into a car on the floor below.

Automatic Regulator

The amount of coal fed, which is regulated by the speed of the engine driving the feed screw, is automatically controlled by a regulator in such a way that a decrease in boiler pressure increases the amount of coal fed, and vice versa. This regulator, which is located behind the boiler, controls the opening of the uptake damper and the amount of steam admitted to the engine which operates the feed. Referring to Fig. 3, the apparatus works as follows: Steam from the boiler is admitted through pipe *A* into the chamber below cylinder *B*, containing a diaphragm upon which the steam pressure acts. Lever *E* pivoted at *D* and carrying weight *F* acts on the diaphragm at *C*, resisting the steam pressure beneath it. The movement of lever *E*, caused by the rise or fall in boiler pressure, opens or closes an electric circuit at contact *G*. When the pressure rises and the contact is made, the current energizes the solenoid *I* and causes its armature to rise, thereby raising the lever *J* which, in turn, reverses the stem *K* and the valve which it carries. This opening of the valve in cylinder *L* permits water under pressure to flow from pipe *M*, which is connected to the fire system, through the valve and pipe *N* into cylinder *O*. This cylinder contains a piston attached to the rod *P*, which rises when the pressure of the water is sufficient to overcome the weight on the piston. The rise of the piston rod, which is connected at *R* by levers to the uptake damper, causes the latter to close an amount corresponding to this movement. Should the piston rise sufficiently, the collar *S* will strike the arm *T*, lifting it together with rod *U* and rack *V*. The movement of rack *V* rotates the spur wheel *W*, which, in turn, moves the valve contained in *X*. The movement of this valve reduces the amount of steam flowing from the boiler through *Y*, *X* and *Z* to the engine operating the pulverizer feed, decreasing its speed, the quantity of coal fed and consequently the rate of combustion.

A fall in pressure permits lever *E* to drop; this breaks the circuit at *G* and shuts off the current from solenoid *I*, the armature of which descends and turns the valve in cylinder *L*. This shuts off the water entering through *M* and connects the cylinder, through pipe *N*, to the waste pipe *Q*, thus permitting water to flow out of the cylinder and allowing the piston and rod *P* to descend. The movement of *P* opens the uptake damper to which it is connected, and, if the movement be sufficient, collar *S* will strike the arm *T* and cause a downward movement of rack *V* which rotates the valve in *X* and admits more steam to the engine, in this way increasing the feed.

The boiler pressure can be adjusted as required by increasing or decreasing the weight *F*. The amplitude of the movement of lever *E* can be regulated by set screws *G'* and *E'*. The stroke of the piston and rod *P* can be adjusted by collar *S*, and the speed of the engine is adjusted with collars *S* and *P* as it should.

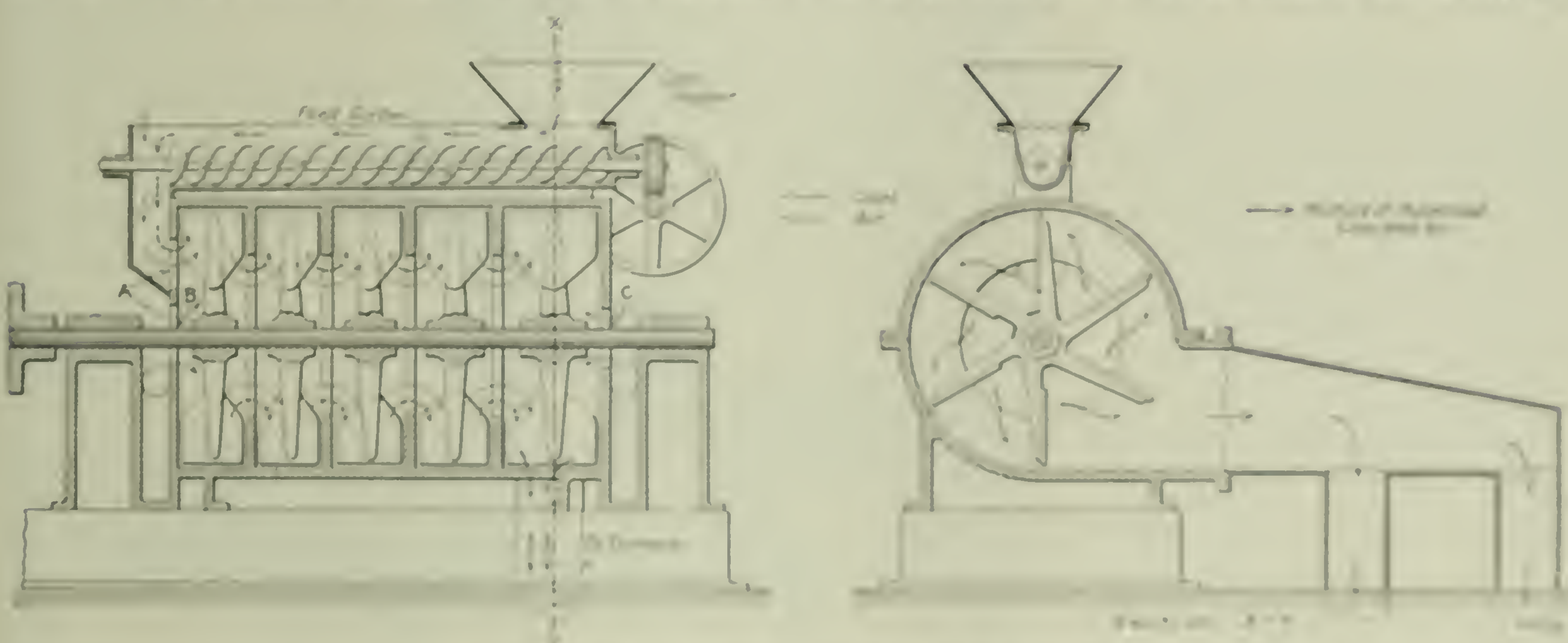


Fig. 2. Section through Pulverizer and Blower

arm T may be clamped to the rod by set screw F'.

The operation of the regulator is very satisfactory and there is no difficulty in regulating the pressure to give a variation of less than five pounds. Although it is used here to regulate only one boiler, it can be used for several.

TEST WITH PULVERIZED COAL AT THE HENRY PHIPPS POWER PLANT.

Duration of test, hours..........	6
Total weight of coal, fired, pounds	5,160
Total weight of water, pounds...	56,160
Average temperature feed water, degrees Fahrenheit............	186
Average steam pressure, pounds per square inch................	162.3
Factor of evaporation...........	1.084
Water evaporated per pound of coal (actual, pounds)..........	10.88
Water evaporated per pound from and at 212 degrees, pounds....	11.725
Boiler efficiency (coal containing 14,350 B.t.u.), per cent........	78.93
Horsepower of boiler............	294.6
Builder's rating.................	300
Temperature of escaping gases, degrees Fahrenheit.............	386
Cost of coal, 2.58 tons @ $1.315 per ton........................	$3.392
Cost of coal per pound..........	0.0006575
Pounds of coal per boiler horsepower per hour...............	2.92
Cost of coal per boiler horsepower, cents........................	0.19199

Economy

The foregoing table shows the results of a test made by the superintending engineer of the plant. This test agrees very closely with other tests which have been made, none of which show a boiler efficiency less than 77 per cent. In making these tests, the evaporation was determined by measuring the amount of water fed to the boiler.

It should be noted that the temperature of the escaping gases is very low. Under the usual working conditions it does not exceed 400 degrees Fahrenheit, and after uniform conditions have been attained it does not vary over 25 degrees. The power-house records show that this boiler is much more economical in coal consumption than the other boilers and it is claimed that the saving in fuel exceeds 11 per cent. In addition to the saving in the quantity of fuel, a considerable saving in the cost of operation is effected because of the following factors: Cheaper coal is used—the coal for the boiler using pulverized coal costs 4 cents per bushel, whereas the coal for the other boilers costs 5 cents; fewer repairs are required; and, in addition to these, may be added for future plants, less cost for attendance and less wear and tear on the boiler, due to the uniform temperature.

Operation and Performance

To get up steam, a wood fire is first built in the furnace and the pulverizer is started supplying air and fuel, moderately at first and finally working up to the normal rate of combustion. There is no difficulty in starting as the mixture ignites readily and burns with a steady flame. The combustion is more perfect, however, when the flame is not cooled by impinging upon the cold surfaces of the furnace. It requires about three hours to heat the furnace to its normal running heat, after which the high temperature of the furnace assists in producing complete combustion. The time required to raise steam depends upon the rate of combustion. Ordinarily steam is raised in about an hour, but this time could be reduced to half an hour if desired.

When normal running conditions have been established, the combustion is completed before the gases pass to the tubes. All parts of the furnace are clearly visible as there is no smoke and the flame is unusually transparent. Moreover, there is practically no noise from the furnace.

The refuse is a fine light powder, resembling fine sand, and containing no unconsumed carbon. It is neither corrosive nor adhesive and can be easily handled with compressed air. This dust collects on the tops of the horizontal tubes but does not adhere to the remainder of the tube surfaces. When the apex of the pile of dust on a tube reaches a certain hight, the powder begins to slide off, and, when once started, nearly all runs off. In view of this it is not considered worth while to clean the tops of the tubes; hence tube cleaning is eliminated from the routine.

In many cases where pulverized fuel is used a large percentage of the refuse passes through the boiler and passes up the stack. With this system, however, apparently none of the refuse passes out through the stack as no traces of it have been found on the roof of the power house nor on those of adjacent buildings. As previously mentioned, the refuse from the furnace is deposited in a collector. There is a comparatively small quantity of refuse and ordinarily the collector is emptied every three or four days. After eight days of operation, when using 750 pounds of low-grade Pittsburg slack per hour, only about three-quarters of a ton of refuse was removed from the collector.

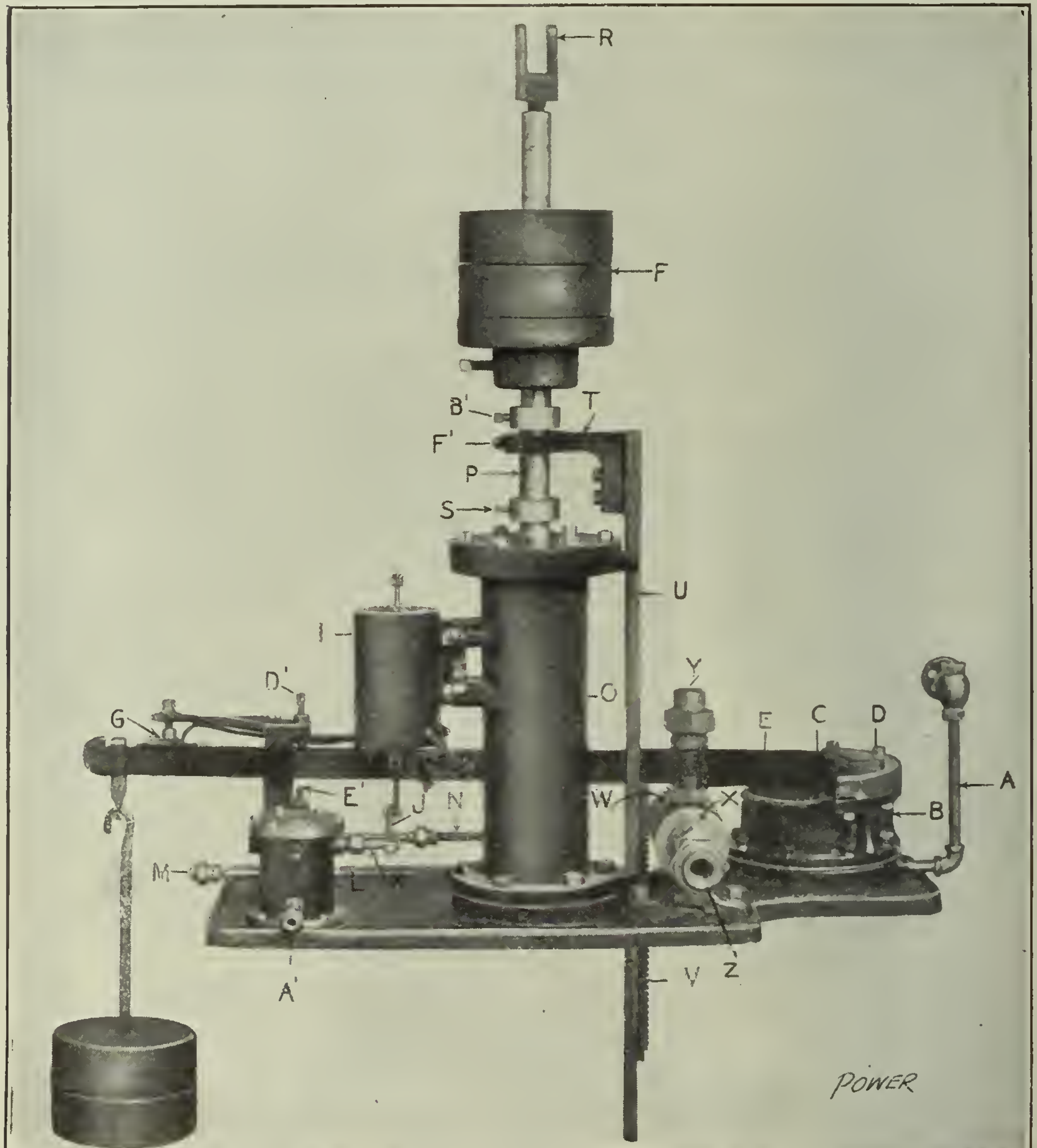


Fig. 3. Automatic Regulator

The tubes immediately above the furnace become coated with a sulphurous deposit which does not appear on the other tubes. This deposit does not exceed ⅛ inch thick and it soon cracks and falls off. The refuse cakes on the firebrick lining of the furnace to a thickness of less than an inch; but this can be easily scraped off. In fact, it is an advantage in that it protects the firebrick and prolongs the life of the furnace.

No difficulties have been experienced by the tubes becoming burned, which is undoubtedly due to the fact that the flame does not impinge on the tubes, and also that combustion is completed before the gases come in contact with the tubes.

Experience has demonstrated that even a large percentage of moisture in the coal has no appreciable effect on the pulverization and burning. The moisture is dried out by the mechanical action of the air during pulverization so that the dust is quite dry and the particles do not adhere. Only two kinds of low-grade coal have been used, but there is little doubt that high-grade coals can be used successfully.

The fineness of pulverization depends upon the quality of the coal, a coal which burns with a long flame being pulverized finer than one having a short flame. Hence, the length of flame can be regulated by adjusting the pulverizer. The rate of combustion can be regulated through a wide range and can be reduced until the heat is just sufficient to keep the furnace hot. The proportion of air to coal is kept constant for all rates of combustion, the quantity of mixture being regulated.

With this apparatus, one man is required to operate the crusher and the pulverizer, and on the boiler floor another attends several boilers. With the apparatus as improved, the supply of fuel will be handled entirely by machinery and the regulation will be automatic, thus considerably reducing the attendance. The cost for repairs has been less than five dollars for 200 days' operation, and it is estimated that the paddles will last at least a year with almost continuous operation. The cost of pulverizing a ton of the coal used in the test herein cited, was 9.2 cents; and it is estimated that the power required for driving the improved pulverizer will be less than 0.04 horsepower per boiler horsepower.

The chief thermal gain in the use of pulverized coal is due to the high degree of perfection in combustion, coal in the powdered state being the best form in which to obtain perfect chemical combination with the oxygen of the air. The rapid combination of the air and coal, however, produces a high temperature, which, in many cases, has been so excessive as to cause failure. The chief difficulties that have been encountered from this source are the fusing of the firebrick lining of the furnace and the fusing of the refuse, forming a slag. To remedy the former, a special firebrick, made from carborundum dust, has been used successfully, but it cannot be said that this disposes entirely and satisfactorily of the difficulties from high temperatures. In the system under discussion, this problem has been solved in a satisfactory way, by regulating the intensity of combustion and in consequence the temperature of the furnace.

Analyses of the flue gases from boilers using pulverized coal show exceptionally good results, there usually being not more than 10 to 15 per cent. excess of air, and no CO, and in most cases the CO_2 is from 13 to 15 per cent.

Pulverized coal is particularly suited to automatic regulation and it is unusually sensitive to control, so that the demands of fluctuating power are easily met. Perhaps the best method is to regulate the mixture automatically so that the correct proportions of air and coal required for complete combustion will be maintained regardless of the quantity supplied. It is obvious that provision should be made for adjusting the air and coal independently to obtain the correct proportions for the particular fuel being used. As the pulverizer described herein was designed for working under practically constant conditions, no provision was made for the automatic regulation of the air in conjunction with that of the coal, but, for future work, provision will be made for the automatic regulation of the air and coal together so that the correct proportions will be maintained under variable conditions.

Either hard or soft coal can be burned satisfactorily in the pulverized state. Coal with a fair percentage of volatile matter seems to be better suited for this purpose as it is more easily pulverized and burns better. Moisture up to 15 per cent. does not interfere with the pulverizing and burning, and in this system the air that is present during the pulverizing and mixing dries the coal sufficiently to prevent the particles from adhering. One of the principal advantages of pulverizing is that coal with a high percentage of ash can be burned efficiently, poor grades of coal having been burned with about the same thermal efficiency as that obtained from high-grade coal. Slack coal requires less power for pulverizing, and is therefore the more desirable.

Pulverized coal is safe providing it is used correctly, but it is hard to convince some that it is not extremely dangerous. Many accidents in the use of pulverized coal have been recorded, but it is safe to say that they were caused by not observing the proper precautions, both in design and operation. A number of accidents have been caused by spontaneous combustion and others by the ignition of a mixture of air and coal dust. Although it is claimed that pulverized coal can be stored with safety, it is obviously better to entirely eliminate this source of danger by not storing it at all. With properly designed machinery, having a short and direct discharge to the furnace, there is no difficulty in preventing the escape of the dust.

Boilers using pulverized coal are not subjected to sudden changes of temperature, such as are hand-fired boilers, hence the uniformity of temperature is a particular advantage.

In marine work mechanical stokers have not been successful, and in this field pulverized coal has the greatest advantages. On account of the limited space on a ship, it may not be possible to prevent the escape of the refuse in the form of dust, but, it is doubtful if this will be very objectionable.

For naval work in particular and marine work in general, its advantages are as follows: Greater economy in fuel can be attained. Maximum power can be maintained as long as the coal can be supplied. There are no fires to be cleaned and the fire-room force can be reduced. There is no smoke and the pulverizers and pneumatic ejectors would take the place of blowers and ash-handling machinery, and it would not be necessary to carry large supplies of spare grate bars, firebrick, etc. The refuse does not cause corrosion and the fire-room bilges would remain in good condition, which also applies to the heating surfaces of the boilers. On account of the uniform temperature, there would be less wear and tear on the boilers. The fire rooms would not be under pressure and could be left open. Low-grade coals could be used.

It cannot be said that firing boilers with pulverized coal has been an unqualified success. In fact, nearly all attempts have failed in one respect or another, and it is the general opinion among engineers that, although it is possible to burn pulverized coal, its use for firing boilers is neither practical nor commercial. This doubt may be dispelled to some extent by the fact that this plant is running practically and is a success commercially. It is expected that further tests will be made in the near future and if these substantiate those already made, there will be no question as to the success of this system of firing boilers in both land and marine practice.

When cutting pipe threads in a lathe it is sometimes difficult to get the exact diameter necessary. When a mistake is made and the threads on a 6-inch pipe are cut a trifle too small, so that it screws right up to the shoulder, then it remains for the workman to get out of the trouble the best way he can. A very good way is to use wire cloth of the brass variety, about 60 or 80 meshes to the inch, similar to that used by the farmer for straining his milk. Wrap a bit of wire cloth around the pipe, daub it with litharge or red lead and screw the pipe home with the wire cloth in the joint. This joint will never leak or come loose.

A plan is on foot to use the power at Great Falls on the Potomac river for a hydroelectric plant to generate current for consumption in the District of Columbia. At present 4450 horsepower is developed, but the power available at Great Falls, even at low water, is considerably over 8000 horsepower, and by using a storage reservoir above the falls it could be increased to about [illegible] horsepower.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Jones; Trouble Killer

First Talk about Power Factor

"Well, well," exclaimed Harvey, "if that ain't Jones cuttin' corners through the back lot I'll eat hay till hell free—"

"You'd oughter eat it, anyhow," broke in the engineer; "I would, if I'd made such a jackass o' myself as you did last time Jones was here."

Further compliments were prevented by the unceremonious entrance, through the spur-track door, of a rotund person wearing a Fedora hat tilted on the left side of his head, a wide opening in his face just below his nose and a nondescript suit of clothes. Nobody ever knew or cared what kind of clothes Jones wore; his hat and his grin caught your attention first and your eyes never got below the grin.

A Rotund Person Wearing a Fedora Hat and a Large Opening Under His Nose

"Hello, boys," sang out Jones cheerily; "what do you know about this for winter weather?"

"Nothin' the matter with the weather," replied the engineer, "except its power factor 's a little low."

"Joke," said Harvey. "No wonder Jones is in a sweat. Say, old man, if you don't hurry and wipe your face, you'll drown."

"Surest thing you know," agreed Jones, taking off his coat and mopping his face and neck with a two-foot bandanna. "But, talking about power factor reminds me that I promised to reel out a yard or so of dope on that subject the next time I got around. How about it, Jim?"

"You sure did," said the engineer, "and the primary class is ready and willin' to take his medicine."

"Well," said Jones, shedding his vest, collar and necktie and turning up his sleeves, "let's see where we'd better begin."

"Hadn't I better run over to the house and get you a suit o' pajamas?" asked Harvey, with mock courtesy.

"S'pose," began Jones, paying no attention to Harvey's effort at bantering, "s'pose your voltmeter showed 115 and your ammeter 30 and your indicating wattmeter 120 kilowatts. You know what the power factor would be, don't you?"

"Yes; because you told me how to figure it," said the engineer, "but I don't understand why."

"Never mind that for the present," said Jones. "Just to get a good start at the beginning, figure that power factor."

"Cinch," broke in Harvey; "lemme do it," and he jotted down these figures on a scratch pad:

115 volts
30 amperes
3450

"A hundred and fifteen multiplied by thirty is thirty-four hundred and fifty—thirty-four hun— oh, you're stringin' us."

"No he ain't," exclaimed the engineer excitedly, "you've forgot that when the voltmeter reads a hundred and fifteen the voltage in the primary line where the ammeter is connected is twenty-three hundred. Here—" and he hastily scrawled Fig. 1. "The voltmeter takes current through a transformer and shows the secondary voltage but the ammeter shows the primary current."

"Right you are," said Jones, beaming like a polished tomato. "The primary class is making headway. Finish the job."

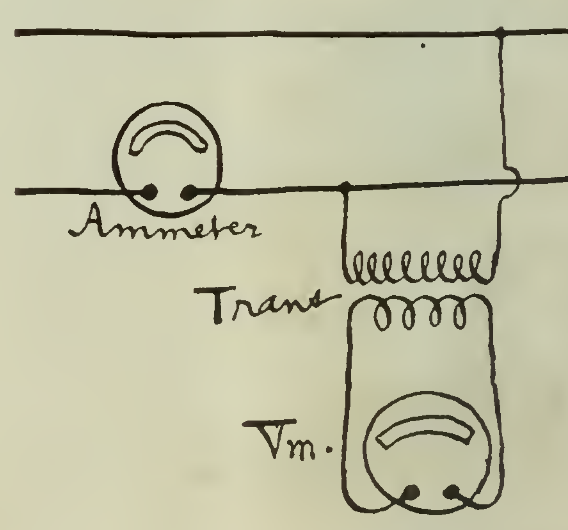


Fig. 1. The Engineer's Sketch

"When the voltmeter voltage is a hundred and fifteen the line voltage is twenty-three hundred because the transformer ratio is twenty. "Let's see—" and he began figuring as follows:

2300 volts
30 amperes
69000 app. watts

69000)120000(

"Thirty times twenty-three hundred is sixty-nine thousand and sixty-nine thousand goes into a hundred and twenty thousand—hold on; that would make the power factor nearly two," he exclaimed.

"Come to," advised Jones, relaxing his grin a couple of points. "You know better than that."

"Thirty times twenty-three—"

"Cut it out," said Jones. "Your arithmetic's all right; no use to keep on repeating that like the man who went crazy saying 'twice two is four, twice three is five.' It's your horse sense that's off—not your figures."

The engineer scratched his head and Harvey stared at the figures with a bewildered expression.

"Oh, stuff!" ejaculated Jones. "You ain't thinking; you're just rattled. Where is your ammeter connected in regularly?"

"In the A phase of the line," replied the engineer.

"Where is your wattmeter connected in?"

"In both pha— oh, damn! The ammeter measures the current in one phase and the wattmeter measures the power in both phases, of course."

"Quite so," agreed Jones; "proceed."

Harvey softly whistled "Every little movement has a meaning all its own," and the engineer chased him into the producer room.

"But you didn't say anything about the current in the other phase," protested the engineer, returning to his seat on a transformer case.

"And you didn't use your brains, so you fell for it," rejoined Jones, increasing his grin to 3½ inches. "Now, start all over again and do it right."

"Or quit," amended Harvey, from a safe distance.

"Better paste that editorial in the middle o' your lookin' glass," suggested the engineer, taking a dig at Harvey's only serious weakness—personal vanity.

"Well," he resumed, "if the two phases are balanced, each one'll carry half the power, so that if the total power is a hundred and twenty kilowatts the power in each phase'll be sixty kilowatts or sixty thousand watts."

"Right," said Jones.

"Then, if the apparent watts in each phase are sixty-nine thousand and the actual watts are sixty thousand, the power factor'll be—" and he made the following division:

```
69000) 60000 (.8695
       552
       ---
        480
        414
        ---
         660
         621
         ---
          390
          345
```

"point eight six, nine, five—practically point eighty-seven."

"All right," said Jones, "but what does point eighty-seven mean?"

"Eighty-seven hundredths."

"Yes; but is that what you'd call the power factor?"

"Oh; eighty-seven per cent."

"Correct. Now you said thirty times twenty-three hundred was sixty-nine thousand, but you didn't say sixty-nine thousand what. It isn't watts, is it?"

"No; apparent watts."

"Yes; that's true enough, but there's a better name for it."

The engineer shook his head.

"Search me."

"Volts multiplied by amperes make what?"

"Appar—"

"You said that before; try something else. Wits gone wool-gathering again?" as the engineer sat staring at him.

"N-o-o, but—"

"Oh, come now; wake up. Volts multiplied by amperes—volts times amperes—volts, amperes—"

"Volt-amperes," said the engineer meekly; "please kick me."

"I'll leave that to your conscience," said Jones. "You see, apparent watts is a good enough name because volts multiplied by amperes would be watts if there weren't any power factor to bother with. But volt-amperes is more descriptive, because it is common custom in engineering to hitch two things together with a hyphen when you are talking about their product and there isn't any name for it. There's feet multiplied by pounds—foot-pounds; kilowatts multiplied by hours—kilowatt-hours, and so on."

"But why do volts multiplied by amperes make volt-amperes in alternating-current work and not with direct current?"

"I never said any such thing," replied Jones; "you've got it twisted. Volts times amperes are volt-amperes every time and in any system, but volt-amperes are the same as watts in a direct-current system, while they are not the same with alternating current unless the circuit is entirely free from inductance, which is not usually the case."

"Then, what's the difference between watts and alternating volt-amperes?" asked the engineer.

Jones manifested signs of impatience.

"How do you figure the power factor of a circuit or a system?" he asked.

"Divide the watts by the appar— by the volt-amperes," said the engineer.

"Then, for heaven's sake why can't you see the relation between watts and volt-amperes?" asked Jones. "Suppose you knew the power factor and the volt-amperes, how would you figure out the real watts?"

The engineer figured on his pad awhile.

"Multiply the volt-amperes by the power factor?" he suggested, doubtingly.

"Of course. Then, why do you ask me what the difference is between watts and volt-amperes?"

"Well, I didn't mean it exactly that way," said the engineer, a little abashed. "I know how watts and volt-amperes and power factor are tied together in arithmetic, but—"

"Let's make sure of that much," advised Jones. "You persisted in saying 'apparent watts' awhile ago when I wanted you to say 'volt-amperes.' Now go back to your apparent watts. Apparent watts are apparent power, and you just said that multiplying volt-amperes or apparent watts by the power factor gave you the real watts, didn't you?"

"Yes; but—"

"Don't butt in. If your apparent power were fifty thousand volt-amperes and your power factor eighty per cent., what would the real power be?"

"Forty thousand watts," said the engineer, after a moment of hasty scribbling.

"Right. Now, don't you see that the power factor is simply the number by which the apparent power is multiplied to get at the real power?"

"Ye-es."

"No you don't, but listen. With fifty thousand volt-amperes and eighty per cent. power factor, the real watts would be forty thousand, you said."

"Yes."

"Then eighty per cent. of your apparent power is *real* power, isn't it?"

"Oh, I see what you are driving at. Sure; I understand that if the power factor is eighty per cent. then eighty per cent. of the apparent power is real power, and if the power factor is sixty per cent., then sixty per cent. of the volt-amperes are real power. But I don't understand why *all* of the volt-amperes ain't real power, like direct current. Why is there any power factor?"

"That's what I'm coming to," said Jones, "but we've wasted so much time on the arithmetic it's time to eat. I'll tell you the balance after we feed." And he made a dive for the wash sink just in time to beat Harvey to it.

Old man Dodder doubled the size of his dry kiln at the planing mill and found that the fan was too small and would not deliver enough hot air. His nephew Bill was back from college and tackled the job. He figured all over the side of the shed and told his uncle that to deliver twice the amount of air he would need a 120-horsepower engine to run the fan, as the rules showed one must cube the horsepower required to run the fan with the old kiln. The old man scratched his head and sent for Jim, the engineer, to help him out. Jim grinned and said that all they would need was another 5-horsepower fan, as the two would deliver double the amount of air.

Dodder [illegible] Bill had [illegible] and help Jim a while.

The Melville-Macalpine Gear for Direct-current Turbine Generators

By Geo. W. Malcolm

In a paper read some time ago before the Engineers' Society of Pennsylvania, J. A. MacMurchie advocated the use of the now widely known Melville-Macalpine turbine gear to drive direct-current generators, instead of coupling them directly to the turbine. Mr. MacMurchie cited, as warranting this practice, the fact that it would permit the use of a generator running at its most economical speed instead of one driven at such a high rate as to entail excessive losses by windage and friction.

A chart was presented with the paper which indicated the following comparisons, based on steam at 150 pounds pressure and a condenser vacuum of 28 inches:

	Pounds of Steam per Kilowatt-Hour.	
Size of unit	1000 kw.	2000 kw.
Direct-driven, direct-current generator	20.6	20.2
Direct-driven alternator and rotary converter	20	19.5
Gear-driven direct-current generator	19.3	19

The combination of turbine-driven alternator and rotary converter was included in the comparison in order to cover all practical methods of obtaining direct-current distribution from a turbine-driven generating plant. It is exemplified by railway practice throughout this country, rotary converter substations being used to change the high-tension alternating current sent out from the generating station into direct current of the proper voltage for the railway. Such a system, however, can scarcely be compared with the turbine-driven direct-current dynamo because the conditions to which the two are rationally applicable are widely dissimilar.

The logical comparison is between the direct-driven and the gear-driven direct-current generators.

According to Mr. MacMurchie's chart, the gear-drive outfit would require 19,300 pounds of steam per hour and the direct-coupled outfit 20,600 pounds, in the 1000-kilowatt size. The heat energy theoretically available by expanding a pound of steam under the conditions stated is 339 B.t.u., if the steam be superheated 100 degrees initially. On this basis the overall heat efficiency of the direct-coupled unit would be 48.8 per cent. and that of the geared unit 52.2 per cent. The following tabulation gives a comparison of the two generators for four values of turbine efficiency and on the assumption that the Macalpine gear has 97 per cent. efficiency:

Turbine Efficiency.	Corresponding Generator Efficiency.		
	Direct driven Generator.	Gear and Generator.	Geared Generator.
54%	90.4	96.7	99.7
56%	87.2	93.2	96.1
58%	84.2	90.0	92.8
60%	81.4	87.0	89.7

Obviously, the combination indicated in the first line is impossible because the generator could not have 99.7 per cent. efficiency. The most plausible combination would seem to be the one in the second line, although 96 per cent. is a little high for the geared generator and 87.2 is unnecessarily low for the direct-driven generator.

It is difficult to imagine such an increase in generator efficiency as the 9 per cent. shown practically throughout the range here considered, due merely to the difference between the speeds of the coupled and geared generators. The windage, iron losses and friction would be increased by the higher speed, but this would be neutralized to a very great extent by the decrease in purely electrical losses. Moreover, the increased fixed charges on the cost of the geared outfit would require a very healthy decrease in fuel consumption to offset it.

Steam Heated Flume Racks for Hydraulic Plants

Operators of power plants in which the generators are driven by waterwheels do not need to be told anything about the difficulties in keeping head-gate racks clear of frazil ice in latitudes where ice forms. An interesting method of eliminating such ice troubles was proposed recently by John Murphy. In a paper read before the Ottawa branch of the Canadian Society of Civil Engineers. Mr. Murphy's plan is to equip the head-gate racks with pipe manifolds and to pass steam through the manifolds. The warm pipes, it is stated, prevent the accumulation of frazil ice at the racks by melting the ice, which is formed in very small particles. Mr. Murphy said that a ton of coal per day of twenty-four hours would make sufficient steam to keep the gates of a 3000-horsepower station free from ice. This, obviously, would be much cheaper than allowing the gate racks to freeze up and driving the generators by auxiliary steam equipment.

When cutting bar steel or rails by the usual method of nicking with a cold chisel, if the nicked part of the material is cooled by laying on a piece of ice, it will be rendered temporarily brittle and fracture easily when struck a blow with a sledge.

LETTERS

Erratic Belt Behavior

A 12-inch belt driving a dynamo persistently runs over one or the other edge of the dynamo pulley when shutting down and starting up, but when pulling the load it runs true with the center line of the pulley. The dynamo pulley is 23 inches in diameter and 16 inches wide; the engine pulley is 7 feet in diameter and 16 inches wide, and the pulleys are 30 feet apart, center to center. Can any reader of Power explain why the belt will not stay in place when starting up and shutting down?

W. S. Hull.

Sheldon, Ill.

A Cranky Induction Motor

Some time ago I was called upon to repair an induction motor that would not carry the load. It was a 220-volt, two-phase machine with a squirrel-cage rotor, rated at 15 horsepower. It had been running a rock crusher about two years and had probably averaged four months' continuous running for each year. It had been out of use about a month when I saw it.

Examination showed that the airgap was not uniform all the way around. The insulation of the stator winding appeared to be in perfect condition and everything else seemed to be all right except the airgap. I equalized this by shimming under the bearings with paper, tested each phase with two 110-volt lamps in series at the motor terminals and also tested them with a magneto; tested for grounds, and finally rewired the autotransformer, thinking perhaps the trouble might be in that, but it is still undiscovered.

The motor will not start until the lever on the autotransformer is in the running notch, but immediately starts on full-line voltage, if started in one direction; if the direction of rotation is reversed, it starts nicely on the second starting point. It apparently takes an excessive current while starting and running in either direction, as it visibly dims the two 110-volt lamps in series on the line.

The motor is supplied from two transformers which do not supply anything else, and each one is of ample capacity to carry one-half the full load. The owner said it had carried the load continuously on a certain Friday and on the following morning had started all right but refused to take any load.

Any suggestions as to what might be the matter with it will be greatly appreciated by me.

H. Blue.

Kirksville, Mo.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Long Stroke and Short Stroke Engines

By Paul C. Percy

It is a matter of common observation in engineering circles that the daily papers usually make themselves ridiculous when they discuss technical matters. This is natural, though amusing. When a professedly engineering journal makes foolish statements, however, it is neither excusable nor amusing.

The immediate provocation for these remarks is an article on the long-stroke gasolene engine, which appeared in a recent issue of a gas-power periodical. The following are the worst specimens of misinformation contained in the article:

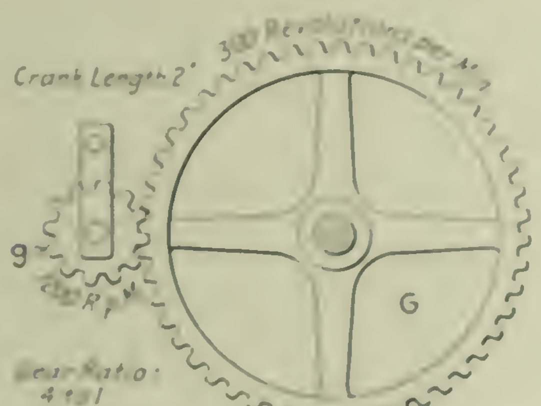


Fig. 1. Gearing of the Short-stroke Engine

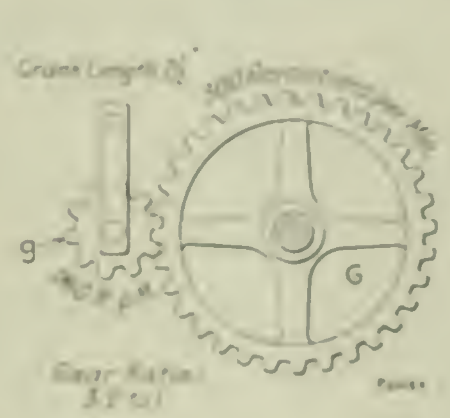


Fig. 2. Gearing of the Long-stroke Engine

1. The long-stroke engine does its work more easily than the short-stroke one for the same reason that a big man walks at four or five miles an hour with an easy swinging stride, while a small man has to "exert himself tremendously" to keep up with the other.

2. In a long-stroke motor the question of leverage enters. The long-stroke motor can turn its crank shaft with less effort than the short-stroke engine because of the longer crank throw, giving greater leverage over the load.

3. The gases in a long-stroke motor, "starting at a higher initial pressure on account of the increased compression possible with the longer stroke, are worked down to a much lower final pressure before they are exhausted into the atmosphere."

4. The gases in a long-stroke engine are expanded to a greater number of clearance volumes than in a short-stroke engine, and the long-stroke engine allows a much greater compression; hence the long-stroke engine is more economical.

5. The exhaust gases of the long-stroke engine are much cooler than those of the short-stroke engine because of the greater expansion.

All of the foregoing statements are absolutely untrue. The long-stroke engine is more desirable than the short-stroke engine in the following respects only:

The short-stroke engine must make a greater number of revolutions per minute than the long-stroke engine to run at the same piston speed. Therefore, the wear and tear on the reciprocating parts, crank pin and crank-shaft bearings is greater, for equal piston speeds.

The piston speed of the long-stroke engine can be made higher than in the short-stroke engine and the number of revolutions per minute kept the same or even be made less; if the latter is done, a smaller piston diameter is required, and this gives a correspondingly smaller total pressure on the connecting-rod boxes and main bearings.

These points are presented clearly and concisely by the numerical comparison in Table 1. These figures are, of course, appropriate for automobile and motor-boat practice. For the ordinary stationary engine the comparison in Table 2 is more suitable.

Both of these tables show clearly that for equal horsepower a long-stroke engine can be made to run at fewer revolutions per minute with the same total piston pressure and piston speed, or with less piston pressure and higher piston speed.

Now, let us see about the question of

TABLE 1

Engine	Short-Stroke, A	Long-Stroke, B	Long-Stroke, C
Piston diameter, inches	4	4	[illegible]
Piston area, sq. in.	12.57	12.57	[illegible]
M.E.P. per square inch	70	70	70
Total mean pressure	[illegible]	[illegible]	[illegible]
Stroke, inches	4	[illegible]	[illegible]
Revolutions per minute	1200	960	[illegible]
Piston speed	800	800	[illegible]
Estimated horsepower	24	24	24

TABLE 2

Engine	Short-Stroke, D	Long-Stroke, E
Piston diameter, inches	[illegible]	[illegible]
Piston area, sq. in.	[illegible]	[illegible]
M.E.P. per sq. in.	[illegible]	[illegible]
Total mean pressure	[illegible]	[illegible]
Stroke, inches	[illegible]	[illegible]
Revolutions per minute	[illegible]	[illegible]
Piston speed	[illegible]	[illegible]
Estimated horsepower	[illegible]	[illegible]

"leverage." In the examples cited in the article I am criticizing, the piston speed was the same for both short-stroke and long-stroke engines, as in the cases A and B, of the first table. Figs. 1 and 2 illustrate this case diagrammatically. In the one case a 2-inch crank (4-inch stroke) revolves 1200 times a minute and is geared to the load shaft at 4 to 1; that is, the gear g on the crank shaft is one-fourth as large as the gear G on the load shaft and therefore turns four times as fast; consequently, the load shaft runs at 300 revolutions per minute. Putting it the other way, while the load shaft is making one revolution the crank makes four.

The diameter of the circle followed by the crank pin is 4 inches; in four revolutions, therefore, the crank pin travels

$$3.1416 \times 4 \times 4 = 50.266$$

inches.

In the other case, Fig. 2, with the same horsepower and the same piston speed the 4x5-inch engine runs at 960 revolutions per minute, and in order to keep the speed of the load shaft at 300 revolutions per minute the gear ratio must be 3.2 to 1 instead of 4 to 1 because the crank-shaft speed is only [illegible] of what it was before. Therefore, when the load shaft makes one revolution the crank makes only 3.2 revolutions. The crank being $2\frac{1}{2}$ inches long, the crank circle is 5 inches in diameter and the crank pin travels

$$3.1416 \times 5 = 15.708$$

inches per revolution. In making 3.2 revolutions, therefore (while the load shaft makes one), the pin will travel

$$15.708 \times 3.2 = 50.266$$

inches, or exactly the same distance the 2-inch crank pin travels during one revolution of the load shaft. Where is the increased leverage over the load?

"But," probably says the author of the criticized article, "I meant the case where the piston speed is increased."

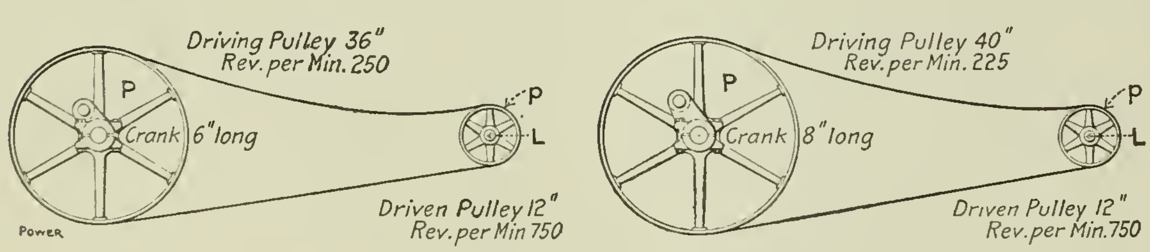
All right; let's see how that pans out, using the figures for engines *D* and *E*, in the second table. Figs. 3 and 4 illustrate the comparison. Suppose the load shaft *L* must run at 750 revolutions per minute, no matter what the speed of the engine may be. That is a practical condition where the machinery driven by the engine runs at constant speed. Also suppose, in order to keep the belt velocity the same, that the pulley *p* is 12 inches in diameter in both cases and that the diameter of the gas-engine pulley is chosen so as to get the desired speed at the load shaft *L*.

In Fig. 3 the short-stroke engine *D* (see data in Table 2) is represented as driving the load. As its speed is 250 revolutions per minute, its pulley must be 36 inches in diameter because the speed ratio is

$$\frac{750}{250} = 3$$

and the pulley ratio must be the same. The orbit of the crank pin is 12 inches in diameter, so that the pin travels

$$3.1416 \times 12 = 37.7$$



FIGS. 3 AND 4. COMPARISON WITH DIFFERENT PISTON SPEEDS

inches when the crank shaft makes one revolution. During this time the load shaft *L* makes three revolutions; consequently, the crank pin travels

$$\frac{37.7}{3} = 12.5667$$

inches for each revolution of the *load* shaft.

Now refer to Fig. 4, where the long-stroke engine *E* is represented as driving the same load. On account of the lower speed of the engine its pulley must be larger; the speed ratio is

$$\frac{750}{225} = 3\frac{1}{3}$$

and the engine pulley is therefore

$$3\frac{1}{3} \times 12 = 40$$

inches in diameter.

The crank-pin circle is 16 inches in diameter; therefore, in one revolution the crank pin travels

$$3.1416 \times 16 = 50.266$$

inches, and for each revolution of the *load* shaft it travels

$$50.266 \div 3\frac{1}{3} = 15.08$$

inches, as compared with 12.57 inches for the 6-inch crank.

"Aha," says the other man, "didn't I say the long-stroke engine had more leverage over the load?"

You did, you did; but hold up a moment. What good is the extra leverage if the force applied to it is less? Refer to the data in Table 2 and you will see that the total piston pressure of the engine *D* is 6283.2 pounds, whereas the engine *E* can exert only 5236 pounds. Of course, these are not the average pressures on the crank pins, but the proportionate pressures are in the same ratio. That is, if the average pressure on the crank pin, throughout one revolution, were 2400 pounds for the short-stroke engine *D*, it would be only 2000 pounds for the long-stroke engine *E*, both developing the same horsepower.

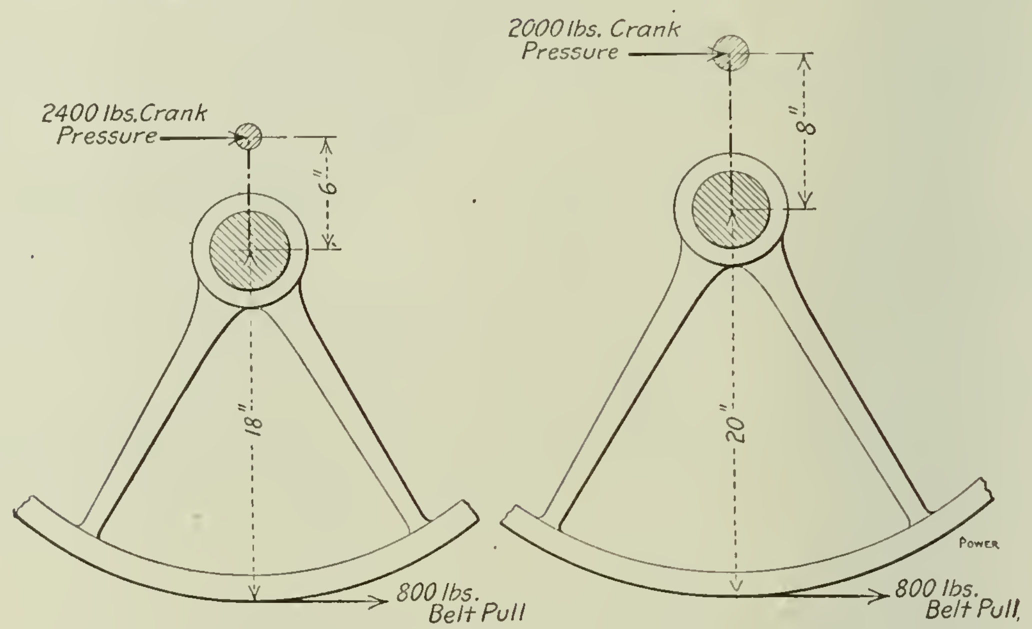
Now, the previous calculations showed that the pin of the 6-inch crank travels 12.5667 inches in the same length of time that the pin of the 8-inch crank travels 15.08 inches. Suppose the average pressure on the short crank is 2400 pounds and that on the long crank 2000 pounds; evidently, it is not any harder for the pressure of 2400 pounds to push the load 12.5667 inches than for the pressure of 2000 pounds to push it 15.08 inches in the same length of time, because

$$2400 \times 12.5667 = 30{,}160$$

and

$$2000 \times 15.08 = 30{,}160.$$

Look at it in another way. As the load pulley *p* is of the same diameter in both cases, the belt velocity is the same and the belt pull the same in both cases. Suppose the belt pull to be 800 pounds



FIGS. 5 AND 6. BALANCE BETWEEN CRANK PRESSURE AND BELT PULL

and the engine to be frictionless. Then 2400 pounds pressure at the pin of the 6-inch crank will balance the 800 pounds belt pull at the rim of the engine pulley, because the radius of the pulley is three times the length of the crank; see Fig. 5.

Now, consider the long-stroke engine *E*. The crank-pin pressure is 2000 pounds; crank length, 8 inches; pulley radius, 20 inches, and belt pull, 800 pounds, as represented in Fig. 6. The pressure of 2000 pounds at 8 inches distance from the center will exactly balance the pull of 800 pounds 20 inches from the center, because

$$2000 \times 8 = 800 \times 20.$$

Since the forward pressure on the crank pin is equal to the backward pull of the load × the leverage, in both cases, where does the long crank get any advantage in "leverage"?

Suppose a big man could lift exactly 300 pounds and no more, and a little man could lift exactly 100 pounds and no more. Could the big man lift his 300 pounds any easier than the little man could lift his 100 pounds? Not so you could notice it. The case of the long-stroke and short-stroke engines is precisely the same, so far as "leverage" and pulling the load "easier" are concerned.

COMPRESSION AND EXPANSION

The statements were made that a higher compression could be obtained with a long-stroke engine and that therefore the initial pressure will be higher, the expansion greater and the exhaust gases cooler.

Of course, if the clearance volume is the same in a 4x5-inch engine as in a 4x4-inch engine the compression would be higher, but no one who had the most elementary knowledge of gas engines would make the clearances the same. The compression pressure is limited by pre-ignition or safe maximum pressure on the moving parts, according to which limit is reached first. In gasolene engines pre-ignition always limits the compression pressure; in producer-gas engines the maximum pressures usually set the limit for compression.

When the builder decides what compression pressure to use, he makes the clearance space of the right volume to get it, no matter what the relation of stroke to bore may be. If a 4x4 engine will not stand more than a certain compression pressure without danger of pre-ignition, neither will a 4x5 engine. On the other hand, if it is safe to make the compression pressure of a 4x5 engine higher than that of a 4x4 engine, then the latter is too low and should be increased by reducing the clearance volume.

To get a numerical comparison of the various points brought up in paragraphs 3, 4 and 5, let us suppose that a small gasolene engine, say of 4 inches bore, cannot be operated reliably with more than 82 pounds compression pressure (absolute). The explosion pressure of such an engine will be about three times the compression pressure and the pressure when the exhaust valve opens will be a trifle over one-sixth of the explosion pressure or one-half the compression pressure. These proportions give the figures in Table 3.

Evidently there is no difference here in anything relating to cylinder pressures except the piston displacement and clearance volume. Now, supposing for the sake of argument, that the same clearance volume could be used in both engines, what would be the comparison? The figures in Table 4 give it clearly. Where is the expansion to lower exhaust pressure and the corresponding lower exhaust temperature? The truth is that statement 2 is absurd. The fact that the initial or explosion pressure is higher does not necessarily make the exhaust pressure lower. The expansion ratio is higher, of course, with a higher compression ratio, and this tends to increased efficiency.

But there is no ground for assuming that the compression pressure can be carried higher in a long-stroke engine than in a short-stroke engine of the same horsepower and using the same fuel. Therefore the comparison in Table 3 is the correct one.

There are true features of comparison which the writer of the article under discussion did not even consider. For example, the short-stroke engine has less wall surface in the cylinder and the heat loss can therefore be made less than in a long-stroke engine of equal power. On the other hand, combustion of the fuel at constant volume can be more nearly realized in the long-stroke engine because the piston is practically stationary at the end of the stroke for a slightly longer time.

TABLE 3.

Engine	A	B
Cylinder	4x4	4x5
Piston area	12.57	12.57
Piston displacement	50.27	62.83
Clearance volume	16.76	20.94
Compression ratio	4	4
Compression pressure	82	82
Explosion pressure	246	246
Expansion ratio	[illegible]	[illegible]
Exhaust pressure	42	42

TABLE 4.

Engine	A	B
Cylinder	4x4	4x5
Piston displacement	50.27	62.83
Clearance volume	16.76	16.76
Compression ratio	4	4.74
Compression pressure	82	[illegible]
Explosion pressure	246	[illegible]
Expansion ratio	[illegible]	[illegible]
Exhaust pressure	[illegible]	[illegible]

These are points of minor importance, however; the main points are the greater wear and tear of the short-stroke engine and, on the other hand, the greater weight and cost of the long-stroke engine. The choice of stroke-to-bore ratio is a compromise between these opposing disadvantages.

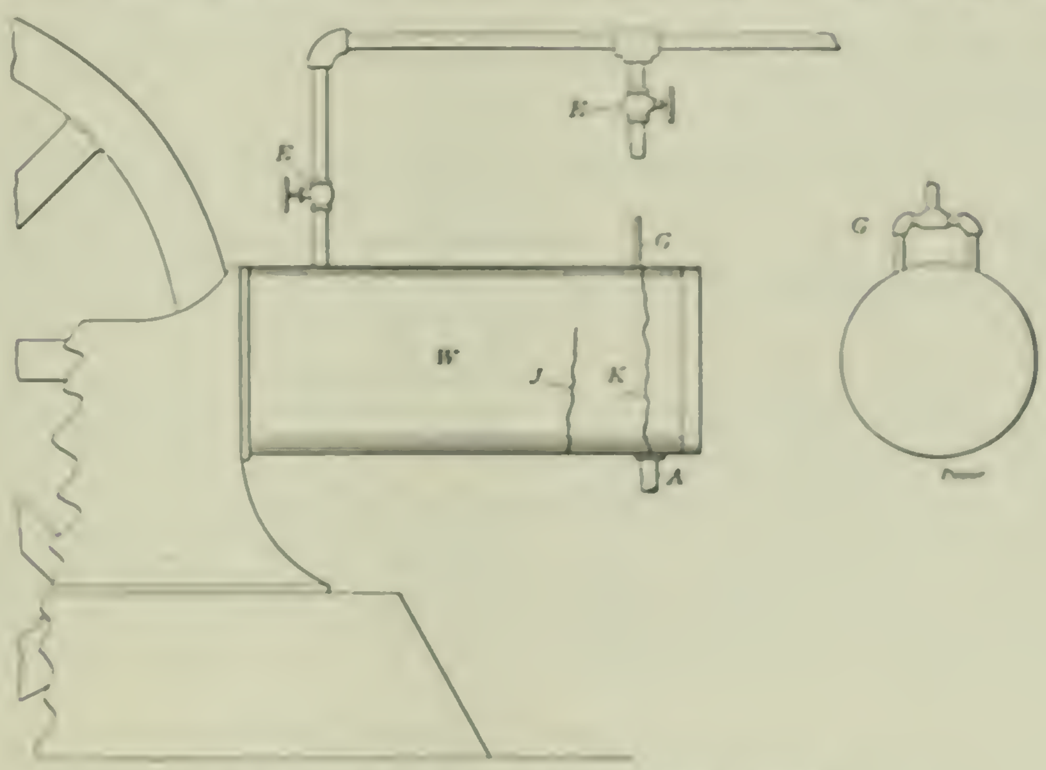
After you have studied a machine for weeks and understand the cause of the trouble, do not expect the boss to take your word for it, or expect him to understand all you try to tell him about it with one explanation.

CORRESPONDENCE

Mr. Booth's Gasket and Mr. Sanders' Cracked Jacket

In the issue of December 6, Frank E. Booth recommends the use of graphite on the gasket between the cylinder and head. I think that would be condemned by most engineers because the gasket would be more apt to blow out. In my experience with gas engines I have used a wire-inserted asbestos cloth in making that joint, and did not put anything on it. On removing the head I used a case knife to cut the gasket loose.

Referring to F. W. Sanders' article on the same page, I cannot see how reversing the flow of the water would change the pressure. I should say that the cool water entering at that point and coming in contact with the hot plate would set up strains that caused the leak. On reversing the flow the water would merely be warmed considerably before reaching this point.



Working with a Cracked Water Jacket

[illegible]

Mohave City, Ariz.

Lignite mining and the manufacture of patent fuel are of growing importance in Germany, according to the British consul in Berlin, the constant increase in consumption being due to the fact that both materials are used for many more purposes in the present day than was possible formerly. New plants are now fitted up with steam boilers that have been specially constructed for the use of lignite and patent fuel. The existing lignite syndicates have established far-reaching organizations for selling lignite, and have forwarded their aims to no small extent by the introduction of stoves specially adapted for heating by briquets.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Making Pipe Covering

When tearing out or changing old pipe work, it is difficult to preserve the pipe covering, especially the cheaper grades, as it cracks and drops to pieces.

Many engineers throw away this old covering, and, in some instances, it is replaced with a new covering at a considerable expense.

The accompanying illustrations show how this old covering may be used to good advantage, and save the expense of purchasing new covering. *A* is a piece

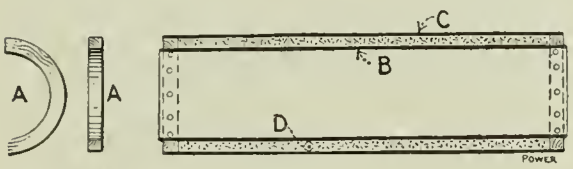


Fig. 1.

of wood about $\frac{3}{4}$ inch thick, cut in a circular form, the inner diameter being equal to the diameter of the pipe to be covered, and *D* being equal to the desired thickness of the covering.

One of these pieces is used at each end of the form, and a piece of sheet iron, bent to fit the outside of the pipe, is put on the inside of the circular pieces of wood.

Another piece of sheet iron is then bent to fit the outside of the blocks, and both are fastened by small bolts, running through the blocks, as shown at *C*.

The old pipe covering is then crushed or broken up, and mixed with enough water to make it work well. The form is laid in a horizontal position, and the plaster poured into the space between the two pieces of sheet iron *B* and *C*.

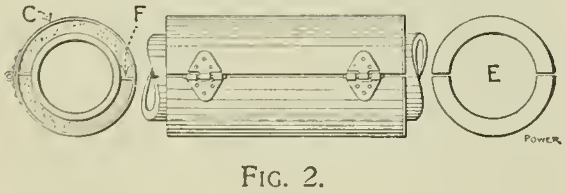


Fig. 2.

Care should be taken to push the plaster down well into the form, so that there will be no holes in the bottom.

If a little portland cement is mixed with the covering before the water is added, it will dry quicker and be more substantial. After it has dried for a few hours, it may be taken out of the form and put on the pipe.

Fig. 2 shows another form which is more convenient for small pipe and may be made for larger pipe, if desired.

Instead of using blocks, the two sides are made as shown and are hinged on one side. A piece of pipe the size to be covered is used for the inside of the form.

A ring *E* is cut, as shown, and one piece is soldered to the lower end of each side to hold the pipe in the center of the form. The covering is then poured in from the top. When it is dry, the form may be opened and the covering taken out.

The projections *F*, on the sides of the form, cause the covering to be cast in two pieces.

The covering will come out easier if the inside of the form is greased a little before putting in the plaster. This will prevent the covering from sticking to the form.

R. L. Rayburn.

Kansas City, Mo.

Don't Neglect the Safety Stop

Our engine has a 12-foot flywheel and runs at a speed of 80 revolutions per minute. A 70-kilowatt generator is belt driven from a jack shaft. The generator was fitted with a 16-inch cast-iron pulley and ran at a speed of 600 revolutions per minute.

One evening this pulley burst, breaking the belt which flew under the rope drive, knocking the ropes from the flywheel and knocked off the governor belt. This would have resulted in a serious wreck if the safety cams had not been properly adjusted, because I was left in absolute darkness until I could get to the switchboard and throw the house-lighting switch on the other engine, which was in service at the time.

I am always very cautious about removing the pin or lever from the governor, and always instruct my assistants to be likewise.

A governor with the pin left in is as useless and dangerous as if it were not a safety-stop governor.

Walter Carr.

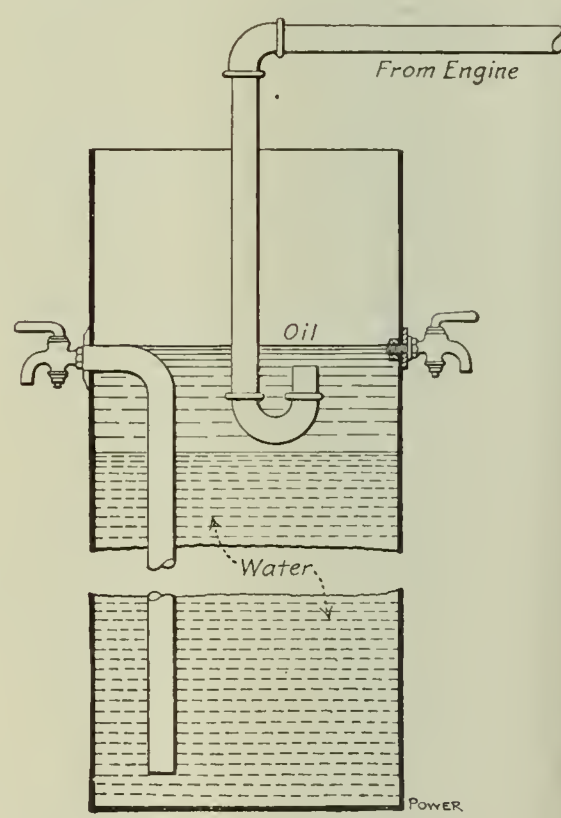
Harrisburg, Ill.

An Oil Trap

A couple of years ago I was running a 500-horsepower tandem-compound engine on which 50 gallons of oil was used per month.

Of course, this was out of all reason, but it was some time before I took a tumble to the fact that the oil was splashing back from the crosshead and guides into the stuffing-box drip and through a pipe into the sewer. Then I devised a separator, which may not be new to the "old heads," but I have never seen one like it, and it may help someone.

I took a can 24 inches deep and 5 inches in diameter, and soldered in a $\frac{1}{4}$-inch cock, $3\frac{7}{8}$ inches from the top, for an oil drip.



Details of Oil Trap and Piping

Then I soldered a piece of lead pipe, 20 inches long, to another $\frac{1}{4}$-inch cock and soldered in this cock at a point 4 inches from the top of the can, allowing the pipe to extend nearly to the bottom of the can. Next, I ran a $\frac{3}{8}$-inch pipe from the engine cesspool, allowing it to dip some 6 inches into the can and ending in a return bend.

The can would fill with water and oil, the oil staying on top of the water of course, and the excess water passing out through the pipe. When four or five inches of oil accumulated, it would rise to the level of the oil drip and flow to the filter, while the water would flow to the sewer from the other cock.

After installing this device the oil bill dropped from $12 to $2 per month.

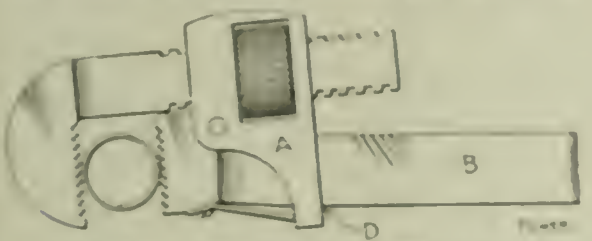
F. B. MILLER.

Defiance, O.

How to Use a Pipe Wrench

Every engineer knows that a pipe can be easily jammed by a pipe wrench, but if my instructions are carried out, one can be used on even thin pipes without jamming them.

Place the wrench on the pipe and get it to bite; then slack off on the nut until the frame *A* comes in contact with the



APPLICATION OF PIPE WRENCH

handle *B*, at *D* (see illustration), thus preventing the jaws from closing; the wrench then has power to turn, but not to jam the pipe.

H. A. GREENE.

Boston, Mass.

Exhaust Head Too Small

On taking charge of my present position, I found that an exhaust head had been installed on the exhaust pipe of the main engine. The exhaust pipe ran from the main engine to the feed-water heater, and from the heater to the atmosphere, and a drip pipe ran from the exhaust head to the heater. With a light load on the engine the exhaust head did its work very satisfactory, but with a heavy load it was not of sufficient size to handle the exhaust steam, and the moaning of the steam through the head could be distinctly heard for some distance. The head was removed and the superintendent did not miss it for nearly a week, when down he came to the engine room to know why I had removed it.

I told him I did not like the sound of the tune it was playing, for one thing, and for another it was difficult to convince the feed-water heater that it was right and proper for it to stop on the job while the exhaust head was in place.

He started for the office, but I got there first and told the manager I understood when I took charge of the steam plant that I was expected to use my best judgement and handle the plant as economically as possible, but that it would be impossible for me to do so if the superintendent was allowed to interfere. I never knew what the manager said to the superintendent, but on his next visit he said, "I believe you are trying to do the right thing around this plant, and I will try and help you all I can"; and he did.

Similar conditions prevail in a good many factory plants where the superintendent and foreman try to run the whole show, and block the engineer when they think he is showing too much ability, for fear that he may get on the inside with the management.

Who should be the best judge of what is right or what is wrong in the care and management of the steam-plant equipment, and who is the best judge of a fireman or assistant if it is not the chief engineer who has had years of experience and made a special study of the work?

W. G. WALTERS.

Stratford, Can.

Governor Arm Broke

About a year ago I was employed in a lighting plant that ran nights only. A 150-kilowatt alternator, direct connected to an automatic engine, was usually started up in the evening and ran until about 11 o'clock, when it was shut down and the load carried on a smaller unit until morning.

One night after the load had been put on the smaller unit and the big engine was being shut down, one end of the flywheel-governor bar carrying one weight broke off close up to the eccentric. I was called, but after looking over the governor I decided nothing could be done until morning, when the shops opened and tools could be obtained that I did not have at the plant.

At 8 o'clock all hands were ready to take off the flywheel and governor bar and try to put an iron strap around it and along the sides to hold it together until a new one could come from the factory. After working until noon and not even getting the flywheel key started, it was seen there would be no lights that night unless something else could be done.

The superintendent suggested that we block the governor wide open, which was done, and the remaining arm of the governor was clamped to a spoke in the flywheel. A pair of wires were run to a voltmeter near the throttle and a man was stationed at the throttle and regulated the speed of the engine by hand for three weeks, until the new governor came.

It was found that there was a bad flaw in the arm of the old governor and the bumping in shutting down finally found the weak spot.

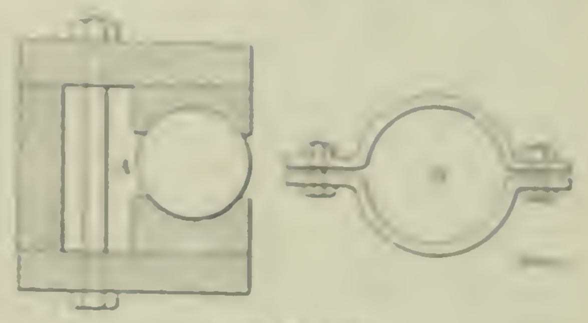
[illegible]

Delta, Colo.

Pipe Clamps

A water or steam pipe may develop a bad leak while the plant is in operation and it is not convenient to cut out the particular pipe line for repairs.

If the leak is not too close to a fitting, a temporary repair may be made with a piece of sheet packing and a couple of



PIPE CLAMP

blocks of wood bolted together as shown at *A*, or a heavy sheet-iron clamp may be made as shown at *B* in the accompanying illustration.

CHARLES H. TAYLOR.

Bridgeport, Conn.

Homemade Tube Cleaner

Some concerns will not invest in the necessary apparatus for the power department, and then it is up to the engineer to do the best he can. The accompanying drawing shows how a tube blower can be made out of a few fittings.

This blower consists of a piece of ½-inch pipe 18 inches long and tapered at

HOMEMADE TUBE BLOWER

the end, that is, screwed into a tee, the end coming to a point beyond the [illegible]. On the other end of the tee is screwed a piece of 1-inch pipe. It is screwed in so that the end reaches to the tapered end piece of the ½-inch pipe.

On the end of the 1-inch pipe is screwed a 1-inch perforated cap which serves to [illegible] the steam into a number of currents which pass into the tube and cleans it of soot.

A piece of ½-inch pipe is screwed into the side outlet of the tee and when steam is turned on the device acts as a syphon and draws a current of air through the handle and prevents it from heating so that the handle is always cool.

[illegible]

[illegible], O.

Getting the Position "Higher Up"

Much has been published in regard to becoming a more efficient engineer in order to assume greater responsibilities. Very little has been published, however, about how to secure the job higher up. It is more of a task to secure the job after one is fitted for it than some seem to think.

To illustrate, a certain uptodate engineer I know is young and progressive and has never let a chance slip whereby he could better himself. He holds a diploma from a correspondence school, is well versed in electricity, combustion and the multitude of things that a first-class engineer should know, and without a doubt is an A No. 1 engineer in every way. His present employer has told me that he is the best engineer he ever employed (and he has employed a good many). Now, in view of the fact that we read good men are always in demand, this man has been trying to get a better position for over two years without success.

Probably one reason why an engineer does not "get next" to better jobs is because he is tied down so close and does not have the opportunity to hear of the openings and is greatly handicapped in that way.

I would suggest that the boys give us their ideas on the following: If an engineer is desirious of securing a larger position, how should he proceed to get it? It is assumed that he is capable of holding it in every way.

OSCAR J. RICHMOND.

Bridgeport, Conn.

Federal Laws

In reading Mr. Blanchard's letter, published in the January 10 issue of POWER, I noticed that he mentions a bill that is to be considered by Congress, relating to the Federal inspection of all locomotive boilers in the United States. I saw a copy, or rather, it was supposed to be a copy of this bill some time ago, and, if I remember right, the Boilermakers' Union is "fathering" it. I noticed one paragraph in particular which reads about as follows: "No applicant will be examined for the position of boiler inspector unless he has had at least five years' practical experience as a journeyman boilermaker." It seems to me that by inserting this clause in the bill the Boilermakers' Union is trying to form a sort of monopoly of all the inspectors' jobs that will be created if the bill becomes a law. We have quite a few good boiler inspectors in the State of Massachusetts and I venture to say that a large percentage of them have not had five years' practical experience as journeymen boilermakers.

I fully agree with Mr. Blanchard in regard to a Federal boiler-inspection and stationary engineers' license law. This would most assuredly be a step in the right direction. In my opinion it is up to the National Association of Stationary Engineers to start the ball rolling.

FRANCIS CLEGG.

Taunton, Mass.

Removing Oil from the Eye

Oil in the eye causes a burning, itchy feeling, but relief can be obtained by filling a wash basin with luke-warm water, in which a teaspoonful of table salt has been dissolved. Then put the eye in the salt water and open and close it slowly a few times.

Next fill the basin with cold water and, after opening and closing the eyes under water, dry them on a clean towel, but do not rub them.

Salt water cuts the oil, and the cold, clear water rinses the eyes and invigorates them.

WILLIAM E. DIXON.

Malden, Mass.

Fitting Piston Rings

Two rings of the snap type were turned ¼ inch larger than the cylinder and had to be cut slantwise before it would fit the cylinder. About ¾ inch had to be cut off and when a ring so treated is sprung together and forced into a cylinder, the sharp points will keep a considerable part of the ring from bearing against the cylinder walls. I therefore filed these points down and rubbed the rings in a bore provided for the purpose and spotted them to an all-round bearing.

Some engineers might expect the rings to wear to a fit. Suppose they will do so without scoring the cylinder, there would be a waste of steam during the wearing process and the result would be an unnecessarily large opening at the joint.

I fitted the rings to the grooves just tight enough to hold the joints together but so they could easily be moved by tapping them with a hammer handle. I have been told that this is much too tight, as the rings should be loose enough to slide in the grooves, or otherwise they would not expand against the cylinder walls.

If piston rings are fitted so that the spring is just compensated by the friction in the grooves, they will expand as soon as the piston begins its reciprocating movement.

If the rings are loose enough to slide they certainly have a side movement, which will increase, and cause them to rattle in a short time. I do not advocate the indiscriminate use of a coarse file, nor do I believe in jamming rings into the grooves, but in carefully fitting them both ways.

H. WIEGAND.

Chicago, Ill.

Water in the Turbine

One morning I dropped into the power house of our electric-light company and the operating engineer was running a high-pressure turbine of 1500 kilowatts capacity. All at once the lights began to grow dim, as the machine began to slow down. The turbine did not sound as though overloaded.

Engineer and switchboard operators were looking for a short-circuit and, being satisfied there was none, the engineer ran to the turbine and was about to make adjustments to speed it up, at the same time giving orders to the oiler to get an exciter and engine ready to cut in, when the lights came on and it seemed that everything was all right; but in about 30 seconds down went the lights again.

Finally the trouble was located in the boiler room; one of the firemen had let his boiler fill up with water and, of course, the machine did not make a very good water and steam turbine. The water did not cause any damage, as when it was lowered everything went along as usual.

Steam was carried at 140 pounds and, the water being high, slugs of it passed over into the turbine.

By being present at that time I got a little education in the variation of sound between a short-circuit or overload and water going into a turbine.

L. O. HUSTED.

Curtis, Colo.

Homemade Babbitt and Belt Dressing

If mining machinery in the mountains, or the drilling outfit of the prospector, miles from civilization, suddenly breaks down, it taxes the resources of the attendant to make repairs and keep things moving.

I recall an experience in the "Rockies" where it was absolutely necessary to have a quantity of good bearing metal at once, and the outfit was 160 miles from the base of supplies. The problem was solved by making a sacrifice of a copper wash boiler from the cook house, and by melting the solder from a collection of tin cans. These, combined at the ratio of one pound copper to ten of the solder, gave us splendid results. Subsequent experiments have shown that an alloy of twenty parts zinc, one of copper and three of tin give an all-round metal very hard to improve upon.

An excellent emergency belt dressing can be made as follows: Take 25 parts of linseed oil and 12 parts of turpentine; heat in a water bath and add 12 parts of pulverized rosin. Stir the mixture thoroughly and allow it to cool. Should the oil, turpentine and rosin not be available, castor oil with 10 per cent. of tallow added makes a very good dressing.

EDWARD VAN ANTWERP.

Brownsville, Tex.

Questions Before the House

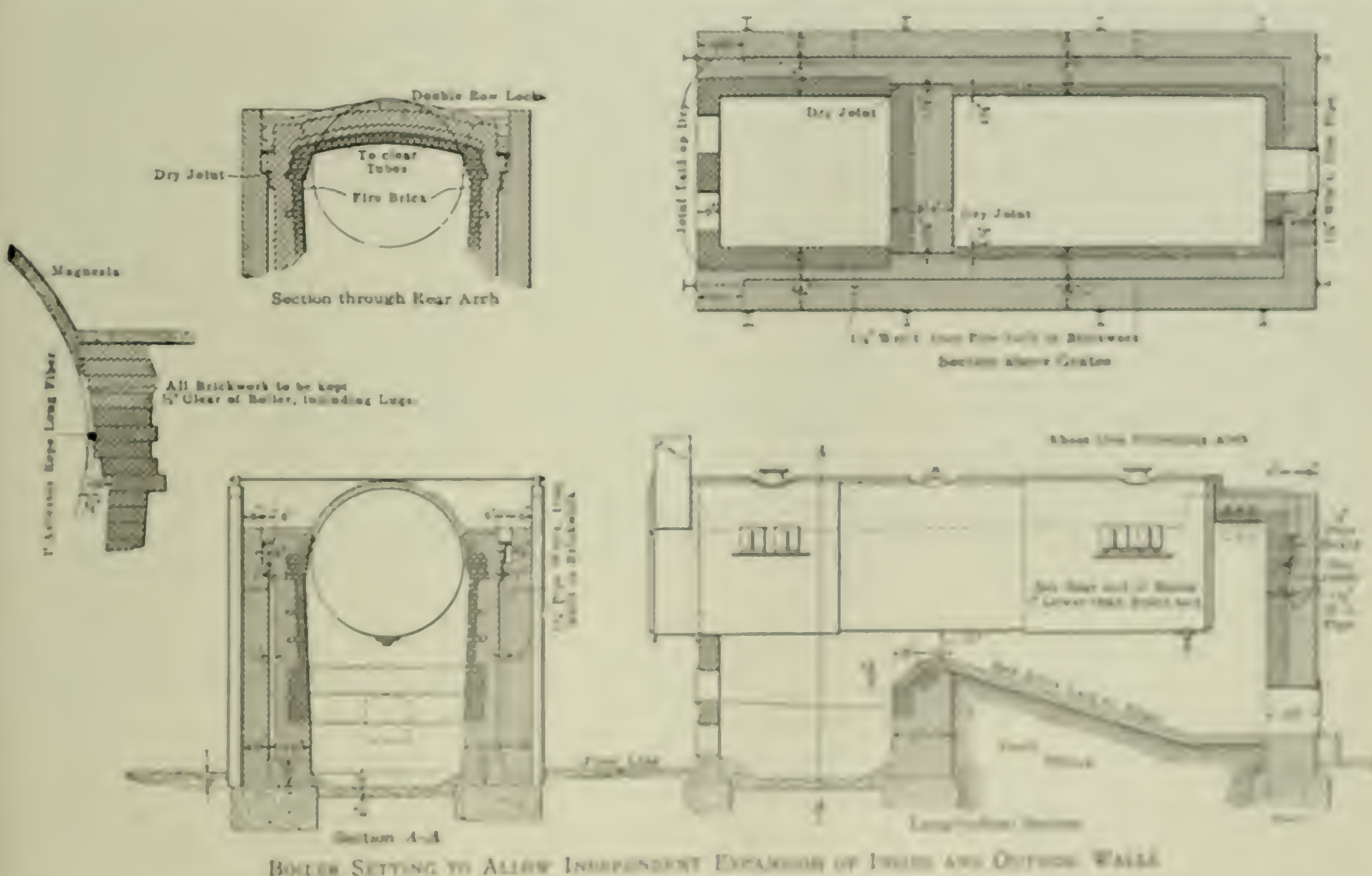
Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Setting Horizontal Tubular Boilers

I read with considerable interest S. F. Jeter's excellent and instructive article on "Setting Horizontal Tubular Boilers" in POWER for January 3. Supplementary to this article I would say that it is the aim of an engineer to so design the brickwork of a horizontal return-tubular boiler setting that it will be as free from cracks due to expansion as possible.

Figs. 2 and 5 of Mr. Jeter's article show the sections of settings as commonly designed and built, in which the inside and outside walls are bonded together at the top of the air space above the horizontal center line of the boiler. When a boiler is in operation the inside walls of a setting are necessarily much hotter than the outside walls and the expansion of the inside walls will of course be the greater. To avoid cracks from this cause I consider that the inside walls should be free to move from this cause independently so far as possible.

The accompanying figure shows a setting which I designed a few years ago with this point in view. This design is used as a standard for boiler setting in the office of Charles T. Main, engineer, Boston, Mass., and a number of boilers with settings so built have proved very satisfactory. The figure is clear enough to be self-explanatory.



BOILER SETTING TO ALLOW INDEPENDENT EXPANSION OF INSIDE AND OUTSIDE WALLS

I presume that some may question the object of the 1½-inch pipes built into the outside walls near the top of the air space. This is to allow a free escape of the vapor arising in the air space as the walls dry out after the boiler is started up. This is not original and is the practice of not a few in boiler-setting design. I do not know whether there is any virtue in it or not, but I do not see that it can cause any harm and it may do some good, and the pipe can be plugged with cement after the brickwork has dried out.

F. B. COLE.

Boston, Mass.

Troubles of a Refrigerating Engineer

In the December 27 issue, Mr. Walters writes about trouble with his refrigerating system. Mr. Walters does not state what kind of a machine he is running. According to his explanations he has what refrigerating engineers call a "dry system"; that is, no outfit without an oiling system (oil cooler, etc.), such as furnished by the Pennsylvania Iron Works, Frick, York, Vilter, etc. With all of these machines, except the Vilter, the ammonia compressors are built vertical. As I do not know what kind of a machine Mr. Walters has, I will take the Vilter machine as an example. This machine has a horizontal compressor. A small pump, driven from the engine shaft by a belt is used to supply with oil the sleeve through which the piston rod works. The oil in the sleeve serves to keep the piston rod from getting hot. Sometimes oil is taken with the piston rod into the compressor. There is also a connection on the suction of the machine to supply the cylinder and valves with oil (ammonia liquid base) now and then.

The stuffing box of Mr. Walters' machine must be in a bad condition, possibly too much clearance exists between the piston rod and the back of the stuffing box. This will permit, after the packing gets worn some, too much oil to get into the compressor, and finally the packing goes the same way. I cannot understand, however, how Mr. Walters could find bits of packing, etc., in pockets in the high-pressure side of the system unless the system was flooded with such matter.

The machine discharges the ammonia and some oil into the discharge tank; the oil falls to the bottom of the tank, while the ammonia gas passes into the condenser to be liquefied and from there as a liquid into the liquid or pressure tank. The discharge tank is provided with a glass gage to indicate the hight of the oil in the tank. Of course, when the passages of the gage cocks are clogged, it is impossible to see the oil. The liquid or pressure tank has also a gage so that one can tell by opening the cock how much liquid is in the tank. In case some oil does get into this tank it will not do any harm; but, if so desired, it may be removed. From the discharge ports of the machine to the liquid tank, including the condenser and storage tank, is the "high-pressure side" of the system. The ammonia liquid is forced through the regulating valves (or expansion valves, as they are often called) to the expansion coils. If the ammonia is free from oil or other substances and not turned on too full, it freezes the coils connected to the suction of the machine. The part of the system from the regulating valves to the compressor is called the "low-pressure side" of the system.

If Mr. Walters will put a metal ring at the bottom of his stuffing box, use a good grade of packing, clean out the discharge tank and, if necessary, the liquid tank, he will find a great difference in the operation of the system. Should he still find the regulating valve to be operating badly, if he will replace it with a new one the trouble will stop. He should shut off the main liquid cock or valve first. All of the regulating valves in the different rooms ought to be marked so that they may be set at the same point again after the new regulating valve is in place. Sometimes one or more of these valves leak; this causes considerable trouble when pumping out one room separately, therefore, he should open them all. Pump the system down to zero, stop the machine and after a while start up again and pump down to zero once more or even a little lower. Not until the low-pressure gage hand remains where it was when the machine was stopped the last time is the system empty. Rap the gage slightly as the hand may hang a little. The suction and discharge valves on the machine may be closed if they are suspected of leaking. If the hand on the low-pressure gage remains at zero, it is safe to break a flange on the valve to be taken out and let the oil, if any, mixed with some ammonia out. Perhaps in Mr. Walters' case the main liquid valve was leaking, or perhaps he did not pump out properly.

In the case of a leaking main liquid valve, the effect will be noticed on the low-pressure gage, the hand will still rise after the system has been pumped back several times in succession.

To replace a valve, get all tools ready that may be needed. Have all of the nuts working easily. Start the machine, pump down to zero or a little below and keep the machine turning just fast enough to keep the pressure below zero. Then, have a good helper ready with a stopper; take out the old valve and have him close up the pipe. After everything is ready, remove the stopper and put in the new valve. If each one knows what to do, it will not be long before the new valve is in place; the quicker this is done the better. Whatever little air that is pulled into the system should not do any harm.

William L. Keil.

Philadelphia, Penn.

Hotel Power Costs

O. L. Sherman asks in the January 3 issue for data on hotel and office-building power plants. My letter in the December 20 issue will give him some figures as to power costs.

The statement for the month of October, 1910, in the above mentioned letter did not contain the total output of the generators for that month, which was 51,750 kilowatt-hours, which makes the cost per kilowatt-hour 2.36 cents. This was brought about by the large sale of current for that month.

As to the cost of the installation per kilowatt, this would depend upon the size of the units, the larger the units the lower the cost per kilowatt.

I take it that Mr. Sherman is in charge of a hotel plant where current is bought from the central station, and the remainder of the power is generated at the hotel. High-pressure steam for the laundry and kitchens is required, also for the pumping equipment and perhaps for the refrigerating machine, and, unless he has electric elevators, these also require high-pressure steam.

He probably has a boiler plant and equipment capable of carrying 100 pounds pressure. As it takes but very little more steam-generating capacity for a generating plant when the exhaust steam is used for heating purposes than when live steam is used to heat the building, he probably would not have to add to his boiler equipment in order to operate electric generators.

The size of the units will depend on the size of the hotel, that is, on the number of rooms used for guests.

Considering all from the above standpoint, and assuming that he has a "250-room house," he would get a night lighting load of about 100 kilowatts, taking in the outside lights and the roof sign, if he were using carbon lamps throughout. If he were using tungsten lamps, it would bring the load down considerably. If he has electric elevators, these would necessitate large units.

Under the requirements for lighting he would require one 100-kilowatt unit for the night load and one 50-kilowatt unit for the day load. This would leave him no spare unit for the night load in an emergency. He might have a "breakdown" connection with the central station; otherwise he would require one extra 100-kilowatt unit.

As to the cost of installation, if he did not have to enlarge the boiler plant, but just installed the steam and exhaust piping and the generating set, the cost would be approximately $45 per kilowatt, complete, including foundations, erecting, piping and pipe covering.

If an extra boiler had to be installed, it would cost from $10 to $15 per horsepower, depending on the size of the boiler. This would cover the cost of a complete boiler installed.

As to which would be the more economical, turbines or reciprocating engines, I could not say; but it seems to me that for small units, reciprocating engines would be better. One thing is certain, whatever type of machine is decided upon, it must be a quiet running one, as vibration or a singing noise would not, or cannot, be tolerated in a first-class hotel.

Mr. Sherman will do well to have all foundations built heavy and substantial, and, if possible, have all steam mains supported from the floor instead of hung from the iron work of the building.

Another point that might be of use to Mr. Sherman is that if he is considering the installing of a generating plant, and if his building is located in a business section where there are office buildings and stores near by, he could derive (by installing larger units) a good income from his plant by selling current outside for light and power purposes, and surplus exhaust for heating, also hot water for domestic use.

He could charge for the current at just a little under the rate of the central station and get plenty of customers. The steam he could charge for at the rate of from 40 to 60 cents per 1000 pounds, depending on the cost of coal; or, if he did not want to install a water weigher, he could charge a flat rate of from $4 to $5 per 1000 cubic feet of space to be heated.

From my plant I take in from $250 to $575 per month for light, heat and ice, depending on the season of the year. I have a very good customer, a theater, to which I furnish both heat and light.

WILLIAM J. BEDARD.

Rochester, N. Y.

Placing the Responsibility

If the authorities to whom is intrusted the duty of investigating and placing the responsibility for boiler explosions would conduct them more after the manner of common police-court investigations, there is reason to believe that a marked decrease in the number of failures would be the result.

Every boiler-explosion investigation that I have ever heard of or read about has apparently been conducted with the object in view of placing before the public a report that contained far more material for the scientific mind to consider than to place before the criminal prosecutor evidence that would show if there had been a probable guilt of criminal carelessness.

What has been the result? So far as I can ascertain no one in this country has ever been criminally prosecuted in connection with any of the thousands of boiler explosions that have occurred since steam boilers became at once a menace and a necessity to the public welfare.

If it were not for the appalling testimony of death and destruction intermixed with the reports of these investigations the reading of some of them would be amusing.

In the early days a report was sure to state that "the engineer admitted cold water into an overheated empty boiler"—especially was this the verdict if the engineer had disappeared with the explosion, as was often the case. This form of report eventually became unsatisfactory, for if the engineer lived he would sometimes contradict and possibly prove that such conditions did not exist.

Overpressure has always been a good explanation to hand to the public when it was bowed down with grief over the premature departure via the boiler-explosion route, of fellow townspeople, it being understood that "overpressure" was merely incidental to the operation of a boiler.

The ironmaker should be held more strictly to account for failure to use the best material and the best process for the manufacture of the iron and steel for the particular use it is intended for.

The boilermaker should be required to follow more stringent rules and should be held to account whenever investigation showed that a boiler had been improperly or carelessly constructed.

The owner should be held accountable for having in his possession a boiler that could in any manner become an unnecessary menace to public safety. He should also be held responsible for the selection of the operatives to whom is intrusted the care of the boiler.

The operatives should be held responsible for the condition and management of the boiler and the condition of appliances that pertain to the safety of its operation.

The inspectors and boiler-insurance companies should be held to a far more strict accounting than can be estimated in dollars and cents for the unfaithful performance of the duties which the words suggest.

Statistics show that comparatively few boilers explode up to a certain age. Then, why should not that age be made the limit for the term of use?

In nearly every instance when a boiler explodes, some circumstance will be brought out that will indicate that dollars were weighed against human life and the dollars weighed the most.

JOSEPH KING.

Boston, Mass.

Air Pressure for Lifting Water

The answer given to the inquiry of A. L. W., in the January 3 issue, in my opinion is not correct.

The air pressure necessary to operate an air lift is governed entirely by the submersion and the friction of the air line, and would be the same whether the lift were 50 feet or 200 feet, although the volume of air required would vary with the lift. The formula would be

Submersion × 0.434 + friction of air line = pressure.

The air pressure required to operate an air lift with 200 feet submersion with an air line of proper size should not exceed 90 pounds. The quantity of water lifted has no effect on the air pressure. The work performed in an air lift is entirely due to the buoyancy of the air and the compressor has no effect on the air after it is liberated at the bottom of the well.

In reference to the statement that the air pressure is "never less than is required to support a column of water of a height equal to the lift," this would be true if we were lifting a solid column of water, but the weight of the column is greatly reduced by being mixed with air bubbles.

In regard to this I wish to call attention to the article on the Harris pump in the March, 1905, issue of POWER, which actually lifted water 300 feet with 40 pounds air pressure and on which the patent office at first refused to grant a patent on the ground that the pump would not work. A number of these pumps have been in successful operation on the Pacific coast for a number of years.

G. A. RICHARD.

Los Angeles, Cal.

Graft

An editorial in the January 10 issue does me the honor of criticizing the communication that appeared over my name in the December 20 issue, entitled "An Engineer's View of Graft." As the editorial so controverts the facts and shows that the opinions I expressed have been misunderstood, I will endeavor to make clearer my ideas as set forth in those parts of the article that the editorial criticizes.

Ability to write so as to be understood is comparatively easy, but to write so that you cannot be misunderstood is an art; this possibly explains why more engineers do not write, a question recently propounded in these columns.

The editorial states that the opinion expressed "is not calculated to accelerate the movement for the abolition of graft." I wish emphatically to state that no such acceleration was intended if, as my article states, the accepting of the usual tokens given in return for honest patronage is to be considered as "graft."

I regret that the editorial did not define the meaning of the word, as one object of my writing was a curiosity to ascertain the scope of the word when applied to engineering.

A great deal of the sentiment expressed in the picture of the "Employer conspiring with his engineer to get more out of the seller of supplies than the face of the bills calls for" depends on the point of view. Considered from an office chair and biased by the assurance of a large salary the subject is apt to present a very different aspect than the view of a man sitting on the edge of a coal bunker, ruminating on the dismal foreboding that the grocery bill will have to go over another week in order that the "kiddie" may have a new pair of shoes.

The idea expressed by the term "conspiracy" has been considerably perverted from what was intended. Instead of "conspiring" to get more out of the seller of supplies than the face of the bill called for, the employer merely sanctions the acceptance of part of the commission that, if not received by the engineer, would remain in the bulging pocket of the salesman.

The simile of "master and menial" in some cases is very good as the engineer works for from 12 to 14 hours a day, six days a week, and receives something like $14 each week for his services. After working a short time under these conditions you can call a man most anything without injury to his feelings.

I cannot answer the conundrum, "Where are the high ideals of the professional engineer?" as I do not believe he has any, my conception of the term "professional engineer" being—One who can receive as *fees* and *commissions* what to the ordinary work-a-day engineer would be considered just plain "graft."

As I particularly desire to be considered among the "immunes," will my criticizer kindly answer the following: Does the acceptance of the premiums offered for the securing of subscribers to POWER, or the premiums offered by advertizers for the purchase of their goods, or the acceptance of a consideration for writing this article, consign me to the "black list"?

AMOS SKEG.

Saugus, Mass.

Experience of an Indicator Man

We are all big children, and like children, like to have the last word.

I would like to reply to Mr. Wheat's comment in the January 10 number on my letter in the December 6 issue. My remarks referred to an article in the issue of November 15, which described a case where an engine could not carry the load, and, upon applying the indicator, it was found that there was 68 pounds mean effective pressure in one end, and only 15 pounds in the other. Now, I think that anyone will agree with me that no such state of affairs could exist, unless the cutoff was so badly out of adjustment that one might say that it was not adjusted at all, and the engine was very little better than a single-acting engine having one power stroke per revolution. I, therefore, maintain that it should be apparent to the novice.

It is customary for erecting men to block up the regulator on Corliss engines about ½ inch and then, while the engine is running slowly, to set the cam rods so that both cams will just unhook the valves. They know all about the effect of the connecting rod on the piston travel, but they leave that refinement to be corrected by means of the indicator. There is no trouble in getting the engine to deliver its full power and with economy. The same might be said about setting the rods from the wristplate to the valve cranks, and locating the eccentric on the shaft. These adjustments are all made by marks on the ends of the valves and the ends of the valve ports, when the cylinder is cold. Heating up the cylinder distorts these adjustments to some extent Also, the shop men are sometimes careless in marking the valves and cylinder, and to get these adjustments right, the indicator must be used; but, speaking in a general way, setting the valves and cutoff in this manner is correct, and adjustments by the indicator afterward are in the nature of refinements.

W. E. HOPKINS.

Torrington, Conn.

I think that Mr. Wheat is too severe with Mr. Hopkins in his letter in the January 10 issue under the above title. I do not believe that Mr. Hopkins meant that an absolutely even cutoff could be obtained by adjusting the dashpots by the eye, and it would seem as though the difference in the rise would have been noticeable and if adjusted so that the rise looked about even, or even if the rise were equalized by the use of a rule, the engine under discussion would have had a much nearer equal cutoff than when found by the indicator man. Of course, this could be improved by giving the crank end more rise; according to one's general experience or knowledge of that particular engine. I know of one in which the difference in rise necessary to equalize the work is ¼ inch.

With engines on which the cutoff can be adjusted while running and which are direct connected to electric generators, the indicatorless man can even up the work done in each end of the cylinder by watching the vibration of the voltmeter pointer and noticing which stroke allows the finger to drop back, giving that end a longer or the other end a shorter cutoff until the finger is steady. Diagrams taken from each end after this adjustment alone might not be of the same shape, but if care were taken in setting the valves, knowing that there was no indicator available with which to check the operation, and then, if after the load on the cutoff was adjusted by the voltmeter, it would seem as though a fair job of valve setting would result.

A. N. BOGART.

New York City.

Effects of Cold Air

In answer to H. C. Fiske, relative to cold air admitted over the fire, I will say that as engineer engaged by the smoke department of one of the Middle West cities I frequently resorted to this practice for one or two reasons. First, the coals in use at that place are very high in volatile contents and there is a great volume of gas distilled during the first three to five minutes after each firing. These gases require a vast amount of air to supply the required amount of oxygen necessary for complete combustion. This air cannot be supplied through the grates as the green fuel just added has temporarily cut off this source of supply. The second reason is that when the rate of combustion is high, the temperature in the furnace is so great as to distil the above mentioned gases in such volume as to be beyond the control of the furnace operator, but, by admitting cold air through the furnace doors, the temperature can be controlled and much better results realized.

I have experienced a good deal of trouble from practical and experienced engineers and firemen who object to this practice for fear of the resultant effect on the boiler; but, after extended experience, I feel confident that no ill effects are caused by a judicious supply of air over the grates in horizontal return-tubular and water-tube boilers, although judgment should be used when this practice is applied to locomotive, Scotch or economic boilers.

H. M. PURNELL.

Erie, Penn.

Pittsfield Boiler Explosion

From information about the Pittsfield boiler explosion gathered from the daily press, as brought out by the coroner's inquest, it would appear that the boiler was fired up previous to the morning of the explosion, and that the safety valve blew freely when the gage registered only about 20 pounds. It was supposed that the gage was out of order and it was removed and brought to the city to be tested. The test seemed to indicate that the gage was correct and it was put in place again. When the boiler was again fired up the safety valve blew at the same pressure. Thinking that the steam gage was correct, it was natural to suppose that the safety valve was out of order, and to alter the tension spring.

It is possible that the engineer first gave the adjusting nut one full turn and waited to see how high the pressure would rise. Probably the valve blew again when the gage showed only a slight increase in pressure. The conditions at the ice plant on this morning possibly were something like this: fine ice-harvesting weather; 100 or more men under pay waiting for the engineer to start up; the owners fussing around, and the engineer a little rattled. What would be more natural than for the engineer to think to himself, if one turn on the nut only increased the pressure two or three pounds, I'll turn the thing down far enough at once and run according to the steam gage, which he proceeded to do.

The expert from the valve makers, the man who set the valve in the shop, says that the nut was screwed down twelve threads lower than when the valve left the factory. In my opinion it was down so far that the spring became practically a solid bushing, and I do not think the valve would have blown off at any pressure.

The results of this accident are deplorable, and the friends of the victims deserve much sympathy; it seems too bad that a little more gray matter was not used in the operation of this plant.

GERALD GRIFFIN.

Hartford, Conn.

Cause of Boiler Explosions

The numerous recent boiler explosions tend to confirm the theory which I have long entertained. Investigations seem to show that the length of time that a boiler has been in service has a strong influence on its safety. This is due to the change in the texture of the metal more than to the wearing away of any particular part of the boiler shell. A new piece of boiler steel can be bent double without showing any fracture; but, a piece cut from a boiler which has been long in service will not stand this test. This is especially true of the thicker plates. The farther the water is removed from the fire, due to the thickness of the plate, the more rapidly does crystallization of the shell seem to take place.

The editorial in a recent issue of POWER in which it is urged that the life of lap-seam boilers be limited, is eminently to the point. There should be an age limit for all boilers of lap-seam construction. The date of construction should be stamped in a conspicuous place on each boiler so that the length of time it has been in use may easily be ascertained.

Another point is that inspections should be more numerous and more carefully and thoroughly made. If it costs more to make such inspections raise the price of the insurance. Often, inspectors do not have sufficient time to make good examinations. There seems to have been too many points that were overlooked by the inspector recently which have led to disastrous results.

C. R. McGAHEY.

Baltimore, Md.

In the discussion of boiler explosions, some express the opinion that the opening of a stop valve too quickly might cause a boiler explosion in accordance with the theory that a sudden relief of pressure causes an upheavel of the water against the shell with explosive force. Others maintain that if this were possible, boilers might explode by the mere popping of the safety valve.

Tests made upon different makes of pop-safety valves, as recorded in a paper read before the American Society of Mechanical Engineers in 1909 by Phillips E. Darling, showed an average lift of 0.07 of an inch at opening for the 4-inch valves and 0.061 inch lift at opening for the 3½-inch valves. So, the discharge area of the 4-inch valve was

$$0.07 \times 3.1416 \times 4 = 0.879 \text{ square inch.}$$

Opening a stop valve quickly would give many times this area and a correspondingly greater discharge. As a safety valve often sucks up water, a stop valve would be much more likely to do so if opened suddenly, and perhaps cause destructive water hammer in the piping.

B. N. EVERITT.

Jamestown, N. Y.

"Something Just as Good"

Upon reading the ad. editor's page in the January 10 issue, I was reminded of an experience I had with a sample of "just as good" hydraulic packing.

I was induced to try a sample, so I packed both plungers of a duplex boiler-feed pump, using three rings in each plunger. This pump was used at night and kept in reserve in the day time. The packing was recommended for hot water and the pump took its supply from a large tank which received the return and pumped through a closed heater to the boilers.

On the third morning after the pump had been packed the night fireman reported that the pump would not throw any water. I at once opened the water end and found the trouble. Of the six rings that I had put in, all were gone but two and these certainly would never be recognized as rings; they looked like bunches of cotton waste.

I repacked the plunger with the packing that I had always used and thought that the trouble was over. But it had only commenced. At noon we had to take the caps off the check valves on the feed-water pipes of three boilers and take some of that packing from under the clappers. That night we had to clean out the check valve on the closed heater; two days later we had to shut down the No. 1 boiler on account of the lower connection to the water column being clogged up. A few days later we had to take off the blowoff cock of the No. 3 boiler as that boiler did not blow down freely. In this boiler we found enough of that packing to fill a quart measure; some of it was in shreds and some was in small lumps like pulp. I have often wondered how they ever got it into ring form.

It certainly did *look* just as good as any other packing, but I found that looks were deceiving and the trial of that "just as good" cost me a few dollars, plenty of worry and a good amount of hard work.

I am now waiting for another visit from that drummer. I am very anxious to have a good confidential chat with him about "just as good" goods.

M. T. MARKHAM.

Burlington, Vt.

Selection and Use of Packing

While Charles H. Taylor, in the January 3 number of POWER, has given a good lesson on the above subject, he has made one statement that upsets a theory of long standing. It is an accepted theory that one surface in moving over another produces a friction which is proportional to the total pressure between the surfaces regardless of the area of contact.

As an illustration of this it will be found that a common building brick will require the same amount of force to drag it across the floor when it stands on edge as when it stands on its side.

Mr. Taylor's statement that a packing with a flat side in contact with the rod produces the least friction because the pressure is more evenly distributed, is not in accord with the theory of friction.

T. E. HAMLET.

Means, Ky.

The Engineer's Education

W. C. Walters has something to say in the January 10 issue about chemistry for engineers. I find that in a great many cases engineers are sacrificing their chances of securing a first-class practical education to fill up during every hour of spare time on chemistry, and the theory of hydraulics, pneumatics, electricity and a dozen other things. These are all good to know, but any man who gets a good working knowledge of mathematics, steam boilers, gas and oil engines, electricity, steam engines, refrigeration and the hundreds of other things essential in a modern average steam plant, cannot possibly get time to become expert in a dozen different professions.

Every engineer must learn a little about chemistry and other things. Some engineers who write for POWER try to convince the readers that they are well up in all of the subjects just mentioned. I have spent several years studying the theory of steam engineering and it has proved of vast assistance to me. But I got my practical education first.

I would advise young engineers to visit as many different steam plants as possible, and when a thing is seen and not understood to ask questions. As Mr. Walters suggests, try to get an idea of the chemistry of the things most important in the plant, as water, coal, etc., but for your own sake do not attempt to wade through the hundreds of things in chemistry and the like that can never possibly be of any use in the engine and boiler rooms. If you must neglect one branch of engineering do not let it be the practical side, and remember, no engineer ever will rise to the top if he has no technical knowledge. But remember also that the technical expert with no practical experience is not a safe man to have charge of any plant, no matter how small. When I say "the top" I mean chief in a steam plant, that is about as high as any engineer with a little knowledge of a dozen different trades and professions can get. This is the day of the specialist, for it has been proved beyond controversy that it takes a lifetime for even a smart, brainy man to make himself a first-class expert in any one of the many different trades or professions into which every engineer must dabble more or less.

JAMES E. NOBLE.

Toronto, Ont.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Governor Pulley and Engine Speed

If an engine having an 8-inch shaft runs 200 revolutions per minute, what diameter of pulley will be required on the governor to drive it 256 revolutions per minute?

T. E. H.

The circumference of a circle is 3.1416 times its diameter.

The 8-inch shaft at 200 revolutions will pass

$8 \times 3.1416 \times 200$ *ft. of belt per min.*

The pulley will at 256 revolutions pass

Diam. $\times 3.1416 \times 256$ *ft. of belt per min.*

and these, of course, must be equal to each other for the same length of belt passes over both pulleys in the same unit of time. Then,

$$Diam. \times 3.1416 \times 256 = 8 \times 3.1416 \times 200$$

$$Diam. = \frac{8 \times 3.1416 \times 200}{3.1416 \times 250} = 6.25\ in.$$

Since the rim speed of the pulley is inversely proportional to the diameter and directly proportional to the rotative speed, the 3.1416 need not be considered and the case may be stated as one of inverse proportion.

Sp. of Gov.		*Sp. of Eng.*		*Dia. of Shaft.*		*Dia. of Pulley.*
256	:	200	::	8	:	6.25

Size of Pump for Given Boiler

How is the diameter of the water cylinder of a pump suitable for feeding a boiler calculated?

J. F. M.

First find the number of gallons of water that will be evaporated per minute, then decide the number of strokes to be made per minute by the pump. Multiply the number of gallons by 231; divide this by the piston stroke in inches; divide this by the number of strokes per minute; divide this by 0.7854. The square root of the result will be the diameter of the water piston required. It is good practice to operate a feed pump slowly, and running at its normal speed it should be capable of supplying double the average requirements.

Clearance and Mean Effective Pressure

What effect has clearance on the mean effective pressure?

C. M. P.

For a cutoff at any fraction of the stroke, the greater the clearance the higher the mean effective pressure will be.

Heat Required to Convert Ice into Steam

A block of ice weighs 10 pounds, and has a temperature of 18 degrees Fahrenheit. Compute the amount of heat required to convert it into steam having an absolute pressure of 30 pounds.

S. C. S.

To raise the temperature of one pound of ice from 18 to 32 degrees requires 7 heat units; to convert it from ice at 32 degrees into water at 32 degrees requires 142 heat units and to convert it into steam at a pressure of 30 pounds absolute requires 1158 heat units. Adding

$7 + 142 + 1158 = 1307$ *heat units.*

Ten pounds will require 10 times this.

Utility of Expansion Tank

Of what use is an expansion tank in a hot-water heating system?

U. E. T.

Like all other substances, water varies in volume with changes of temperature and the expansion tank placed at the highest point in the system furnishes room for the increase of volume of water in the boiler, piping and radiators as it is heated.

Size of Steam Pipe

How can I determine the proper size of steam pipe to supply a given size of cylinder?

S. S. P.

Multiply the cross-sectional area of the cylinder by the speed of piston travel in feet per minute and divide the product by 6000.

$$\frac{Piston\ area \times piston\ speed}{6000} = Pipe\ area$$

Ratio of Expansion by Volume

In a 12x18-inch engine the clearance is 5 per cent. Cutoff takes place when the piston is 6 inches from the end of the stroke. What is the real cutoff and what is the ratio of expansion by volume?

S. S. C.

The distance swept through by the piston is 18 inches, 5 per cent. of which is 0.9 inch; this makes a total cylinder length of 18.9 inches. If the cutoff takes place at 12 inches of the piston stroke the real cutoff will be $\frac{12.9}{18.9}$ of the cylinder volume, and as the ratio of expansion by volume is the final volume divided by the volume at cutoff. The volume at cutoff in this case is proportional to 12.9 and the final volume to 18.9. Hence the ratio of expansion is

$$18.9 \div 12.9 = 1.46.$$

Power Required to Drive Vessel

If 4000 horsepower will drive a vessel at a speed of 14 knots, how fast will 2000 horsepower drive the same vessel?

P. R. D.

The power required to drive a vessel is proportional to the cube of the speed, and inversely the speed will be proportional to the cube root of the power expended; hence,

$$\sqrt[3]{4000} : \sqrt[3]{2000} :: 14 : S$$

$$\sqrt[3]{4000} = 15.8\ .\ \sqrt[3]{2000} = 12.6$$

then

$$15.8 : 12.6 :: 14 : S.$$

$$S = (12.6 \times 14) \div 15.8 = 11.$$

If 4000 horsepower will drive the vessel 14 knots, 2000 horsepower will drive the same vessel 11 knots.

Diameter of Pipe for Given Flow

What will be the diameter of a pipe 150 feet long which will deliver 600 pounds of steam per hour with a pressure drop of 5 pounds, the boiler pressure being 75 pounds?

P. G. F.

A much used formula for the flow of steam in pipes is,

$$W = 56.68 \sqrt{\frac{w\,(p_1 - p_2)\,d^5}{L}}$$

in which

W = Weight of steam flowing per minute;

w = Weight of 1 cubic foot of steam at higher pressure;

$p_1 - p_2$ = Drop in pressure;

d = Diameter of pipe in inches;

L = Length of pipe in feet.

Substituting the known values,

$$10 = 56.68 \sqrt{\frac{0.2044 \times 5 \times d^5}{150}}$$

$$100 = \frac{3220 \times 0.2044 \times 5 \times d^5}{150}$$

$$d^5 = \frac{100 \times 150}{3220 \times 0.2044 \times 5} = 4.55$$

$$d = 1.35\ inches$$

As there is no pipe made in this size, 1½-inch pipe will be required.

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Contents

POWER

The Engineer and the Machine

Through many channels the field of the operating engineer is being invaded and with a success that depends entirely upon the alertness of the particular engineer whose plant is selected by the outsider as a possible source of revenue. The lubricating engineer, the supervising engineer and the emissary from the central station are all looking for business and the isolated plant is the land of promise they seek to exploit.

So great has been the improvement in machinery designed to displace or render needless the skill of the human hand and brain that whole trades have disappeared and armies of skilled hand workers have been reduced to the ranks of common laborers, tenders of machines, etc.

In the supervising engineer one form of the machine idea manifests itself, for in one individual is all the skill considered necessary for the economical operation of several plants, the routine work being done by rote by the commonest labor, which costs so much less than skilled labor that the payroll shows quite a decrease after deducting the fees of the peripatetic supervisor.

In the lubricating engineer the machine idea takes another form. Claiming to have saved a large percentage of the fuel used in this or that plant by intelligent lubrication. The fuel buyer's ear is readily gained and the skill of the engineer as a user of oil is rendered useless if the professional oiler gets a foothold and makes good. A cheaper man will do the oiling in the future.

But the greatest menace the engineer faces is the central station, which with its lines reaches to the limits of human habitation and industries. It stands ready to displace the engine with a motor that will run for months or years without either oil or supervision and may be started or stopped by pushing a button in any convenient location.

It is the engineer's problem to prove that it is cheaper for the power user to buy his skill than the partially or wholly machine substitute. Power generation and transmission is the field in which the special skill of the engineer is required and it depends upon his alertness or inertia whether he holds the field to himself, shares it with another at a reduced wage or is forced out altogether with no wage at all. The man in charge of a power plant, whether large or small, is directly the determining factor in the economy of its operation, and he should know more about every detail of this operation than is possible for any outsider, however well equipped he may be.

Successful steam engineering requires special training and special knowledge along several lines. Special knowledge comes only from special application. The engineer has in his own plant, small and unimportant though it may be, better facilities for special study of his own conditions than any other man in the world and he must use them to the limit of his ability or be displaced by some one of the many forms of skill-supplanting machines, human or mechanical, and take his place with the workless workers of other excluded trades.

Milwaukee Garbage Destructor

In the December 7 issue of the *Municipal Journal and Engineer*, there appears a statement attributed to H. E. Briggs, commissioner of public works, of Milwaukee, which, if true, would constitute a severe arraignment of Milwaukee's new garbage destructor, some test figures from which were given in our issue for November 29. The statement is to the effect that it is costing the city of Milwaukee two dollars and eighty-five cents per ton to dispose of garbage at the new plant, when, as a matter of fact, this figure includes not only the cost of incineration but also of collecting the garbage. Of the total cost of two dollars and eighty-five cents, therefore, not more than approximately eighty-five cents can be charged to incineration, the remainder of the charge being for hauling and labor incidental to the delivery of garbage at the plant. When the conditions of the test as reported in Power are understood it is easy to see how the cost is divided. The specifications called for a test run to include only the actual operation of the fire, stoking, etc., and keeping the grates clear of ash and clinker. The test was not to include the costs of supervision, hauling, weighing, unloading, dumping of ash and clinker, or repairs, as it was assumed that these items would be the same for any system of disposal and could therefore be eliminated. The percentage of garbage in the present [illegible] tor in the cost of operation and the test figures were obtained when using forty-one per cent. of this constituent. At the present time the everyday cost of operation is somewhat higher than the figures given in the test, by reason of the fact that the condition of the garbage and refuse as delivered to the plant varies with the season of the year, and from fifty-five to sixty per cent. of garbage is now being incinerated. Also the pay of a fireman has increased from two dollars to two dollars and fifty cents per eight-hour day.

In the *Journal* of Associated Engineering Societies, for December, S. A. Greeley, superintendent of the plant, gives the cost figures for the first five months of its operation, the cost ranging from eighty-two cents to one dollar and seven cents per ton. According to these figures the average amount of material disposed of per day was one hundred and ninety-four tons; the average percentage of garbage was sixty-six; the percentage of ash was twenty; of rubbish, eleven, and manure, three; while the average cost of disposal during this period is given as ninety-five cents per ton. For the month of November, 1910, the cost was seventy-eight cents per ton.

There is one interesting feature of this installation which has not been touched on and which will throw considerable light on the management of municipally operated institutions. Some months ago, in the effort to economize in op[illegible]ion, the labor expense for the pl[illegible] [illegible]duced to such an extent as t[illegible] the expense for disposal of refuse per ton from eighty-eight cents to seventy-eight cents. This was unsatisfactory to the labor organizations and the city administration ruled that the men should be reinstated. Whenever a municipally operated project is proposed the cry goes up that on account of the high wages and short hours commonly associated with such institutions the project cannot compete with a privately operated plant. Here we have an example of a municipally operated property run by a Socialist administration which is extremely friendly to union labor and where the difference in labor cost between satisfied and dissatisfied union workers represents roughly only twelve per cent. of the total cost of operation.

Smoke and Health

At a meeting of the Engineers' Club of Philadelphia, a short time ago, at which the subject of smoke prevention was discussed, an eminent physician made the following statement:

"Is it any wonder that respiratory diseases and diseases of the mucous membranes are so common and habitual in our big cities, where railway and factories daily pour forth volumes of black smoke? Sore eyes and catarrh of the nose, throat and bronchial passages may be produced directly by the mechanical irritation of smoke particles. Smoke does not produce tuberculosis. The infective agent of this disease is carried in dust. However, the smoke evil, if not a direct producer, is indirectly an important and serious predisposer to the disease. This happens in two ways: First, by a local irritation of the membrane of the air passages it sets up a catarrhal susceptibility to infection; secondly, by the habitual catarrhs and insufficient quantity of fresh air so contaminated by smoke the general systematic resistance to disease is diminished, and when the recuperative and reparative powers of the body are thus debilitated and weakened, the bacillus soon finds favorable soil and lodgment, and ready access to the vulnerable tissues."

So much for the injurious effect of smoke, but how about the sulphurous gases with which the air of large cities is contaminated due to the burning of coals high in volatile sulphur?

President Taft's Water Power Policy

On February 1, President Taft approved a plan for the leasing by the Government of water-power sites on public lands. The essential features are that the Federal Government shall continue to own and control the water powers on the public domain. Legislative authority must be sought for issuing term leases for periods not to exceed fifty years. Those leasing from the Government must pay for what they get and must promptly and fully develop the powers so that there shall be no unnecessary limitation of output. Rates to consumers declared exorbitant by the Supreme Court shall be ground for the cancelation of the lease. At the expiration of the lease, it is proposed to give the lessee a preference right to renewal unless the Government desires to use the property for public purposes; and, provided the lessee fails to secure a renewal either because the Government desires the land or because another applicant offers better terms, the previous lessee shall receive compensation for the actual value of improvements on the ground or be allowed to remove such equipment.

As president of the National Conservation Association, Gifford Pinchot highly commends President Taft's water-power policy. It is in full accord with the principles for which the association stands, and the policy as outlined has been enforced by the United States Forest Service so far as the existing law would permit.

The rigid enforcement of this policy will mean a great deal to the country. It will prevent a monopoly in water power, tend to keep the rates for power at a reasonable figure, and above all keep the water powers in the hands of the people. It should be enacted by legislators, rigidly enforced by employees of the Government and supported by the people.

The Isolated Plant Association

The motto "In union there is strength," seems to be the keynote of the present movement to resist the encroachment of the central station on the field of the isolated plant. It is not alone the engineer who feels the ground slipping from under him; the manufacturer, the salesman and everyone even remotely concerned with them, feel the pinch that is to come when but one public-service corporation shall furnish all the power required in a community. Accordingly these various interests have united in an organization known as the National Isolated Plant Association.

As is the case with all such organizations its success or failure will depend largely upon its policy at the start. It must gain the confidence and coöperation of all parties concerned, and in order to do this it must be manifest, both in words and action, that the common interest alone is to be served.

Little will be gained by adopting a hostile attitude toward the central station, but much progress can be made by proceeding along competitive lines, based upon actual knowledge of the facts. It must be conceded that there are a few classes of service wherein the central station can legitimately furnish power cheaper than the isolated plant, and it should be the policy of this organization to show the consumer just where the line should be drawn. In short, its duty will be to seek the truth, even though the shoe may pinch in certain instances.

In his annual report, Pres. Henry M. Whitney, of the Rhode Island Coal Company, made the following statement: "The coal is of excellent quality, and the so called 'treatment' has been found to be unnecessary, since the coal burns as well without as with it." Over a year ago Power gave some little attention to Rhode Island coal and we are glad to see that Mr. Whitney's present opinion concerning the value of the treatment verifies our prediction.

According to reports of the United States Geological Survey, California contains approximately one-tenth of the total oil-producing territory in the United States. Yet it is estimated that she furnishes one-half the probable minimum and one-third the probable maximum oil production of this country.

Some engineers imagine that because they have kept a small power plant running, they can handle a large central station.

Falling Stack Kills Engineer

During a high wind that swept over New Jersey, Saturday, January 25, a 90-foot brick stack at the Caledonian mill of the United Box Board Company, Whippany, N. J., was blown down, instantly killing the engineer, George Lockwood, and severely injuring Superintendent William Purcell.

Fig. 1. Tilted Iron Stack

The stack stood at one end of the boiler house and served one of three return-tubular boilers. The other two boilers were each served by a separate 60-foot iron stack. When the brick stack collapsed, it parted the guy wires of one of the iron stacks, causing it to tilt over as shown in Fig. 1.

In falling, the brick stack crashed diagonally through the engine-room roof and that of the stock room of the main building. It was in this latter room that Lockwood was killed. Fig. 3 shows the crumbled condition of the base of the chimney and the wreck of the buildings. Most of the chimney fell into the engine and stock rooms, partially wrecking the engine and other apparatus. Fig. 2 shows a partial view of these rooms after much of the débris had been removed.

Lockwood was found pinned under an 8x12-inch timber which had supported the roof and it was this same timber that partly protected the superintendent, who is expected to recover.

This stack was erected about fifty years ago. It was recently repaired, but according to the consensus of opinion the stack was unstable at the corner next to the mill, where the brick had weakened with age. This and the high wind were sufficient to cause the disaster. From the appearance of the brick débris, the base of the stack collapsed, allowing the upper part to settle, and, then losing its equilibrium, to topple over onto the roof of the building.

Men were set to work cleaning away the wreckage and a good deal of the stack had been removed before a Power representative could get to the scene of the accident.

A report that seems to be borne out by the evidence is to the effect that the chimney had been considered unsafe for some time, and that the engineer, becoming anxious about it in the high wind, looked up the superintendent and that both men were on their way to the boiler room when the crash occurred.

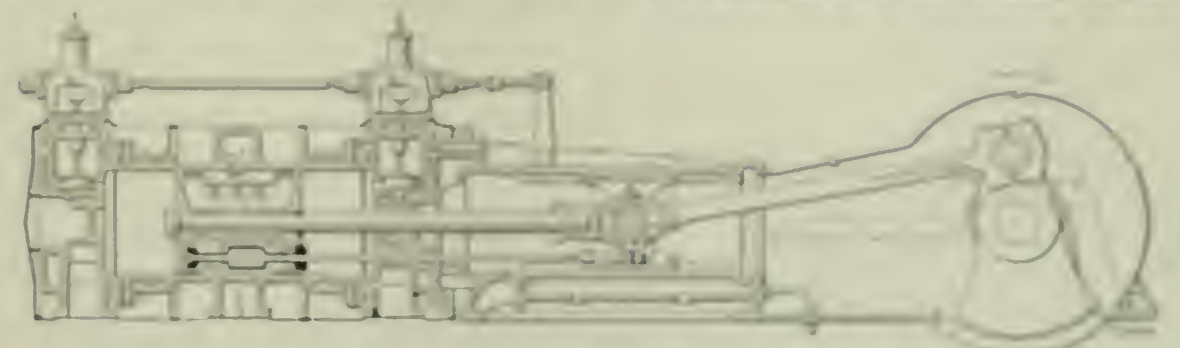
Fig. 2. Engine and Stock Rooms

Fig. 3. Crumbled Stack Base and Wrecked Wall

They're buildin' Lock 26 on the Ohio river near Gallipolis, an' the other day I got a picture postal from there showing the "Coffee Dam" an' the battery of bilers fer makin' er. Now I wonder what brand of coffee'd be strong enough to dam the Ohio?

Latest Design of Straight Flow Engine

In the article by Rudolf Klein on the straight-flow engine, which appeared in the January 31 issue of Power, reference was made to Fig. 5 as the latest design of noncondensing straight-flow engine. A cross-section of a condensing engine designed for connection to a jet condenser was inadvertently substituted for the accompanying illustration. Mr. Klein's description was as follows:



Longitudinal Section through Straight-flow Engine

The latest design of noncondensing straight-flow steam engine, which bears witness of the resourcefulness of the inventor, is shown in Fig. 5. A piston valve is placed inside the piston directly below the rod. It is operated by a little rocker arm, which is attached to the crosshead end of the connecting rod, and rocks about the crosshead pin as center. The valve alternately opens one side of the piston or the other to the respective cylinder ends, providing passage for the exhaust steam from these ends through its seat and the holes in the side of the piston to the exhaust slots. These valves close a trifle after the exhaust slots are closed by the second set of piston edges passing them. Pressure inside the piston is kept atmospheric throughout the stroke.

The third paragraph from the end of the article should have contained the word balancing, as this is the feature referred to.

Oldest High Pressure Steam Engine

By B. M. Baxter

This engine, which was without doubt the first of the high-pressure early cutoff type, was built by Oliver Evans at Philadelphia in 1801. It is still in good condition and at present is the property of the University of Pennsylvania.

A steam engine, which bears the date of 1801, and probably antedates any other of its kind built on this side of the Atlantic, is to be found at the mechanical-engineering laboratories of the University of Pennsylvania. It is complete in every respect with the exception of the flywheel and could be put into running order with very little trouble.

The engine, as shown in Fig. 1, is of the vertical-beam type, sometimes called the "grasshopper" type, and has a 12-inch cylinder and a 20-inch stroke. The slide valve is driven from an eccentric on the main shaft, through a rocker arm and shaft and vertical side rods attached to a yoke which, in turn, is connected to a vertical valve stem. In Fig. 2 this valve gear is clearly shown.

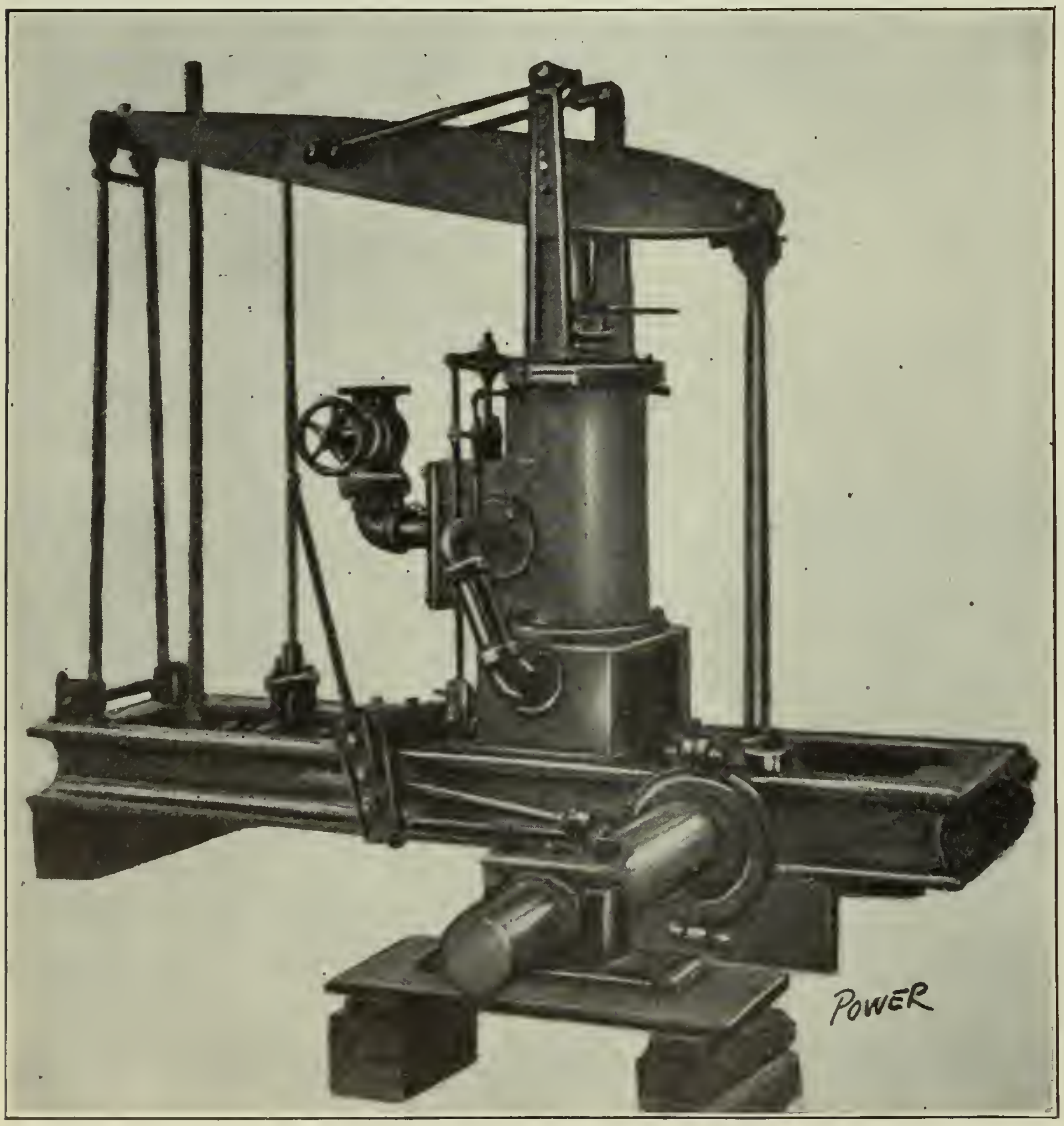


Fig. 1. General View of Engine

The crank is of the overhung type, and all the rod ends are strap ended with gib and key adjustment, similar to that used on many engines of modern design. The vertical rod attached to the beam, to the left of the cylinder, operates a plunger pump, which was probably used for the boiler feed. The discharge pipe from the pump projects vertically upward near the end of the frame.

There are two brass plates attached to the beam, which bear the following inscription:

OLIVER EVANS
1801

The inscription on a third plate, apparently of great age, is not legible, and another one of more recent date reads:

PRESENTED BY THE WILLIAM CRAMP & SONS SHIP AND ENGINE BUILDING COMPANY TO THE UNIVERSITY OF PENNSYLVANIA.

This engine is of the high-pressure, cutoff type, in contrast to the Newcomen or Watt engines which used steam merely as a means of producing a vacuum, the atmospheric pressure doing the work.

Oliver Evans has a good claim to being the inventor of the cutoff engine, the principles of which are outlined in his book entitled, "The Abortion of the Young Steam Engineers' Guide," which was published in Philadelphia in 1805. Quoting from this work, regarding this type of engine, he says, "Although the inventor had obtained a patent in the State of Maryland, he was so engaged with the introduction of his mill improvements that he could not prosecute his inventions on steam engines, further than filing drawings and specifications of the principles in the patent office in 1792, and trying some experiments which confirmed him in the principles. In the year 1801 he commenced the execution of an engine and in the winter of 1802 had it in full operation." This extract relates to the use of high-pressure steam with early cutoff, pressures of 120 pounds per square inch being mentioned elsewhere in the book.

The Use of Crude Petroleum as Fuel

At a recent meeting of the San Francisco branch of the American Society of Mechanical Engineers, a number of papers were presented upon the subject of oil fuel. In a paper entitled the "Relative Heat Value of Light Oil as Compared with Heavy Oil," Professor Le Conte stated that crude petroleum consists principally of hydrogen and carbon together with small amounts of nitrogen, oxygen and sulphur. The nitrogen and oxygen and any incombustible residue or ash may be classed as inert impurities, while the sulphur, although a combustible, has a low heat value and is otherwise injurious.

The oils rich in hydrogen are of light specific gravity as compared with those rich in carbon; also, the former contain more heat units per pound than the latter. Water in emulsion in crude oil acts as an inert impurity and as it must be converted into steam it reduces the heat value. From the tests of a number of samples of the heavier fuel oils, it was shown that the heat value increases inversely as the specific gravity, but does not increase so rapidly as the weight per unit of volume decreases. Therefore, the heat value per barrel of the heavier oils is greater than that of the lighter ones.

Mr. Weymouth, in a paper upon "The Arrangement of Furnace for Using Oil Fuel," described the Peabody furnace. In this the bridgewall is set back from the boiler front 8 to 10 feet, with the burner of the back-shot type, inserted from the boiler front under the furnace floor and turning up at the bridgewall, without there being any direct impingement of flame. With this design of furnace a boiler efficiency of 83 per cent. has been attained. The paper further stated that when admitting a large excess of air and an average amount of oil, the flame length is a minimum and the temperature of incandescence is reached at the surface of the envelope separating the vaporized oil and air. This bright flame is sought by the untrained fireman, but it results in a loss of heat, as the subsequent mixture of the products of combustion with the excess of air, not in contact with the flame, means a lower mean furnace temperature. With economical firing the flame lengthens before coming in contact with sufficient air for complete combustion, and with the highest furnace efficiency this temperature varies from 2500 to 2800 degrees Fahrenheit.

Due to the high furnace temperature with oil fuel the location of the heat-absorbing surfaces becomes of utmost importance; consequently the first pass should be located directly over the furnace, thus providing for the most direct transmission of heat, both by convection and the absorption of radiant heat.

A paper on "The Size of Stacks with Oil Fuel," by Mr. Dunn, called attention to the fact that in burning coal a large part of the total draft (from 35 to 70 per cent.) is required to overcome the friction through the fuel bed. This is done away with in burning oil fuel, consequently a shorter stack may be used, a stack of 80 to 100 feet in hight usually being sufficient.

An interesting paper upon the "Atomization of Oil Fuel" was read by Mr. Hunt. This was in part as follows:

General practice is to deliver the oil to the burner under pressure, and inject and atomize it, using either steam or air as the atomizing medium. The oil injected into the furnace should be entirely gasified or burned while in suspension in the air; otherwise, if particles of unconsumed oil fall to the bottom of the furnace, coke will accumulate. If the oil is injected into a cold furnace not inclosed by brick walls which become highly heated, it must be in the form of a fine spray. But if the walls are highly heated, the radiation from them will aid greatly in vaporizing the particles of oil and the larger particles will be consumed before they drop.

Most of the oils used for fuel are of a heavy and viscous character and their viscosity is reduced by a rise in temperature. Therefore, it is desirable that the oil be preheated before being fed to the burners. The form of burner is of small importance compared with the furnace construction, proper air supply, etc.

Some work has been done toward atomizing the oil without the use of air or steam. The oil, having been preheated to 220 to 260 degrees Fahrenheit, is injected into the furnace through a needle nozzle having a small orifice. The portion of the needle stem inside the cylindrical part of the nozzle has a screw thread cut on it, which imparts a rotary motion to the oil. The sudden release of pressure and the rotary motion cause the heated oil to issue in the form of a spray sufficiently fine to burn successfully.

From a number of tests, using steam as an atomizing agent, the amount of steam varied from 2.5 to 5.7 per cent. of the total evaporation. It may be said, however, that in designing a plant it is safe to assume 5 per cent. of the evaporation of the boilers as the steam necessary to operate the burners; but, if this exceeds 5 per cent. in actual operation, it may be concluded that conditions may be bettered.

Except in special cases, the use of compressed air as the atomizing agent may be said to offer no opportunity for a saving in fuel over the use of steam.

Capacity of Absorption Machines

By F. E. Matthews

The capacity of an absorption, like that of a compression, ice machine can be estimated by two different methods, either by determining the amount of anhydrous ammonia made in a given length of time or by finding the amount of cooling effect actually produced on brine.

Since the so called "anhydrous" ammonia entering the receiver of an absorption machine is often far from free of water, the latter method is to be preferred.

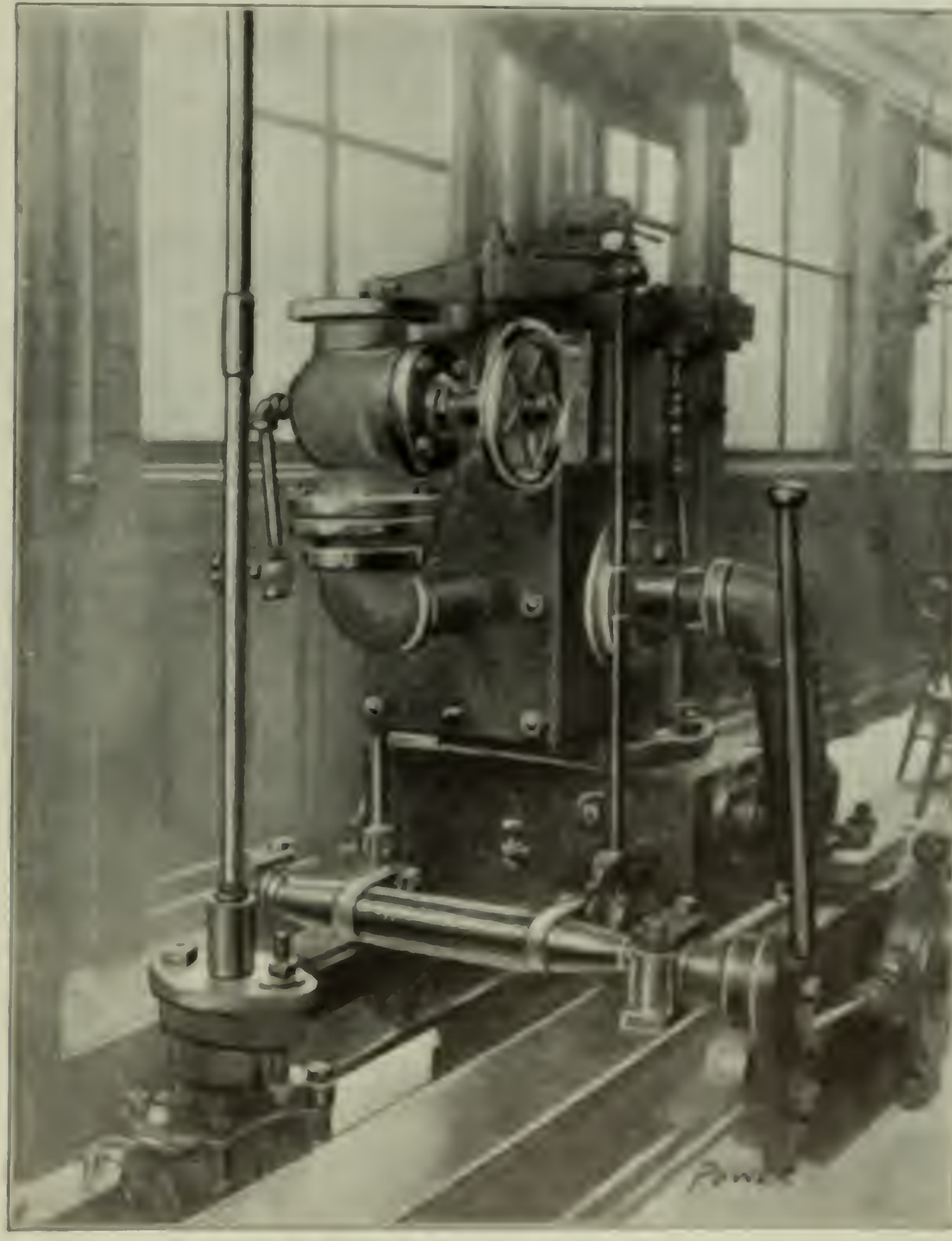


Fig. 2. View Showing Valve Gear

For very rough estimates of the capacity of a machine a cooling effect equivalent to that of five gallons of brine cooled through five degrees Fahrenheit per minute, or what is sometimes known as 25 "heat gallons," is considered a ton.

Since the amount of refrigeration required to cool brine, or in fact, any other substance, depends on the specific heat of the substance as well as on the amount chilled in a given time and the range of temperature chilled through, it is obvious that careful determinations of the specific heat of the brine should be made where accurate results are expected.

Specific heats taken from tables of properties of the kind of brine being used and corresponding to the density of the brine in use as determined by a hydrometer—due correction being made for temperatures—should give fairly accurate results.

If an absorption machine is operating on zero brine, calcium would ordinarily be used. In order to just escape freezing at this temperature, its density would have to be 22 degrees Baumé, corresponding to a specific gravity of 1.179. The specific heat of brine of this strength is 0.834. As a matter of fact, for safety against freezing, a somewhat stronger brine should be used, common practice being to use about 24 degrees Baumé, the specific heat of which is 0.817.

For every pound of brine of this quality cooled, one degree 0.817 B.t.u. of cooling effect is required.

To determine the refrigerating effect being produced, determine the amount of brine, in pounds, being chilled in a given length of time; determine also the range in temperature chilled through. Multiply the number of pounds by the range in temperature giving "pound degrees" and then by the specific heat giving B.t.u.

A ton of refrigeration is the equivalent of the heat absorbed in the melting of 2000 pounds of ice having a latent heat of fusion of 144 B.t.u.; that is, 288,000 B.t.u. The expenditure of cooling effect equivalent to the above per 24 hours is a ton of capacity.

Since there are 24 hours in a day, a ton capacity is also equal to the absorption of 1200 B.t.u. per hour; and since there are 1440 minutes in a day, it is also equal to the absorption of 200 B.t.u. per minute.

To arrive at the tonnage capacity of the machine under test, divide the number of B.t.u. of cooling effect produced on the brine per minute by 200, or the number per hour by 1200, or the number per day by 288,000.

The quantity of brine cooled can be arrived at roughly by the use of a meter, still more roughly from the size and number of strokes of the brine pump; but actual weighing is to be recommended where great accuracy is required.

One cubic foot of water at 62 degrees Fahrenheit weighs 62.355 pounds, and one gallon 8.336 pounds. To get the weight of brine of any density per cubic foot or per gallon, multiply these weights by the specific gravity of the brine determined at the same temperature.

If the brine has a strength of 24 degrees Baumé, for example, equivalent to a specific gravity of 1.2, the weight per gallon will be

$$1.2 \times 8.336 = 10 \textit{ pounds.}$$

With brine of these characteristics, the cooling of five gallons through five degrees, making 25 heat gallons per minute, would represent a cooling effect of

$$\frac{10 \times 5 \times 5 \times 0.817}{200} = 1.021$$

tons per 24 hours.

TABLE OF PROPERTIES OF SALT (NaCl) AND CALCIUM (CaCl) BRINES.

Sodium Chloride (Salt) Brine.			Calcium Chloride Brine.		
Degrees Baume.	Specific Gravity.	Specific Heat.	Degrees Baume.	Specific Gravity.	Specific Heat.
1	1.007	0.992	3	1.027	0.980
2	1.015	0.984	6	1.041	0.964
3	1.019	0.980	9	1.058	0.936
3.5	1.023	0.976	10	1.076	0.911
4	1.026	0.972	11	1.085	0.896
4.5	1.030	0.968	13	1.103	0.884
5.5	1.037	0.960	15	1.121	0.868
6.5	1.045	0.946	20	1.159	0.844
7.6	1.053	0.932	22	1.179	0.834
8.7	1.061	0.919	24	1.199	0.817
9.7	1.068	0.905	26	1.219	0.799
10.7	1.076	0.892	28	1.240	0.778
12.6	1.091	0.874	34	1.305	
15.7	1.115	0.855			
20.4	1.155	0.829			
24	1.187	0.795			
25	1.196	0.783			
25.8	1.204	0.771			

Steam Turbine Economy in Europe

Interesting results of recent turbine practice in Europe are given in the accompanying table, reproduced from the *Zeitschrift des Vereines Deutscher Ingenieur,* of December 10. The values have been converted into English units.

EUROPEAN TURBINE TESTS.

Type of Turbine.	Manufacturer.	Rated Capacity, Kw.	Steam Pressure, Pounds Absolute.	Super-heat, Degrees Fahrenheit.	Vacuum. Inches of Mercury.	Vacuum. Pressure, Pounds Absolute.	Steam Consumption, Pounds per Kw.-hour.	B.t.u. per Kw.-minute.	Steam Consumption, Pounds per Kw.-hour, Load ¾	½	¼
Parsons	Brown, Boveri & Co	3500	162	134	28.7	0.55	13.7	290	.....	.....	.....
Lindmark	Laval Gesellschaft	1500	187	167	28.3	0.75	16.7	343	.....	.....	.....
Rateau	Oerlikon	488	176.5	130	27.5	1.13	18.6	369	19.42	21.57	25.84
Zoelly	F. Ringhoffer	3000	176.5	99	27.5	1.17	15.5	320	16.24	17.89	19.89
Zoelly	Escher, Wyss & Co	5000	172	167	26.2	1.79	16.12	321	.....	.....	.....
Zoelly	Masch. Fabr., Augsb., Nürnb'g	1400	187	178	27.4	1.28	14.2	286	.....	16.61	20.32
Zoelly	Masch. Fabr., Augsb., Nürnb'g	1250	188	205	28.75	0.56	13.05	268	13.97	15.40	.....
M & PF	Breitfeld, Danek & Co	430	162	220	28.2	0.85	17.8	374	18.34	20.37	24.92
M & PF	Breitfeld, Danek & Co	3585	167	91	28.25	0.81	16.05	344	16.44	17.50	20.33
M & PF	Melms & Pfenninger, G. m. b. H. (Limited).	1000	196	259	28.0	1.03	15.65	329	.....	.....	.....
M & PF		1000	193	212	28.5	0.70	15.19	316	.....	.....	.....
Zvonicek	Boehm. Maehr. Masch. Fabrik, Prague.	710	165	129	26.2	1.86	19.2	376	.....	.....	.....
Zvonicek		3167	164	107	28.5	0.69	14.72	294	.....	16.39	.....
A. E. G. Curtis	Allgem. Elektr. Gesellschaft, Berlin.	2236	198	272	29.25	0.29	11.75	275	11.98	12.98	14.45
A. E. G. Curtis		3000	198	210	29.00	0.43	12.79	273	12.99	13.98	15.28
B. B. & Co.	Brown, Boveri & Co	500	155	212	28.5	0.73	16.29	337	17.26	18.49	23.79
B. B. & Co.	Brown, Boveri & Co	1100	191	194	28.5	0.73	14.72	306	15.16	16.50	19.44
Masch. Fab., Augsb.	Maschinen Fabrik, Augsburg	1250	188	205	28.7	0.56	13.05	273	13.95	15.33	.....
Masch. Fab., Augsb.	Maschinen Fabrik, Augsburg	700	145	217	29.0	0.47	13.58	308	14.05	15.48	19.83
Curtis	British Thomp. Houston	2500	131	66	28.5	0.73	15.88	309	.....	.....	.....
B.E.W.	Bergmann Electr. Werke	1545	195	202	28.4	0.68	12.92	270	13.30	14.73	.....
B.E.W.	Bergmann Electr. Werke	292	157	232	27.25	1.03	18.85	391	19.64	22.25	.....
B.E.W.	Bergmann Electr. Werke	556	204	63	28.5	0.73	17.33	341	17.49	20.5	25.73
B.E.W.	Bergmann Electr. Werke	702	17	Exhau't	26.9	1.47	33.90	605	36.38	41.68	.....
E.B.M.	Erste Bruenner Masch. Fabr.	650	176	57	27.5	1.18	18.72	360	.....	20.22	.....
E.B.M.	Erste Bruenner Masch. Fabr.	1250	191	206	27.7	1.03	14.3	294	.....	16.44	.....
E.B.M.	Erste Bruenner Masch. Fabr.	6000	191	206	28.2	0.87	12.75	265	.....	13.90	.....
E.B.M.	Erste Bruenner Masch. Fabr.	225	18	44	27.5	1.18	39.4	722	.....	47.7	.....
E.B.M.	Erste Bruenner Masch. Fabr.	200	206	188	.....	58	50.5	965	.....	58.1	.....
E.B.M.	Erste Bruenner Masch. Fabr.	1100	191	194	.....	22	30.5	562	.....	39.08	.....
E.B.M.	Erste Bruenner Masch. Fabr.	2000	160	119	27.5	1.03	13.72	284	.....	.....	.....

The National Isolated Plant Association

At a meeting of the National Isolated Plant Association, held at the Engineering Societies' building on Monday evening, January 30, a constitution was adopted and the permanent officers elected. These were as follows:

President: C. G. Armstrong, consulting engineer for the city of New York.

Vice-president: F. E. Stiles, chief engineer of the West Street building.

Secretary: E. D. Fieux, of the Wing Manufacturing Company.

Treasurer: W. B. Elliott, of the Garwood Electric Company.

Council: Mr. Buxton, operating engineer; Mr. Kimball, consulting engineer; Mr. Ferguson, manufacturer; Mr. Katten, salesman; Mr. Elliman, plant owner. The president and treasurer are *ex officio* members of the council.

Committee on admission of members is made up of the following members: Mr. Dalbec, operating engineer of the Patten estate; Mr. Wing, of the Gotham Manufacturing Company; Mr. Torrence, of the Carbondale Machine Company; Mr. Spooner, of the Ridgway Dynamo and Engine Company; Mr. Edgerton, constructing engineer; Mr. Bierck, of Borne Scrymser Company, and Mr. DeGress, of the Crocker-Wheeler Company.

Except in the case of the operating engineers actually engaged in the direction or operation of isolated plants, the initiation fee for members is $15 and the annual dues $10. No initiation fee is charged the operating engineer and his dues are $2 per year. Candidates for membership must be proposed by two members, who shall submit to the committee on admissions full particulars regarding the business and qualifications of the candidate.

As yet a complete program of procedure has not been decided upon, but it is planned to make complete tests upon numerous isolated plants now in operation with a view to collecting cost data for the enlightenment of the owner against the encroachment of the central-station solicitor.

PERSONAL

C. A. Tupper, of the Alliance Engineering and Sales Company, Inc., Milwaukee, has sailed for a cruise among Mediterranean ports and a trip through the greater part of Europe in behalf of various manufacturing interests. He is accompanied by his wife and son.

S. F. Jeter has resigned as mechanical engineer for the Bigelow Company, of New Haven, Conn., to accept the position of supervising inspector for the Hartford Steam Boiler Inspection and Insurance Company. With the exception of a short period of time, Mr. Jeter was in the employ of this company from [illegible] to 1900, first as inspector and then as special agent. He will be recognized as the author of numerous valuable contributions to our reading columns.

OBITUARY

Louis R. Alberger

Louis R. Alberger, president of the Alberger Condenser Company, died in New York City on January 31. He was born in Buffalo in 1864 and, after leaving high school, entered Yale, but later left to enter business with his father, who was engaged in the vacuum process of producing salt. In 1887 he went with Henry R. Worthington, where he remained until 1901, leaving to form the Alberger

Louis R. Alberger

Condenser Company and the Alberger Pump Company, both of which he became president of. The interment was held in Buffalo on February 3.

William B. Mason

William B. Mason, president of the Mason Regulator Company, and inventor of numerous valve and engine appliances, died at his home in Dorchester Lower Mills, Mass., on Saturday morning, February 4. He had been ill for some time, the last four weeks of which he was confined to his house.

He was born in Freeport, Me., and at an early age went to work in the Grand Trunk machine shops, where he learned the trade of machinist. Coming to Boston as a young man, he worked on stationary and marine engines, and as an engineer on harbor tugs. He joined the navy as a machinist, and was assigned to the U. S. S. "Omaha," serving for two years on the Pacific station.

Returning to Boston, he entered the employ of Crosby & Noyes, and here perfected his first invention, a governing

William B. Mason

regulator. Soon after this he produced the reducing valve now in use on three-fourths of the locomotives in this country, a device which permits the heating of cars. In [illegible] he formed the company, of which he was the head, for the manufacture of his devices.

At his factory was built the first automobile steam engine used by the Stanley Motor Carriage Company, and subsequently between [illegible] and [illegible] automobile engines were turned out. He remained active in the conduct of his business until a few weeks ago.

Mr. Mason was a member of the American Society of Mechanical Engineers, and also of the New England Railroad Club. He is survived by a widow and one daughter, Mrs. [illegible], of Brunswick, Me.

NEW PUBLICATIONS

An Introduction to Thermodynamics. By John Mills. Published by Ginn & Co., New York, 1910. [illegible] pages, [illegible] inches, [illegible] illustrations. Price, cloth $2.

A purely theoretical treatise adapted especially to the needs of the class room. The text presupposes a knowledge of calculus and is intended to follow a college course in general physics, although a brief résumé is given of such portions of this subject as are essential as a basis upon which to develop the subject of thermodynamics. It is felt that many of the definitions of the fundamental terms could have been expressed less vaguely, and the addition of more tables would have added greatly to the usefulness of the book.

MECHANICAL ENGINEERING. By Charles M. Sames. Published by the author, at Jersey City, N. J. Flexible leather; 218 pages, 4x6½ inches; illustrated. Price, $2.

This is the fourth annual edition of Mr. Sames' handy little pocketbook and, although its thickness does not appear to have been increased appreciably, it contains no small quantity of new material. This achievement, however, has its drawbacks. The contents are so condensed that it is not always easy to grasp the sense of a statement and the typographcial congestion is confusing to the eye.

The reviewer has not looked for errors, but noticed accidentally an incorrect statement at the bottom of page 59 and several at the top of page 61.

SOCIETY NOTES

A meeting of the Boston section of the American Institute of Electrical Engineers, with the coöperation of the American Society of Mechanical Engineers and the Boston Society of Civil Engineers, will be held on Friday evening, February 17, in that city. R. A. Philip, of the Stone & Webster Engineering Corporation, an associate member of the American Institute of Electrical Engineers, will present a paper on certain phases of the general subject of economic limitations to aggregation of power systems.

The Mississippi Electric Association, which represents the central-station industry of the State, had a meeting at Meridian, Miss., on January 19, when, after thoroughly canvassing the wishes of the members and receiving a unanimous indorsement, it was voted to affiliate with the National Electric Light Association. The president, A. B. Patterson, and A. H. Jones, secretary and treasurer, were instructed to make the necessary arrangements with the national body for putting this affiliation into effect. The national society has already a number of members in the State and this new union will be particularly beneficial to the smaller companies that hitherto have belonged to the local organization only.

On Saturday evening, January 28, 1911, Colonel Goethals Branch No. 1 of District 9 of the Institute of Operating Engineers was formed at Yazoo City, Miss., with a charter membership of 13. The election results are as follows: F. C. Holly, branch chairman and representative to district council; L. B. Smith, secretary and treasurer; F. C. Holly, W. W. Brannon, W. G. Richardson, councilmen for three years; Davis Chisholm, W. R. Vernon, Albert Walker, councilmen for two years; Ray Madden, Parks and Wince Hoover, councilmen for one year. W. G. Richardson, lecturer on apprenticeship training and plant operation and chairman of committee on apprenticeship training; W. W. Brannon, lecturer on educational subjects and chairman of committee on educational subjects. The chairman appointed Messrs. Vernon and Walker as assistant lecturers on apprenticeship training and plant operation, and Walker and Chisholm were appointed as assistant lecturers on educational subjects. The meetings of this branch are to be held the second and fourth Saturday nights of each month. The address of the secretary and treasurer is, P. O. Box 297, Yazoo City, Miss.

The annual banquet of the Atlantic City Council of the American Order of Steam Engineers has for some time assumed a more than local color. The fourteenth banquet, held on February 4 at the Hotel Windsor, drew a number of visitors from New York, New Jersey and Pennsylvania, including representatives of the State legislatures of New Jersey and Pennsylvania.

The large banquet hall of the hotel was filled with the members and their guests. After the inner man had been satisfied, an address of welcome was made by John Best, who also introduced the toastmaster, Mayor Franklin P. Stoy, of Atlantic City. The speakers included Senator Walter E. Edge, Postmaster Harry Bacharach, and Assemblyman Isaac Bacharach, who was responsible for Atlantic City getting the State legislature to grant it permission to pass the engineers' license law. Mr. Bacharach spoke of the great advantage to the city of having licensed men in charge of the power plants of the hotels, thus insuring to their guests that the boilers, etc., were in competent hands.

Over two hundred licenses have so far been granted.

Boiler Tube Bursts

It is reported in the daily press that on January 26 two firemen were seriously burned by the bursting of a boiler tube in the plant of the Alkali Rubber Company, Akron, O.

Boiler Explosion in Kentucky

On February 2, a boiler in a grist mill at Bruin, Elliott county, exploded, killing two men and injuring others. At the present writing further particulars are not available.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York. Next meeting in New York City, May 29 to June 3.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Commander U. T. Holmes, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., O. P. Chamberlain; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Pres., R. P. Bolton; sec., W. W. Macon, 29 West Thirty-ninth street, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting at Detroit, Mich., January, 1912.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION.

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

POWER

NEW YORK, FEBRUARY 21, 1911

RECENTLY, a prominent engineer remarked that most people know less about their own business than is known by some outsider.

While this may be putting it rather too broadly, the remark, nevertheless, contains a grain of truth.

The operating engineer, being constantly on the spot, should know his plant better than anyone else.

This does not imply merely a physical knowledge of the plant equipment, such as a knowledge of the function of every valve, etc., but, in addition, all phases of operation, and then some.

Yet, many engineers become so absorbed in their daily routine work that they lose sight of the high points, only to awaken to the sudden realization that some outsider has seen the opportunity and is making capital out of it.

This accounts for the increasing business of the consulting engineer, the lubrication expert and the economic engineer.

Although the present is often referred to as an age of specialists, they should be employed only when necessary.

Undoubtedly, these specialists are able to materially decrease the operating expenses of many plants. In fact, in certain cases the available data at their command and their particular training makes their employment essential. But in the majority of cases a competent operating engineer could carry out the work just as well.

This applies to the more simple forms of construction and erection, as well as innovations in operation. If a new engine, boilers or auxiliaries are to be installed, there is no reason why the chief engineer of the plant, aided by the data and blueprints furnished by the manufacturers, should not be able to cope with the problem without an appeal to outside aid.

This, on the one hand, would save the owner considerable expense in fees to the expert; and, on the other hand, would not only increase the engineer's field of usefulness, but would also save his pride from being sacrificed by the intrusion of an outsider.

To be properly equipped for such work an engineer must be conversant with up-to-date practice. He must know what it should cost to produce a kilowatt-hour in such a plant as the one he is operating. He should be able to judge the quality of the supplies and should know their cost. It is important that he cultivate the habit of observing, not merely seeing, and while keeping a keen eye to the small things about the plant at the same time, he must not become lost among the details. In other words, he must occasionally break away from the regular routine work and view the plant as an outsider through a binocular.

These characteristics, combined with the ability to successfully and systematically carry out a definite purpose, will fortify the engineer against encroachments upon his vocation.

Power Plant of a Newspaper Building

By Osborn Monnett

The interesting features of this installation are the water supply system, the arrangement of pumps and the hydraulic elevator piping. In connection with the latter, advantage was taken of the fact that in this service the load is always on the down trips, and the energy thus developed is utilized to raise the empty elevator.

About two years ago the entire printing establishment of the Cleveland *Plain Dealer* was destroyed by fire and in its place has been erected one of the most complete and uptodate newspaper-publishing establishments in the Middle West.

The power plant is in a well lighted corner of the basement with a 100-ton coal-storage bin conveniently located under the sidewalk. Coal is wheeled from the bin in a one-ton car, and is weighed on a Hunt scale before reaching the boilers. Two 150-horsepower Stirling boilers, equipped with Detroit stokers, furnish steam to three American-Ball engines direct connected to generators of 50, 75 and 125 kilowatts respective capacities.

The water-supply system is especially complete for a plant of this size and is arranged to operate with high-pressure lines to the upper floors and low-pressure to the first floor and basement, the water flowing by gravity from a storage tank supplied from the city mains. A plan of the system is shown in Fig. 2 and the operation is as follows: Water flows from the city mains directly to the storage tank, in which the level is maintained by a float valve. From this tank it flows to the house pumps and is pumped into tanks in which a pressure of about 40 pounds is automatically maintained by the action of the pressure regulators on the line. There is, however, a fluctuation of 20 pounds or more in the city-water supply, and should this pressure at any time exceed that maintained in the tanks, the water would flow directly to the tanks through the bypass and check valve *K*, in which case all floors would be supplied directly from the city mains. When the city pressure decreases below that maintained in the tanks, the pumps begin to operate; the discharge is prevented from returning to the city main by the check valve in the bypass. This arrangement automatically takes advantage of periods of high pressure in the city mains and thereby saves steam, which would otherwise be used in the house pumps during these periods.

Another notable feature of this plant is the pumping equipment. Vertical Cameron pumps are used and are mounted on the engine-room wall, each one on a handsome polished brass panel, as shown in Fig. 4. By this method a large pumping capacity is installed with the minimum of floor space and the pumps are easily accessible for inspection.

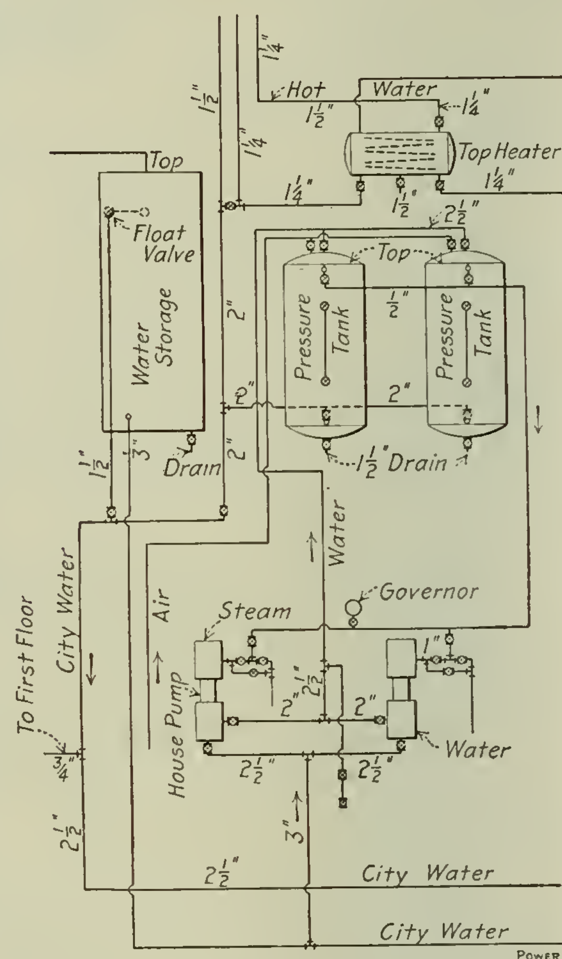


FIG. 2. WATER SYSTEM FOR HOUSE SERVICE

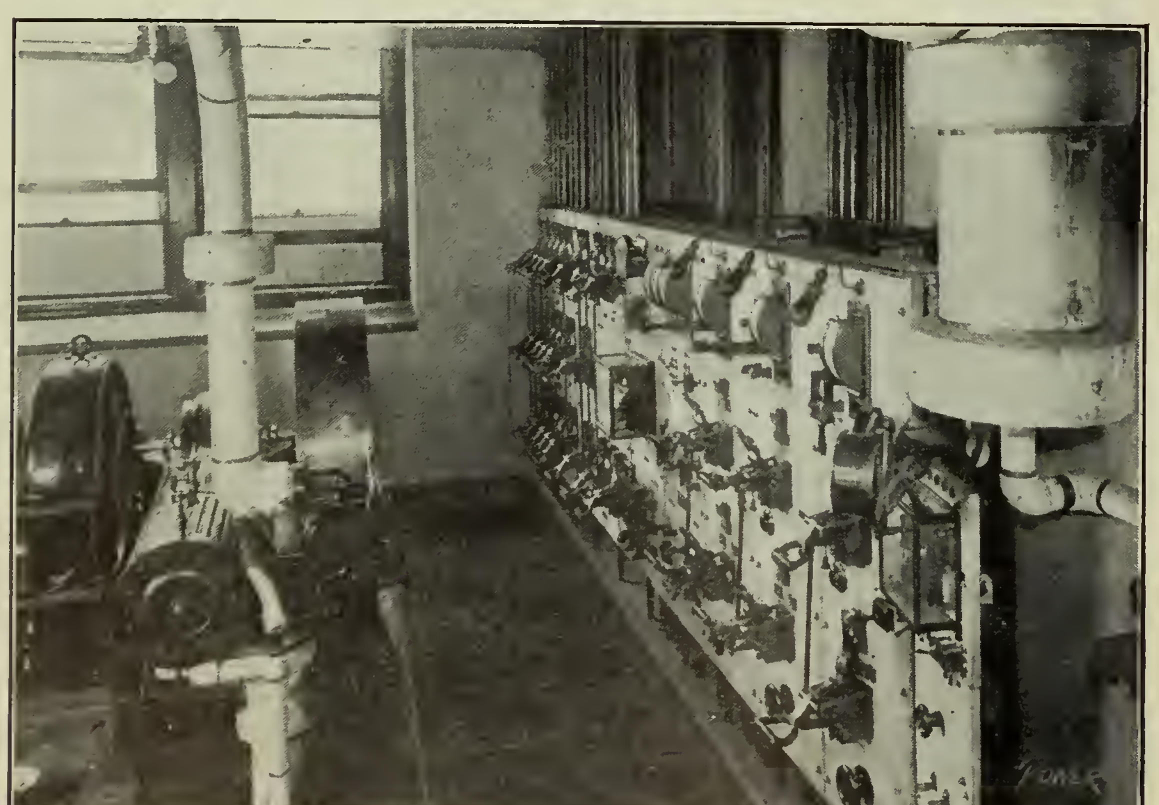


FIG. 1. SWITCHBOARD AND ENGINE

The piping layout for a hydraulic elevator used in the printing establishment is rather unusual. This elevator is employed in bringing rolls of paper from the store room to the press room and conditions are such that the load is always carried on the down trips, and the elevator goes up empty. Advantage has been taken of this circumstance to raise the elevator through the energy developed by the load in coming down; the way in which this is accomplished is shown

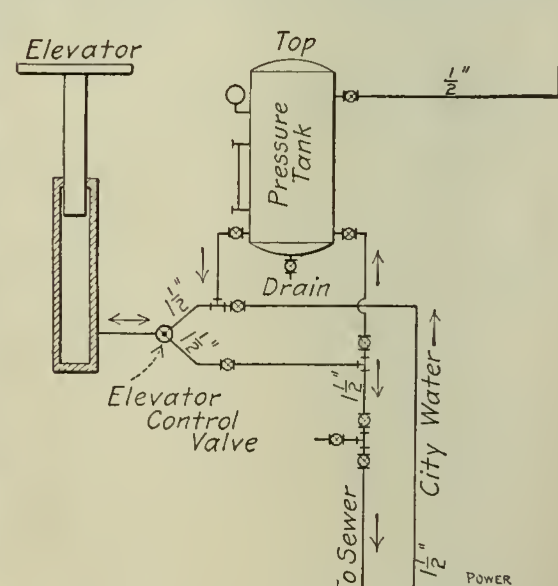


FIG. 3. HYDRAULIC ELEVATOR SYSTEM

in Fig. 3. During its downward travel the elevator discharges into a pressure tank partly filled with water, and this accumulated pressure is utilized to raise the empty elevator. A three-way control valve is placed so that, if desired, the elevator can be worked directly from the city-water mains in the ordinary manner, the water discharging to the sewer in this case.

The electrical distribution is on the 230-volt, three-wire system, with balancer sets supplying lighting current at 115 volts. The switchboard, which is shown in Fig. 1, contains no switches, except for the instruments, their place being taken by circuit-breakers.

Every machine in the establishment is direct-driven by motors, ranging in size from one-quarter to 60 horsepower, and the load on the plant for lighting and power is continuous, a 24-hour service being maintained. H. J. Graham is the chief engineer in charge of the plant.

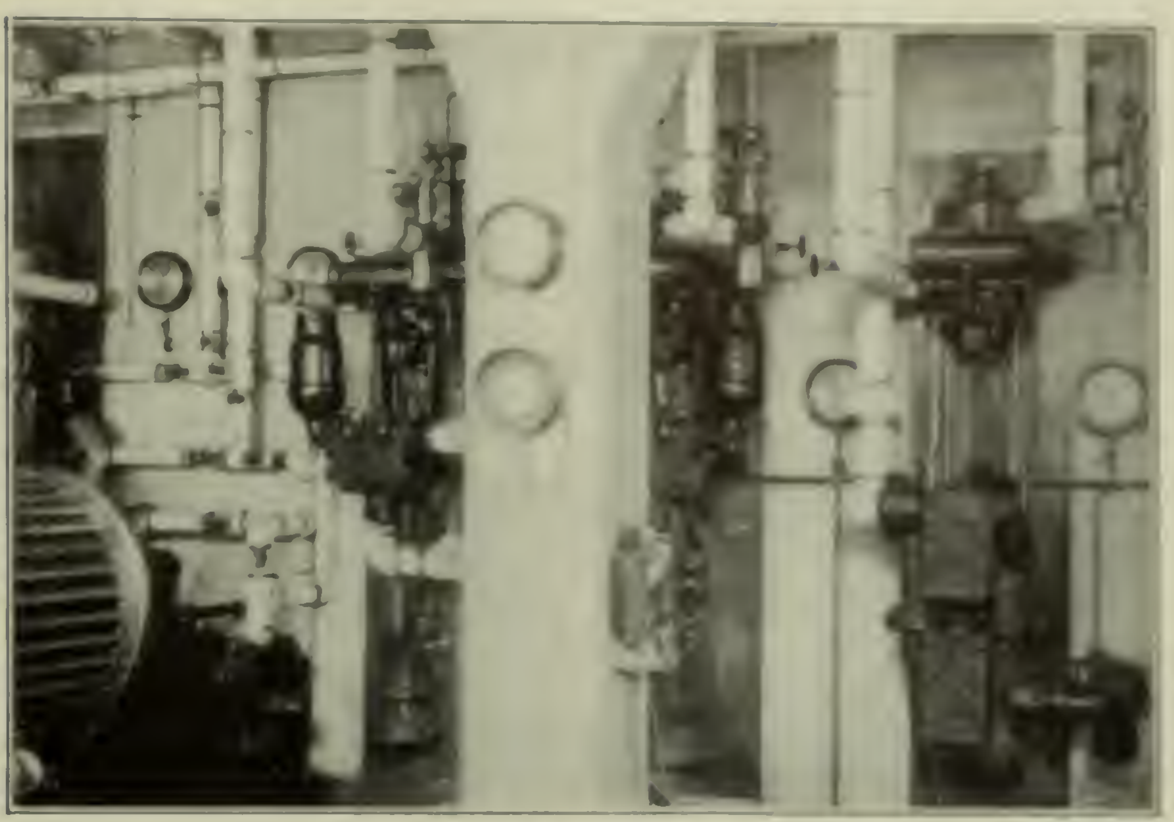


FIG. 4. PUMPS MOUNTED ON WALL

Piping for Central Station Heating*

By B. T. Gifford

General remarks on the manner in which the probable quantity of heating is ascertained. Method of laying out pipe lines and determining the pipe sizes.

*Abstract of paper presented before the American Society of Heating and Ventilating Engineers.

In the design of a central-station heating plant two things must be definitely determined: the location of the central station and the amount and location of the business to be served.

A method which the writer has used for some time with satisfactory results is as follows: First, prepare a map of the city drawn to scale, and of a size convenient to carry in the field; sometimes it is necessary to divide the map into two or more parts. Show on this map all streets and alleys, and the relative elevation of each street intersection. Note also the paved streets and the kind of pavement. Show also each building and mark the kind of building, whether for business, church, residence, bank, hotel or other purposes, together with the number of feet of radiation that will be required to heat it. After this information has been secured, make a survey and a careful study of the different sections of the city, noting on the map the best sections for the central heating plant to serve, taking into consideration at all times the future growth of the city. It is in this part of the design that experience is needed, and many times the engineer will find that he has made a poor guess. The word guess is used because in many cases central heating plants have grown beyond the wildest dreams of their designers.

In a good residential section where the houses are owned by people of moderate wealth, 90 per cent. of the possible business will be connected within five years. Any vacant lots in such a section should be considered as built upon with a building to compare favorably with the surrounding buildings.

In a business section 60 to 70 per cent. of the available business will be connected within five years. This is greatly dependent upon the kind of heat to be sold, whether steam or water, and whether the buildings are already equipped for heating with steam or water. As a rule, steam service is more popular in business sections, while in residential sections water seems to be more desirable.

The rapidity with which business is acquired depends upon the management, but the designer should anticipate a rapid growth in the number of consumers and the amount of business. After having determined the location and the amount of business possible and the central-station location, work on the details can be started.

Commence by laying in the lines on the map, in such a way as to reach the greatest amount of business with the least number of feet of pipe line. This requires [illegible] cut-and-try methods. Whether to use alleys or streets depends upon two things: First, the relative cost of street and alley construction; second, the location of the buildings relative to the street or alley. The writer has found that alley construction, other things being equal, will cost 15 to 20 per cent. more for the labor, owing to the difficulty of working in narrow places. Another thing affecting the cost of construction is the pavement, which has to be taken up and relaid.

In most cities the heating companies are obliged to bring their service pipes to the curb line in the street, and to the property line in the alleys. This item of expense should not be overlooked, for in a wide street the extra cost for service lines will more than eat up the saving in labor effected by street construction.

Assume for calculation a good residence section, as shown in Fig. 1, block 2. It can be assumed that 90 per cent. of the available business on this block, which is approximately 11,000 square feet of water radiation, or approximately 6600 square feet of steam-radiation surface, will be secured.

It is necessary to allow for future extensions for block No. 1, and possibly more yet, but in this layout it will be assumed that eventually block No. 1 will equal block No. 2. Block No. 2 is 400 feet long, and block No. 3 is of the same length. There is then altogether 22,000 square feet of water radiation to be handled, but some of it will be taken off in the first 100 feet, and about 25 per cent. of it will be served by the time the center of block No. 2 is reached; 25 per cent. more will be taken off by the time D street is reached, and 25 per cent. when the center of block No. 3 is reached.

The writer has found it better practice

to throw most of the line friction into the trunk line and to have the friction loss in the laterals very small, and to make the friction loss in the laterals in proportion to the circulating pressure (difference in pressure) at the point at which the lateral begins. As an example, assume that at the point the lateral for blocks Nos. 1 and 2 tap off the circulating pressure is five pounds. Now, there must be at least one pound of circulating pressure at the end of the lateral; therefore, four pounds can be lost in friction between the ends of the lateral, or one pound per 200 feet, which is five-tenths of a pound per 100 feet. Following are the conditions:

First 200 feet of line must handle 22,000 square feet of radiation.
Second 200 feet of line must handle 16,500 square feet of radiation.
Third 200 feet of line must handle 11,000 square feet of radiation.
Fourth 200 feet of line must handle 5500 square feet of radiation.

From the curves in Fig. 2 it will be seen that a 6-inch pipe will handle 22,000 square feet with this friction loss, and a 5-inch will handle 16,500 square feet, a 4½-inch will handle 11,000 square feet with a ½-pound loss, and a 3½-inch pipe will handle 5500 square feet of radiation with this friction loss.

A rule which the writer has followed is never to run a smaller water main than 3 inches in the initial layout; this will always allow for some future extensions.

In figuring a branch line off of a lateral, consider the circulating pressure at the point the branch leaves the lateral, as the originating pressure and one pound as the circulating pressure at the end of the branch.

The writer advocates the use of pipe bends instead of elbows or fittings in the lateral lines.

It has been the practice of some engineers to run a larger return line than flow line; for instance, a 3-inch flow and a 4-inch return line. This method, it is claimed, gives a more equal circulating pressure all over the system. The writer has found that by limiting the heavy friction loss to the main trunk lines, this objection is equally well overcome and the investment is slightly reduced.

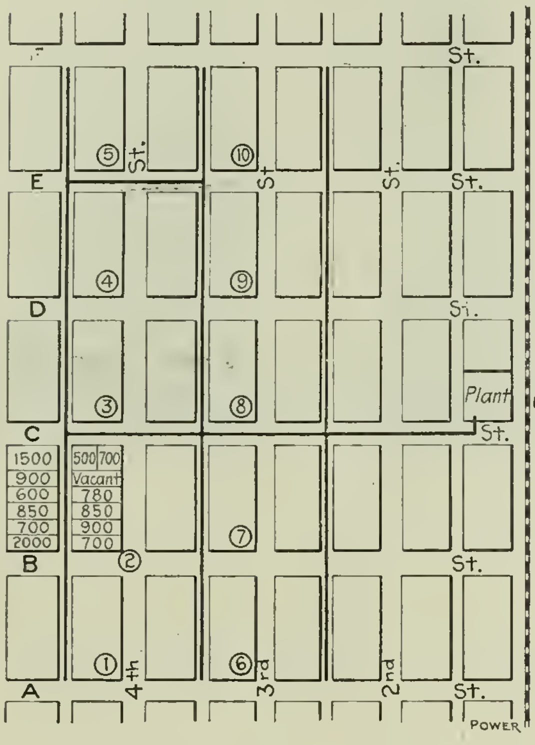


Fig. 1. Plan of Area to be Heated

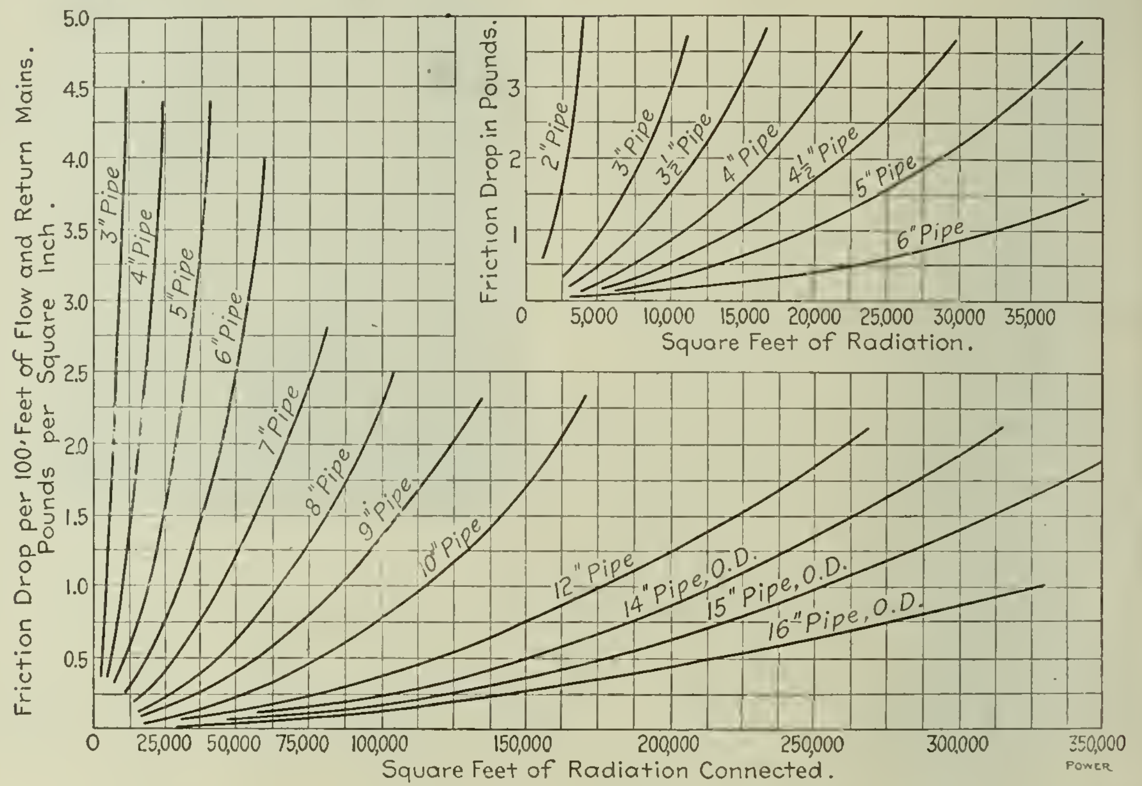


Fig. 2. Diagrams of Pressure Drop Due to Friction in Hot-water Heating Mains

Pipe-line Design for Steam Heating

In designing a central-station steam-pipe line the same general plan is used. In this case, however, the friction loss is dependent upon the maximum back pressure allowed on the engines if connected as a byproduct system. A live-steam central heating plant should be designed along the same general plan as a hot-water heating system, with 25 pounds as the maximum pressure on the pipe line. The curves in Fig. 3 show the steam-pipe capacities.

Assuming the same territory, viz., blocks Nos. 1 and 2, the following calculations would determine the steam-heating pipe sizes. In this case it will also be assumed that the original pressure where the line begins is three pounds. There will be required at least one pound pressure at the end of the line; therefore, two pounds can be lost in friction. This allows 0.25 of a pound per 100 feet of pipe. Following are the conditions for a steam-heating system:

First 200 feet of line must handle 13,200 square feet of radiation.
Second 200 feet of line must handle 9900 square feet of radiation.
Third 200 feet of line must handle 6600 square feet of radiation.
Fourth 200 feet of line must handle 3300 square feet of radiation.

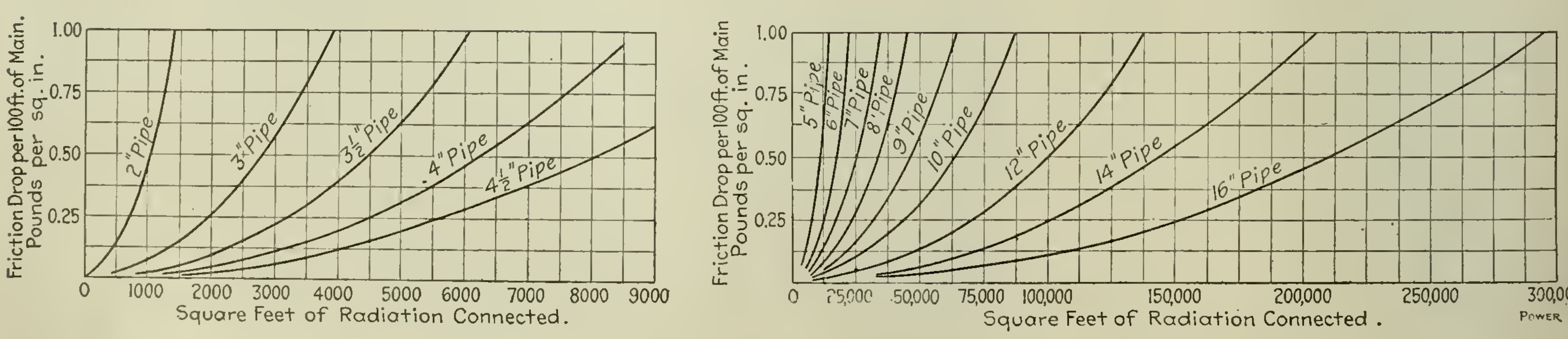


Fig. 3. Diagrams of Pressure Drop Due to Friction in Steam-heating Mains

From the curves in Fig. 3 the pipe sizes may be ascertained in the same manner as in the previous example on hot-water heating.

As in the case of the hot-water heating system, there should be a minimum size of pipe to install as a main and in steam heating the writer has fixed upon 4 inches as the minimum.

Efficiency of Live Steam Feed Heater

By Prof. A. H. Gibson

Use of heater with locomotive boiler raised efficiency 1.08 per cent. Gain attributed to higher rate of heat transmission due to a lower temperature of the plate in the vicinity of the feed inlet.

In view of the diversity of opinion among engineers as to whether the addition of a live-steam feed heater to a steam boiler may in any case lead to increased efficiency of working, the author recently decided to carry out a series of trials to test the effect of such a heater on the steam boiler forming part of the laboratory equipment of University College, Dundee, Scotland.

This boiler is specially equipped for testing; all measurements of fuel burnt, of water evaporated and of temperatures can be made with great accuracy. The steam produced was used for driving a brake-loaded experimental engine whose load could be maintained constant or varied as required from test to test.

The boiler was of the locomotive type with an internal diameter of 3 feet 6 inches; and contains 47 tubes, 3 inches in

Fig. 1. Locomotive Type of Boiler

diameter and 6 feet 10 inches long. It has an effective grate area of 7.5 square feet, with a heating surface of 315 square feet, and its general arrangement is shown in Fig. 1.

The feed water is supplied by a force pump worked from the crosshead of the main engine. When supplied to the boiler cold it enters through an opening in the side of the boiler, as shown at *A* in Fig. 1.

When the live-steam feed heater is in use the cold feed enters at the top of the boiler, at *B*, Fig. 1, and passes through the heater before finally escaping into the water space of the boiler. The heater, Fig. 2, was constructed specially for the tests, and consists simply of three shallow tin-plate dishes superposed and connected to each other by distance pieces. The feed water admitted by the feed pipe to the bottom of the upper dish overflows into the second. A central overflow pipe maintains a constant depth of about ½ inch in this dish, and overflow takes place through this pipe into the bottom dish, from which it overflows and drops into the water space of the boiler. The heater was supported in the steam space of the boiler on two convenient longitudinal stays. It was made as large as could be conveniently got into the very constricted space available, but could with advantage have been made larger, the feed water not remaining in contact with the steam for a sufficiently long interval of time to enable it to attain full boiler temperature before mixing with the water in circulation.

The temperature immediately before overflow was measured by means of a mercury thermometer in a pocket situated as shown in Fig. 2.

The boiler is operated under natural chimney draft regulated by a damper at the outlet from the smoke box, and in order to insure a thorough mixing of the hot gases before taking their temperature, this was measured, by means of a platinum-iridium thermocouple, at the center of the outlet flue at *C*, Fig. 1.

Four tests were carried out, those on Wednesday and Thursday, December 7 and 8, 1910, having the heater in operation but with very different loads on the boiler, and those on Wednesday and Thursday of the following week without the heater, but with rates of evaporation similar to those in the two preceding runs. In each case the boiler was under steam on the Tuesday, while on the days of the trials the actual test did not commence until the plant had been running under normal conditions sufficiently long for a steady state of affairs to be obtained.

From results obtained in the tests it was figured that the relative gain in efficiency by use of the heater was 1.08 per cent. for light loads and 1.083 per cent. for heavy loads. Some of the more important deductions from the tests are given in the accompanying table.

DEDUCTIONS MADE FROM TESTS

	Light Load		Heavy Load	
	With Heater	Without Heater	With Heater	Without Heater
Heat transmitted per square foot of heating surface per hour, B.t.u.	1970	[illegible]	[illegible]	[illegible]
Weight of fuel fired per square foot of grate per hour, lb.	[illegible]	[illegible]	[illegible]	[illegible]
Weight of dry fuel per square foot of grate per hour, lb.	[illegible]	[illegible]	[illegible]	[illegible]
Water evaporated per pound of fuel as fired, lb.	[illegible]	[illegible]	[illegible]	[illegible]
Water evaporated per pound of dry fuel, lb.	[illegible]	[illegible]	[illegible]	[illegible]
Equivalent evaporation from and at 212 deg. F. per pound of dry fuel, lb.	[illegible]	[illegible]	[illegible]	[illegible]
Weight of feed from and at 212 deg. F. per square foot of heating surface per hour, lb.	[illegible]	[illegible]	[illegible]	[illegible]

Reasons for Increased Efficiency

With a view to throwing some light on the reason why such a method of feed heating should lead to more economical working, a series of experiments were afterward carried out on an open cast-iron vessel about 8 inches in diameter and containing about 3 inches of water. This was heated up by means of a ring of gas jets giving a flame whose mean temperature was 2000 degrees Fahrenheit. The temperature of the water side of the plate was measured by means of a platinum-iridium thermocouple placed in intimate contact with the plate, a shallow depression, 1/64 inch in diameter, being made in the plate to receive the point of the couple. The temperature of the water was taken by means of a mercury thermometer, and the results of the experiments are as follows:

Temperature of water, degrees Fahrenheit	120	160	180	200	212
Temperature of plate, degrees Fahrenheit	140	208	212	200	212.4
Difference, degrees Fahrenheit	20	48	32	40	0.4

In these experiments the water was stirred vigorously during the whole period of heating, and they do confirm what has been pointed out by previous experimenters that, under given conditions of heat transmission, the difference between the temperature of the water and of the water side of such a plate is very much greater when the water is being heated up to boiling point than when it is in ebullition, and this, although the water is circulating vigorously over the hot surface.

Fig. 2. Primary Heater

In these experiments, too, however great the ebullition, it was found impossible to increase the temperature of the water side of the plate to more than 213 degrees Fahrenheit, and in the great majority of cases the temperature was, as nearly as could be measured, identical with that of the water.

As a result of these experiments it

would appear reasonable to assume that over the tubes, in the neighborhood of the feed inlet to a boiler, the temperature of the water side of the plate, and, therefore, of the fire side of the plate for a given rate of heat transmission, would be appreciably lower—possibly as much as 40 degrees Fahrenheit lower, and probably at least 20 degrees Fahrenheit lower—with the heater in operation than without it. At first sight it would appear that such a small difference is totally inadequate to account for any appreciable difference in heat transmission and hence in the efficiency, for since the temperature of the gases has a mean value of probably 1200 degrees Fahrenheit, the mean difference between the temperature of the gases and that of the tube surface will be about 850 degrees Fahrenheit, and a difference of 20 degrees Fahrenheit in this, assuming heat transmission to vary as difference of temperature, would only affect heat transmission by a little over 2 per cent. Assuming the heat transmission from gas to plate to vary as the square of the temperature difference, this would increase the effect to, roughly, 5 per cent.

Even though the great proportion of the heat is transmitted by conduction from gas to metal, it appears, however, that a cooling of the metal surface is likely to be much more effective than a corresponding increase in the temperature of the hot gases. As is well known, transmission of heat by conduction from stratum to stratum of a hot gas is a mass phenomenon, and depends on the velocity (therefore greatest near the center of a tube where velocities are greatest), on the difference of temperature, and increases directly as the density. Owing to the rapidity of the motion, heat is readily transmitted from the central filaments in such a tube to those nearer the walls, but with considerable less ease in the immediate neighborhood of the walls where the motion is comparatively sluggish. In the neighborhood of the walls, however, the gas is cooled down to a temperature approximating much more nearly to that of the cool surface; its density is considerably greater than in the center of the tube, and is greater as the tube surface is cooler, so that any cooling of this surface has a double effect in increasing the rate of transmission.

On the whole it would appear that these differences in the rates of heat transmission, though severally small, when acting cumulatively offer a possible explanation of the gain in efficiency undoubtedly obtained in the present series of tests by the use of the live-steam feed heater.

The reason for the greater gains in efficiency, in the case of the more heavily worked boiler, is probably due to a greater portion of the heating surface being occupied in heating up feed water rather than in the process of evaporation, in such a boiler, than in one more lightly worked. With feed water at 40 degrees Fahrenheit over 25 per cent. of its total heat is given to the water during this process of heating up, and the proportion of the whole heating surface affected by this must be roughly proportional to the weight of cold feed per minute. From this and other considerations it may be expected that such a heater will be found to be most effective:

1. In a given boiler when this is most heavily worked.
2. Where no economizer is fitted to take advantage of the heat rejected in the flue gases.
3. Where the boiler is fed with cold feed water.
4. Other things being equal, in a boiler in which the heating surfaces are somewhat incrusted.

Could Not Damage the Turbine

When a 1500-kilowatt Westinghouse steam turbine was loaded on a flat car at the company's works, ready for shipment to the Cia Minera Las Dos Estrallas mines at Tultenango Est de Mexico, there was every reason to believe that the shipment would reach its destination in good shape.

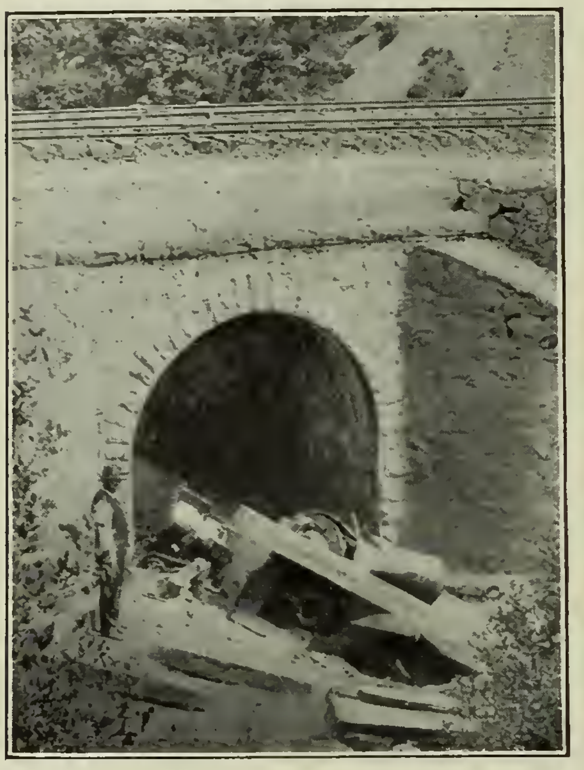


Fig. 1. Showing Where the Turbine Landed

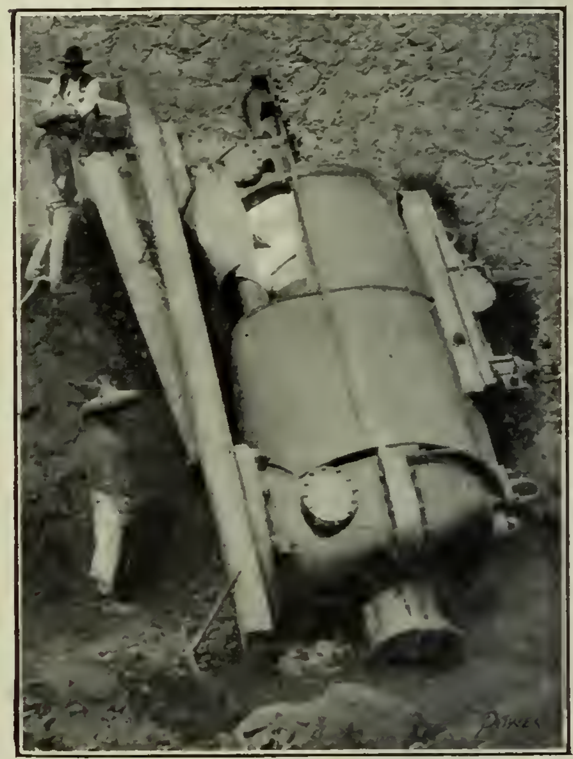


Fig. 2. Broken Platform and Lagging

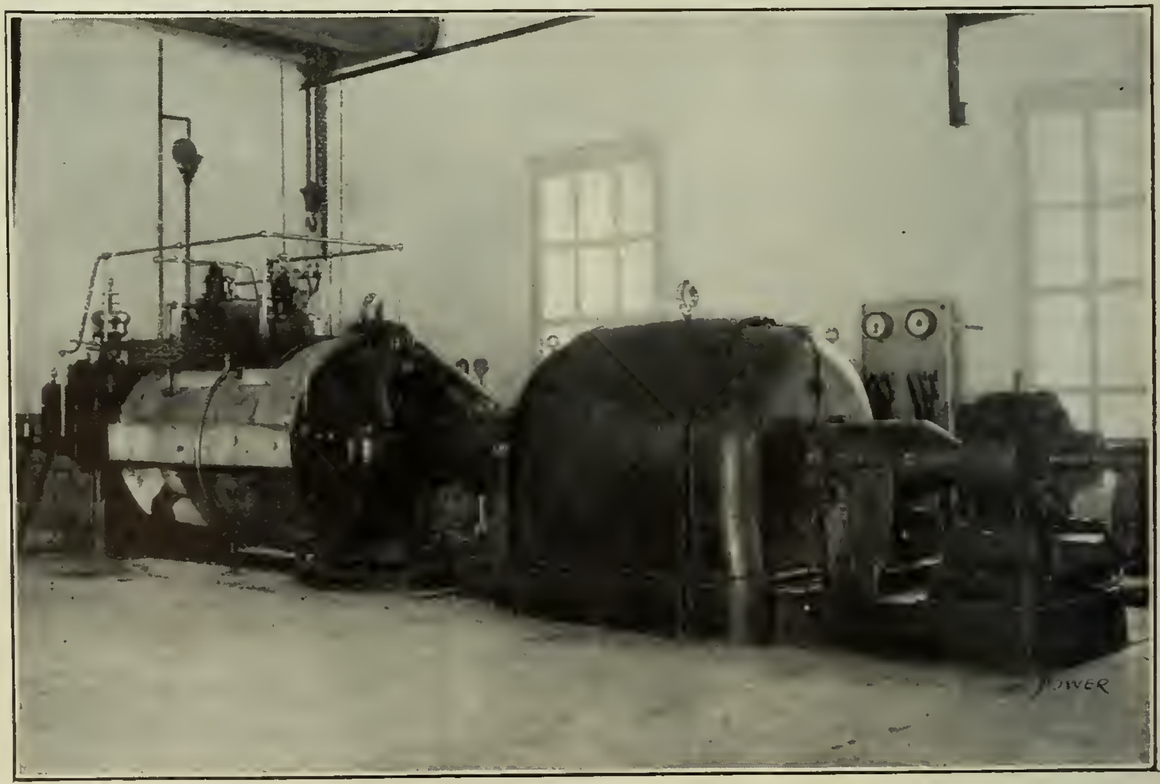


Fig. 3. Turbine Set Up and Put in Operation before Any Repairs Were Made

Matters went well until the train reached a 20-foot embankment in which a stone bridge had been built. Just as the car on which the turbine was loaded reached this bridge the car collapsed and the turbine took a drop of 20 feet, making one complete revolution in its descent and landing in the river bed, as shown in Figs. 1 and 2.

For three weeks the turbine lay where it fell, while a spur track was being built to it, as no tackle was available for hoisting the turbine onto a car on the main track. The turbine finally reached its destination, was set up and had been in operation for some time before the manufacturers were aware of the accident.

After a month's delay a man was sent from the factory, who took the turbine down and examined every part. No injury to the machine was found, with the exception of the breaking of the polished steel lagging and the upper platform, as shown in Fig. 2.

Fig. 3 shows a view of the turbine after it had been set up and before the lagging had been replaced.

There may be a prevailing idea among engineers that the general run of steam plants in Mexico are of ancient design. There are, however, many modern steam installations, and the plant in which this particular turbine is installed is uptodate in every particular. The turbine is rated at 1500 kilowatts and is run condensing. Steam pressure at 150 pounds gage is carried and the boiler-room equipment is every bit as modern as that in the engine room.

Capacity of Refrigerating Plant

How much refrigeration will be required to cool a cold-storage compartment, 8x9x10 feet high, to a temperature of 35 degrees, and cool 1000 pounds of butter through 20 degrees every 24 hours. The cooler walls consist of two layers of tongue and groove sheathing with paper between, a 4-inch air space, two more layers of sheathing with paper, a second 4-inch air space and finally a third pair of layers of sheathing with paper between. Will a single-cylinder single-acting ammonia compressor operating at 70 revolutions per minute about six hours per day do the required work?

Which is the best, an open or inclosed type, vertical or horizontal compressor?

How much direct expansion piping will be required?

How much condenser surface?

The heat transmission through insulation of the above construction has been given, in a series of values of different types of insulation published by the Armstrong Cork Company, as 3.43 B.t.u. per square foot per degree difference in temperature inside and outside for 24 hours. The superficial surface of a cooler of the above dimensions is 484 square feet, the maximum difference in temperature is

$$90 - 35 = 55 \textit{ degrees}$$

from which the total heat transmission is found to be

$$3.43 \times 484 \times 55 = 91{,}770 \textit{ B.t.u.}$$

or

$$91{,}770 \div 144 = 637 \textit{ pounds}$$

per 24 hours.

The cooling of 1000 pounds of butter through 20 degrees Fahrenheit requires

$$1000 \times 20 \times 0.5 = 10{,}000 \textit{ B.t.u.}$$

or 69.4 pounds per 24 hours, making a total duty of 706.4 pounds, or 0.353 ton.

A 5x5-inch single-cylinder single-acting compressor operating at 70 revolutions per minute when producing temperatures around 36 degrees, should develop a capacity of 0.64 ton per 24 hours and would consume approximately 1⅓ horsepower.

To operate only six hours per day the compressor would have to be increased in proportion to the reduced operating time. The required cooling effect, as determined above, is 0.353 ton per 24 hours. If the work is to be done in twelve hours, the capacity of the machine must be twice as great, or 0.706 ton, and if in six hours, four times as great, or 1.4 tons. Since the capacity of the compressor operating at 70 revolutions per minute was found to be only 0.64 ton per 24 hours, the speed of the compressor will have to be increased in the ratio,

$$0.64 : 1.4 :: 70 : S$$

which gives for S, the required speed, 153 revolutions per minute. The horsepower will have been increased in proportion to the speed, or,

$$70 : 153 :: 1.33 : H.P.,$$

which gives $H.P.$, the required horsepower to perform the cooling work in six hours, as 2.9 horsepower.

If possible to do so, it would be much better to operate the compressor in question twelve hours per day, in which case about 75 revolutions per minute would be a sufficiently high speed, and only about 1½ horsepower would be consumed.

It would not be safe to use less than a three-horsepower motor for operating the machine as single-acting machines and especially single-cylinder single-acting ones require a considerable initial starting power over that required to drive the machine under the conditions of normal operation.

Double-cylinder machines, while somewhat more expensive to build, are much more satisfactory in this respect than single-acting ones, and they possess the additional advantage of having half their capacity available in case of a broken suction or discharge valve on one of the cylinders. Operating one side of the machine above its normal speed longer than its usual time of operation may save the stored products, while repairs for the other are being procured.

As regards the relative merits of open and inclosed crank-case types of compressor, each has advantages over the other. The inclosed crank-case machine, which is also a vertical machine, would in all probability be found most satisfactory for the limited requirements. Packing against ammonia pressure in this type of machine is made on the rotating crank shaft instead of on a reciprocating piston rod as in other types. It is much easier to keep the former packing tight, especially where the machine is not to be operated continuously.

It would be good practice to use a compressor with the suction valve located in the piston head, as the effect of inertia at the lower end of the stroke causes the prompt closing of the valve, thereby preventing any undue opportunity for gas that has entered the cylinder, to escape without being compressed. Similarly, inertia tends to open the valve as the piston begins its downward stroke, thereby giving full opportunity to fill the cylinder during the whole of the downward stroke.

If the machine is to be operated only six hours per day at 27 pounds back pressure, on which the capacities previously given were calculated, about 5400 running feet of 1¼-inch direct-expansion piping should be used. If the machine is to be operated twice as long, the piping can be reduced, but not in the same ratio, 3500 to 4000 running feet being required.

If cooling water at the usual temperatures is available and the condenser is to be of the double-pipe type in which the cooling water passes through the inner pipe and the ammonia gas between the inner and the outer pipes, about 20 running feet per ton is a good ratio, or for the above machine operating six hours per day, about 28 feet. If it is to operate twelve hours, about 20 feet would be ample so far as the actual work to be done is concerned. It is customary, however, to put in condensing and expansion surface equal to the entire capacity of the machine as first indicated.

The *Manchester (England) Union* is sponsor for the following addition to the gaiety of the nation:

"The story is told of the times of Aretas Blood and the old Manchester Locomotive Works, that a student came to Mr. Blood once and wanted to study the business of locomotive building in his vacation days. The student came well recommended, and Mr. Blood, who never had much use for these 'tech' people, sent him down to the boiler shop and placed him in charge of the old foreman. The old man took the 'tech' chap around, and in the course of the inspection of the shop they came across one boiler on the inside of which was a man at work.

"'How does that man get out?' inquired the 'tech' man.

"'Oh,' said the venerable pilot, 'he doesn't get out. We always count upon losing at least one man in building a boiler.'"

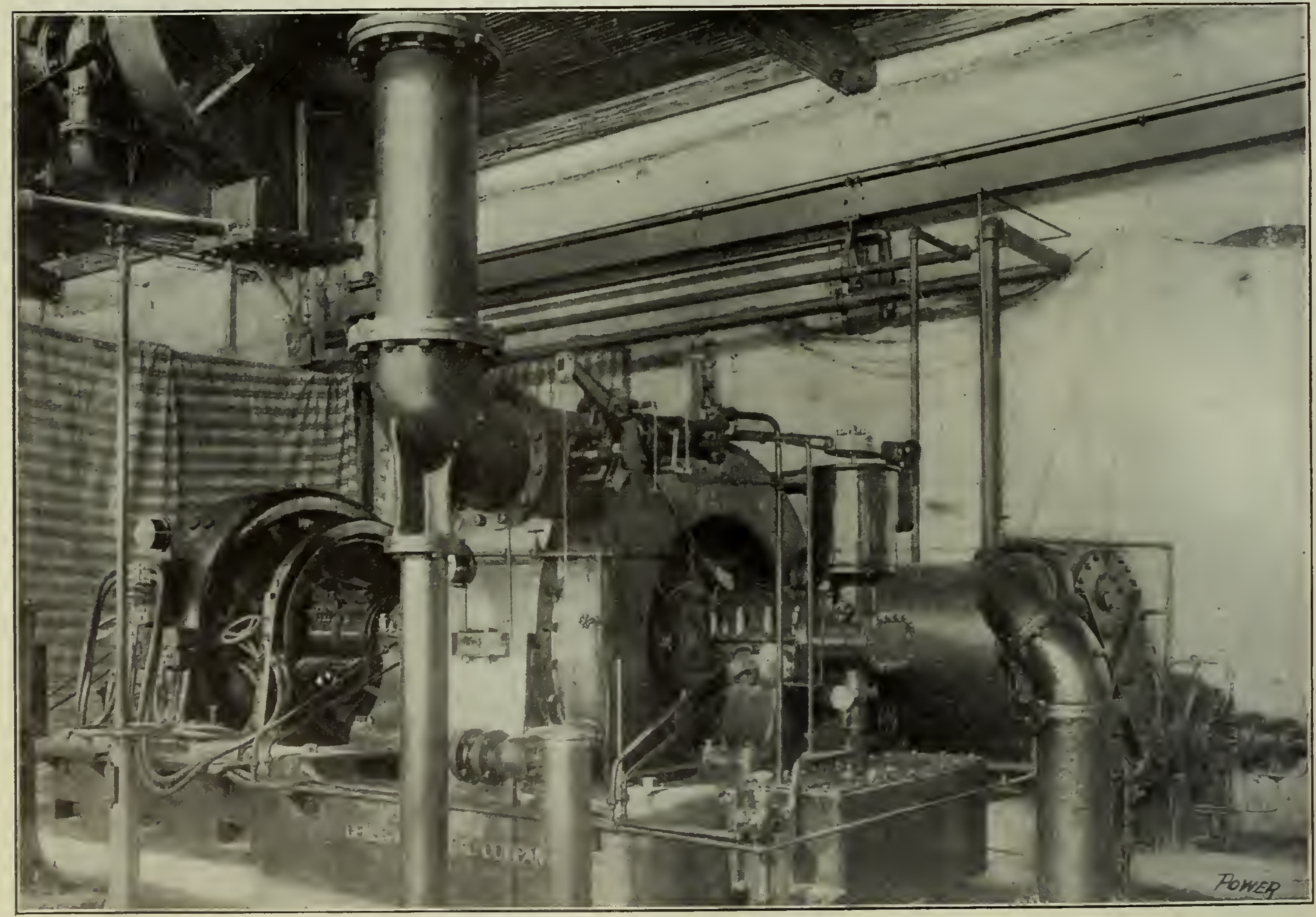
Low Pressure Turbine in Davenport

By P. Bendixen

A 500-kilowatt unit takes exhaust steam from engines, pumps and air compressor and develops about three-fourths of the energy delivered to the primary units.

About two years ago the Bettendorf Axle Company, of Davenport, Ia., was considering an addition to its electrical equipment, due to the growth of the plant, and made a thorough investigation of the various prime movers suitable for the purpose. Taking into consideration the heating of the shops in winter and the fact that the old power plant was running noncondensing, all factors pointed to the low-pressure or exhaust turbine as the most suitable power unit to install, from the standpoint of reliability, simplicity, economy and maintenance.

The power equipment at that time consisted of two 100-kilowatt direct-connected high-speed tandem-compound engine-driven units, a number of hydraulic pumps and an air compressor exhausting into one header, making an ideal arrangement for connection to an exhaust turbine. The company decided to install a 500-kilowatt horizontal Curtis turbine. This turbine was put in operation in September, 1909, and has been in service for about 14 hours per day since. It supplies all electrical power required by the plant, which at present amounts to 250 kilowatts average load, this power being used mostly for the operation of cranes, the lighting of shops, and for lifting magnets. When machinery now under construction is completed and installed, the load will be increased to about double. The main steam supply is derived from the exhaust of the hydraulic pumps, but, owing to the fact that these pumps are subject to interrupted service, due to breakdowns on the system, other means of supplying steam had to be provided and a connection was therefore made from the exhaust header to the high-pressure steam pipe through a 4x8-inch Foster pressure-reducing valve. By means of this connection the required amount of steam to keep the turbine in operation is secured. This arrangement works very satisfactorily, as the valve operates within a range of one-half pound drop in pressure. The average back pressure is about three pounds, and to take care of an excessive back pressure the exhaust header is provided with a 12-inch relief valve set to operate at five pounds pressure. All steam to the turbine passes through an 18-inch two-stage separator, which separates all oil and moisture from the steam. A Worthington condenser with 3150 square feet of surface is installed, the condensed steam being returned to the boiler feed-water heater.



Low-pressure Turbine Installation in Plant of the Bettendorf Axle Company

While no figures are available to substantiate a statement as to the exact performance of the turbine, it is thought possible, when running with 28-inch vacuum, to recover 75 per cent. of the energy delivered to the pumps, compressors and reciprocating engines. In cool weather it has been possible to run for weeks with a vacuum of from 29 to 29½ inches, this, of course, making quite a difference in the steam consumption. In order to maintain a good vacuum, it has been found necessary to pipe the steam seal in which the carbon-packing rings are located with high-pressure steam to insure against any leakage of air around the shaft. The amount of steam required for this purpose can best be found by experiment, and when once adjusted requires very little attention.

Before putting the turbine in service it was run for a few days under various loads, the generator being loaded on a water box. It was found that sufficient exhaust steam was available to furnish 425 kilowatts continuously, and as much as 575 kilowatts for short periods. Six boilers of about 120 horsepower each were in service at that time. The results of the test would indicate that 75 to 80 per cent. of the energy delivered to the engines and auxiliaries was recovered.

With a load fluctuation of about 500 amperes, the variation in potential does not exceed two or three volts. The lighting load consists of inclosed-arc, flame-arc, mercury-vapor and incandescent lamps.

Good results are obtained without the use of a receiver generator between the units and the turbine, as the reducing valve makes up for any deficiency in the steam supply which might be due, as stated before, to the stoppage of one of the engines or pumps. With this arrangement a sufficient supply of steam is always assured.

The longest continuous run so far made with this turbine has been five days and nights. No shutdowns due to trouble of any kind with the turbine have occurred since the turbine was first put in operation, and this company can conscientiously recommend the installation of a low-pressure turbine in any place where a sufficient supply of exhaust steam is available for its operation.

Verdict in Pabst Explosion Case

Growing out of the boiler explosion described in Power, November 9, 1909, this interesting case has been decided in favor of the Pabst Company, a verdict of $97,400, with interest from December 1, 1909, being awarded. The case was immediately appealed.

The case of the Pabst Brewing Company versus the Hartford Steam Boiler Inspection and Insurance Company, growing out of the boiler explosion which occurred at the Pabst plant on the morning of October 25, 1909, has just been heard in Milwaukee before A. L. Sanborn, United States district judge for the western district of Wisconsin.

The Pabst Brewing Company sued on two counts, the first being that the Hartford company "represented and held itself out to the public as skilled and expert in the examination and inspection of steam boilers and that its inspectors would make the skilled and careful examinations necessary to determine the safety and condition of the exploded boilers and that the results of all inspections would be promptly and truly reported to the Pabst company so that the latter would be kept continuously and accurately informed as to the true condition and safety of said boilers."

The plaintiff alleged "on information and belief that on and prior to the fourth day of September, 1909, said boilers were not free from dangerous defects and were not in good condition, but that each of said boilers contained, among others, the divers and dangerous defects following: Checks, cracks and openings along, and in connection with, the reinforcing strip or plate of the drum of each of said boilers; defective, imperfect and broken rivets on each side of said reinforcing plate and elsewhere in each of the drums of said boilers, and other dangerous defects which this plaintiff is unable of its own knowledge or on its information and belief to particularly set forth and specify."

The plaintiff further alleged "that the boilers were in an unsafe and dangerous condition and said defects were of such a nature as to be obvious to anyone having any knowledge, skill and experience in the examination of steam boilers, and that the defendant ought, in the exercise of ordinary care and prudence and reasonable skill, to have discovered said defects and advised and informed the plaintiff thereof, prior to the explosion."

Also it was alleged "that the defendant was careless, reckless and negligent in making inspections, failed to observe and discover the dangerous defects, and wrongfully and negligently failed to inform the plaintiff as to the true condition of its boilers." "That by reason of said wrongful and negligent inspection the boilers were continued in operation and did explode on the 25th of October, 1909, and that by reason thereof the plaintiff was prevented from carrying on its business and suffered damage to the amount of $11,060.57."

For a second cause of action the plaintiff alleged "that the defendant contracted to insure against all loss or damage, which might result from the explosion of any one, or all, of the six Manning boilers contained in the boiler house which was damaged, not to exceed the sum of $150,000 and that three of these boilers did explode while the policy was in force, causing a property loss of $114,361.91."

It will be seen that the suit was first for the recovery on the ground of negligence, of $114,000 direct damage, subsequently reduced by conference to $97,400, and some thirty-odd thousand indirect damages; and, secondly, for the recovery under the contract for the direct damages only.

The question from the standpoint of the defense seemed to hang largely on the wording of the policy, in which there was a limiting clause covering damage due to any one explosion. The policy affected to insure the Pabst Brewing Company "for $150,000 against all immediate loss or damage except by fire to the property specified in the policy, or resulting from loss of life or injury to persons caused by the explosion, collapse, or rupture, of any or all steam boilers covered by the policy." It further covenanted "that by the terms 'explosion, collapse or rupture' was to be understood a sudden substantial tearing asunder of the boiler or any portion thereof or the sudden crushing or forcing inward of the furnace or flues, etc." In a "rider" on the policy, however, it was further provided "that the total liability of the company from loss or damage from any one explosion should not exceed the sum of $50,000, and in case of more than one explosion the entire liability of the company should not exceed the sum insured by the policy, viz., $150,000."

Immediately following the explosion the Pabst company engaged a committee of four engineers, consisting of C. J. Davidson, H. D. Tomlinson, E. E. Adams and Owen P. Davies, to make an examination of the exploded boilers and report their opinion as to the probable cause of the disaster. In the testimony for the plaintiff the result of this investigation was brought out. All four of the investigators were unanimous in their belief that the initial rupture occurred along the center line of a reinforcing plate riveted to the drums of the boilers as is the regular construction for that make of boiler, and shown in the accompanying sketch. They testified to their belief that the presence of this strip of metal, which was ½ inch thick, riveted to the ½-inch drums was, owing to the unequal expansion and contraction of the two pieces of metal, a serious menace to the life and safety of the boilers. The history of the boilers was brought out quite thoroughly during the presentation of the case. It developed that extensive leaking had been noticed along this reinforcing seam and that many rivets had become loose and been replaced in the effort to stop this leaking. Also the outside edge of the plate had been repeatedly calked with the same object in view. The examining committee had investigated the condition of Nos. 5 and 6 boilers, which did not explode, and testified to finding cracks easily visible between the row of rivets holding the reinforcing strip to the shell of these boilers, these cracks being attributed to the breathing action resulting from holding a portion of the boiler shell rigid under the reinforcing strip, allowing the remainder of the shell to expand and contract with the steam pressure, and also to the unequal expansion and contraction due to the different thickness of the two pieces of metal. It was contended by the plaintiff that, inasmuch as Nos. 5 and 6 boilers were found to be in this condition, it was reasonable to suppose the exploded boilers, being of the same age and having the same general treatment throughout their lives, were in the same weakened condition, making them dangerous for the working pressure carried in the plant.

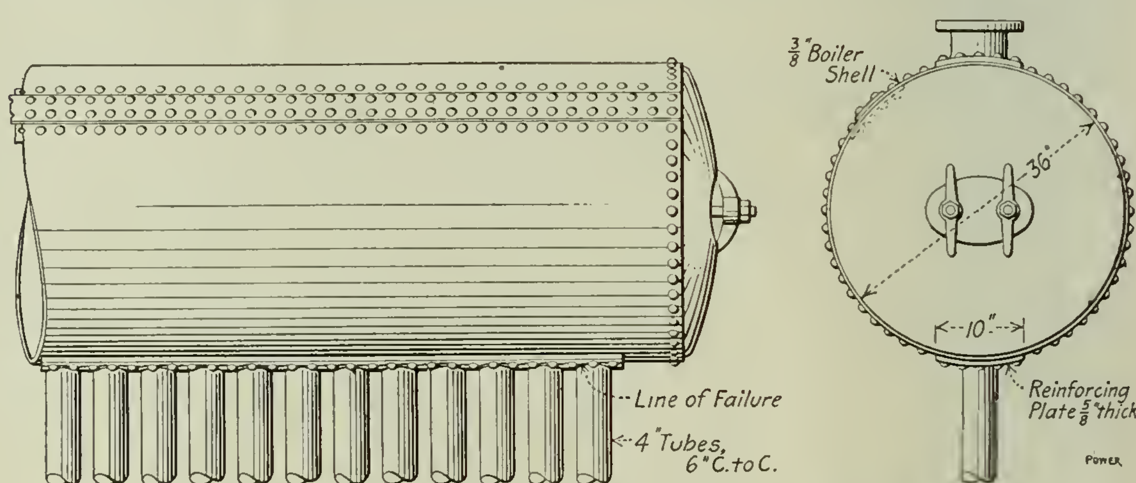
In answering the charges, the defendant alleged "that in the event of an explosion of all, or any, of the boilers the total liability for all loss or damage resulting from any one action, or explosion, however caused, should not exceed the sum of $50,000. That said boilers and property mentioned were destroyed and injured by one accident or explosion within the meaning of the policy, and that by reason thereof the liability did not exceed the sum of $50,000; and that the explosion was caused by the neglect and carelessness of the plaintiff. That, in case of more than one accident occurring during the three-year period covered by the terms of the policy, the entire liability of the defendant should not exceed the sum of $150,000."

In opposition to the claim based upon negligence the defense, while denying any lack of diligence in this respect, maintain that, although the policy gave the defendant permission to make boiler inspections, still it was not bound to do so, and that what inspections were made were simply and solely for the information of the defendant itself, and that it was not obligatory that these reports should be given to the owner of the insured boilers. In all cases, however, it was contended that such information had been given after each inspection.

Answering the technical features of the case, B. J. Morrison, of St. Mary's, O., testified for the defense, that in his opinion the initial rupture came in the main steam line of the plant or some of its principal connections and that the water, flashing into steam, caused an overproduction of pressure which exploded the boilers. He also believed that the leaking around the reinforcing seam came from where the tubes were expanded into the drums. In his opinion the cracks between the rivet holes were caused by rolling the plates in process of manufacture and after the row of rivet holes had been punched.

These cracks, he believed, were entirely covered by the reinforcing strip in such position as to be impossible of detection when making boiler inspections. He admitted that it would be only a question of time until the drum would fail under these conditions, as there would be a breathing action along this row of rivets. In regard to the effect of differential expansion he believed that this could be set down as negligible, the movement, if any, being so absolutely small as not to warrant serious consideration. Mr. Morrison was of the opinion that none of the cracks between the rows of rivets in the reinforcing seam could have been visible before the explosion and believed that if six or more cracks had existed entirely throughout the sheet, between the rivet holes in the reinforcing seam, it would have been impossible to keep water in the boiler or maintain steam pressure. In answer to the contention that Nos. 5 and 6 boilers were found to have dangerous cracks in the shell along this reinforcing seam, he testified that in his opinion these cracks were not there before the explosion but were caused by the violent concussion of the explosion. Nos. 4 and 5 boilers, it developed, were connected to the line at the time the explosion occurred, while No. 6 was disconnected, and not under steam. He believed that the reason Nos. 4 and 5 did not explode was because Nos. 1, 2 and 3 happened to be the weaker, owing to the breathing action along the reinforcing seam, and that they were unable to stand the concussion brought about by failure in the steam line.

Prof. L. P. Breckenridge, of New Haven, Conn., also testified in the defense. It was his belief, according to the testimony, that the primary cause of the explosion had been a failure in the steam line or some of its principal connections and that the sudden release of pressure had created an instantaneous steam pressure higher than the drums could stand. He criticized severely the design of the boilers, testifying that he believed the drums were prevented from assuming a true circle, owing to the presence of the heavy reinforcing plate having a tendency to make this part of the drum rigid and flatter than the other points. This, he believed, contributed largely to the failure of the boilers, as during the entire life of the boilers there would have been a breathing action, setting up stresses along the length of the drums. He also criticized the boiler with respect to circulation, although he did not think that any of these points had a direct bearing on the cause of the explosion, and the fact that all the drums let go along the reinforcing strip showed merely that this was the weakest part of the boiler and that the failure would naturally occur at this point after being set off by the breakage of the steam line.



Drum of Munoz Boiler, Showing Line of Fracture

Regarding the cracks found in Nos. 5 and 6, he testified that in his opinion they were developed by the concussion when the other boilers exploded and that these cracks could not have been in the boilers before; otherwise it would have been impossible to keep water in them or maintain the steam pressure. He also believed that differential expansion between the boiler shell and the reinforcing plate was of very little consequence, owing to the fact that this part of the boiler was not subjected to the direct heat of the fire and was considerably removed from the zone of high temperature.

The judge held that whether or not there were negligence on the part of the defendant, the Hartford Steam Boiler Inspection and Insurance Company could be held only for the amount and kind of damages specified in the contract, so that had the jury decided that there had been but a single explosion the damage would have been limited to the $50,000 admitted by the defendant. He did, however, allow the jury to determine what the indirect damages would be, in case of reversal on appeal, and they placed them at $810. The jury found also that there was more than one explosion within the meaning of the contract and awarded the $97,400 agreed upon as direct damages. The case was immediately appealed.

Methods of Governing Steam Engines

By John Davidson

The two general methods of governing, requirements for speed regulation of different types of engine and a description of several well known throttle governors.

In nearly all cases where a steam engine is used, it is of primary importance to maintain the speed constant, or nearly so. The two principal conditions affecting the speed are the steam pressure and the resistance which the engine has to overcome. Therefore the governor must be able to regulate the quantity or the pressure of the steam, so that the power developed by the engine is just sufficient to overcome all the resistance when running at its normal speed.

The degree of accuracy required depends generally upon the kind of machinery to be driven. For many purposes a governor which is capable merely of preventing the engine from running at an excessive speed is sufficient, whereas for other purposes it is necessary that the governor should maintain the speed under all conditions of load and steam pressure within very closely defined limits, which in special cases are within 1 to 1½ per cent. of the normal speed. Also, the load required of the engine may vary rapidly, and in this case it is necessary that a very sensitive governor be used; or, on the other hand, the variation in load may take place gradually, in which case a slow-moving governor will serve the purpose.

The governor of a steam engine can control only the mean speed of rotation, as the steam is admitted periodically to the cylinder. Between each admission of steam, a variation in the angular velocity of the rotating parts takes place, and this can be minimized only by adding flywheel power. For many purposes it is necessary that this angular variation should be kept within fine limits, in addition to the mean speed of rotation, and under these conditions heavy flywheels are generally used. Besides maintaining a uniform speed of rotation during each revolution, the flywheel greatly assists the governor in cases where a variation in load takes place very rapidly, as is the case where the engines are used for rolling mills and for driving electric generators supplying power for electric railways.

There are two principal methods of governing engines: by throttling the steam and by altering the point of cut-off, that is, varying the degree of expansion. In the first case the quantity of steam admitted to the engine is constant under all loads, the pressure being varied to suit conditions; in the second case the amount of steam admitted to the engine is varied to suit the load, the pressure remaining constant, or practically so. Sometimes the two methods of governing are combined, and when this arrangement is used the engine is usually controlled by the throttle governor entirely at light loads.

Throttle governors are used mostly for small engines, in nearly all cases for high-speed engines of all powers and in cases where the load changes very little and the governor is required principally as a safety device, as for pumping engines, etc. As is generally understood, with throttle-governed engines the most economical load is the maximum load the engine will develop with any fixed cut-off. Therefore, it follows that where a wide variation in load takes place the throttle governor does not give the highest efficiency. It should be noted, however, that where the variation in the load is not very great the difference in economy between variable expansion and throttle governors is practically a negligible quantity.

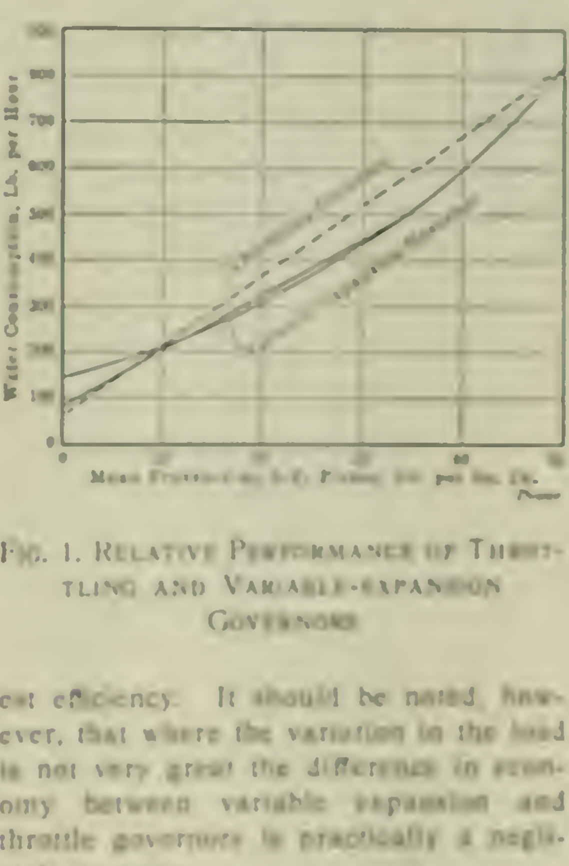


FIG. 1. RELATIVE PERFORMANCE OF THROTTLING AND VARIABLE-EXPANSION GOVERNORS

At light loads nothing is to be gained by variable expansion; consequently by carefully designing an engine it is possible to arrange the cylinders for a degree of expansion which will give good economy over a large range of load. To make this clear, in Fig. 1 is shown the relative steam consumptions of an engine under the same conditions of load when controlled by variable expansion and by throttling.

Suppose that the engine be altered in capacity so that the mean effective pressure referred to the low-pressure piston in pounds per square inch is about 32, then the steam consumption with the throttling governor will be as shown by the full straight line. This shows that, between 32 and 12 pounds mean effective pressure, very little is gained by a variable expansion, and below that load the throttle-governed engine is the more economical.

To maintain maximum economy in throttle-governed engines of the compound and triple-expansion type, when they are required to develop overloads for short periods, bypass arrangements are often fitted, to enable high-pressure steam to be admitted directly to the second cylinder, thus converting the triple-expansion engine for the time being into a compound engine, and a compound into a simple engine. This arrangement is simple, and enables an engine to develop heavy overloads in cases of emergency. However this practice is not to be recommended, as the distribution of power between the cylinders of the engine when dealing with overloads is very unequal, and unless the moving parts are specially designed to suit these conditions, it is liable to cause unequal wear and overheating. As regards the speed regulation, there is practically no advantage in one method of governing over the other, as the controlling mechanism may be made to act instantaneously in either type.

For special purposes it is often necessary to maintain the speed of the engine constant under all conditions of load. With an ordinary governor, in which the controlling force is due to weights revolving about a given center, it is an impossibility to fulfil this condition, as it is necessary that the speed of the engine vary before there is any change in the position of the governor and consequent variation in the amount or pressure of the steam; that is, the governor itself takes up its position by a change in the speed of the engine. To maintain an engine at a constant speed it is necessary to have a regulating device which automatically speeds up the main governor as soon as a change in the load has taken place.

Types of Governors

For throttle-governed engines the governor and the throttle valve may be combined and driven from the engine crankshaft by means of a belt, ropes or chain. This arrangement of governor gear is generally used for small engines, where a device for preventing the engine from running at an excessive speed is practically all that is required. In every case where the governor is driven from intermediate gearing, such as a belt or ropes, an automatic arrangement should be fitted to shut off steam entirely in case the ropes or belt should break. Many serious accidents have occurred through engines not being fitted with an arrangement of this kind.

Engines running at a high rotative speed usually have the governor attached directly to the crank shaft, thus dispensing with all gearing and making a very compact and safe arrangement. The throttle valve is usually connected directly to the governor, and the latter is fitted with a speeder device, the spring of which acts in such a manner as to close the throttle valve in case the governor itself should break down. The

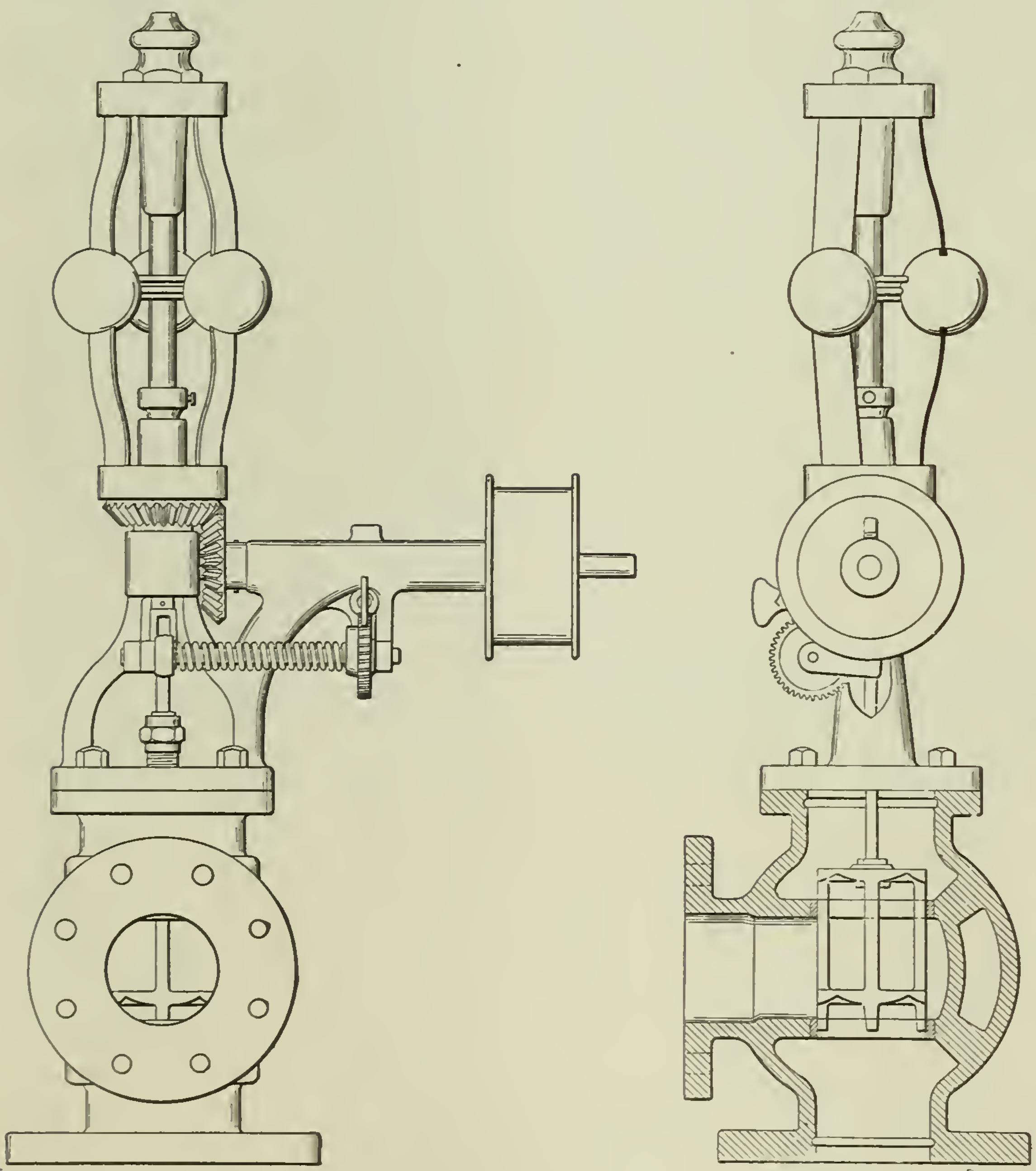


Fig. 2. Pickering Governor

high speed of rotation makes it possible to adopt this arrangement; but, of course, with slow-speed engines it is absolutely necessary to provide intermediate gearing if a powerful high-speed governor is required.

Slow-speed engines are usually fitted with steam-distributing valves actuated through trip gears; consequently the governor acts upon the tripping device to modify the point of cutoff. Very little power is required to operate the governor in proportion to the size of engine, as the gears are easily tripped. In the case of engines fitted with rotary cutoff valves, similar to the Ryder gear, a more powerful type of governor gear is necessary, and a governor controlling a relay motor is by far the most satisfactory.

Medium-speed engines are sometimes fitted with governors of the crank-shaft type. In this case the governor has to drive the valve in addition to modifying the position of the gear to change the point of cutoff; hence they are usually of massive construction. This type of governor at one time was extensively used for engines of a high rotative speed but it has now been almost entirely abandoned by English engineers, the throttle type taking its place. A few designs of this type of governor are made, and will be described later.

Owing to the demand for economical high-speed engines, especially for large powers, variable-expansion governing has again been adopted, but in combination with throttle governing. Governors of the flywheel type are not used, and the piston valve is driven in the usual way from an eccentric having a constant travel, the cutoff being varied by slightly rotating the valve which is provided with angular ports, with the liner having angular ports to correspond. Even in this type of governor, as considerable power is required to rotate the valve on its spindle, relay motors are generally adopted in place of putting this additional work on the governor. The governor then simply controls the main throttle valve, and alters the position of a small piston valve in connection with the relay motor.

As a full consideration of the theory and workings of governor gears would be out of place in this article, only the principal designs of governors in general use will now be illustrated and described.

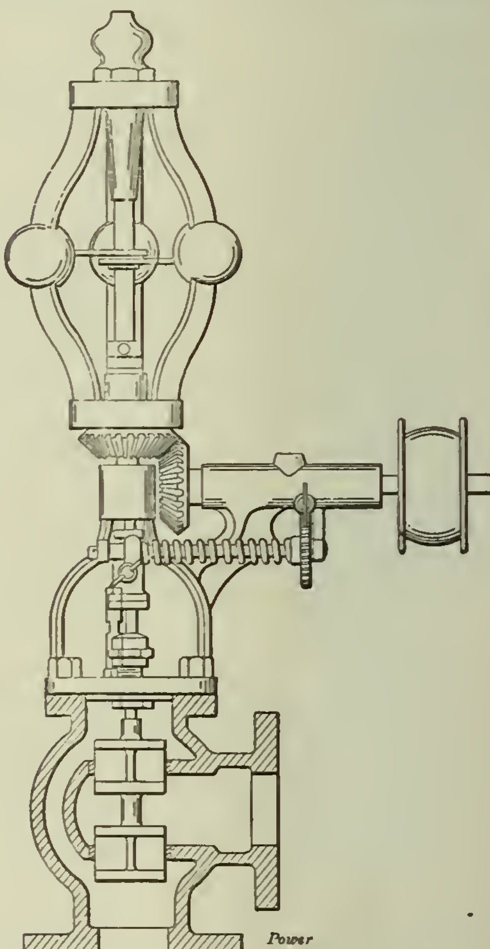


Fig. 3. Pickering Governor with Equilibrium Valve Attached

Throttle Governors

The most common form of combined governor and throttle valve is the Pickering, the general design of which is shown in Fig. 2. In this governor all arms and joints are replaced by flat springs, dispensing with all pin joints and the consequent wear and friction. A neat form of speeder gear is generally fitted, consisting of a torsional spring which tends to close the throttle valve by means of a lever, the pressure being adjusted through the small worm and wheel. The throttle valve being of the double-seated type is balanced, and the edges are vandyked so as to give a gradual opening.

A very effective type of knockoff gear is manufactured by Pollock, McNak & Highgate, of Glasgow, under "Smith's" patent, for this type of governor. The ordinary knockoff gear for governors driven through a belt or ropes consists of a loose arm carrying a jockey pulley, the pulley running on the driving belt or ropes, and dropping in case they should break. This arrangement is not altogether satisfactory for the following reasons: It places the whole stress of the governor on the tension spring, which has to carry the weight of the valve and knockoff gear acts only when the belt breaks, the action of the arm then releasing the spring and causing the valve to close. It does not act when the belt

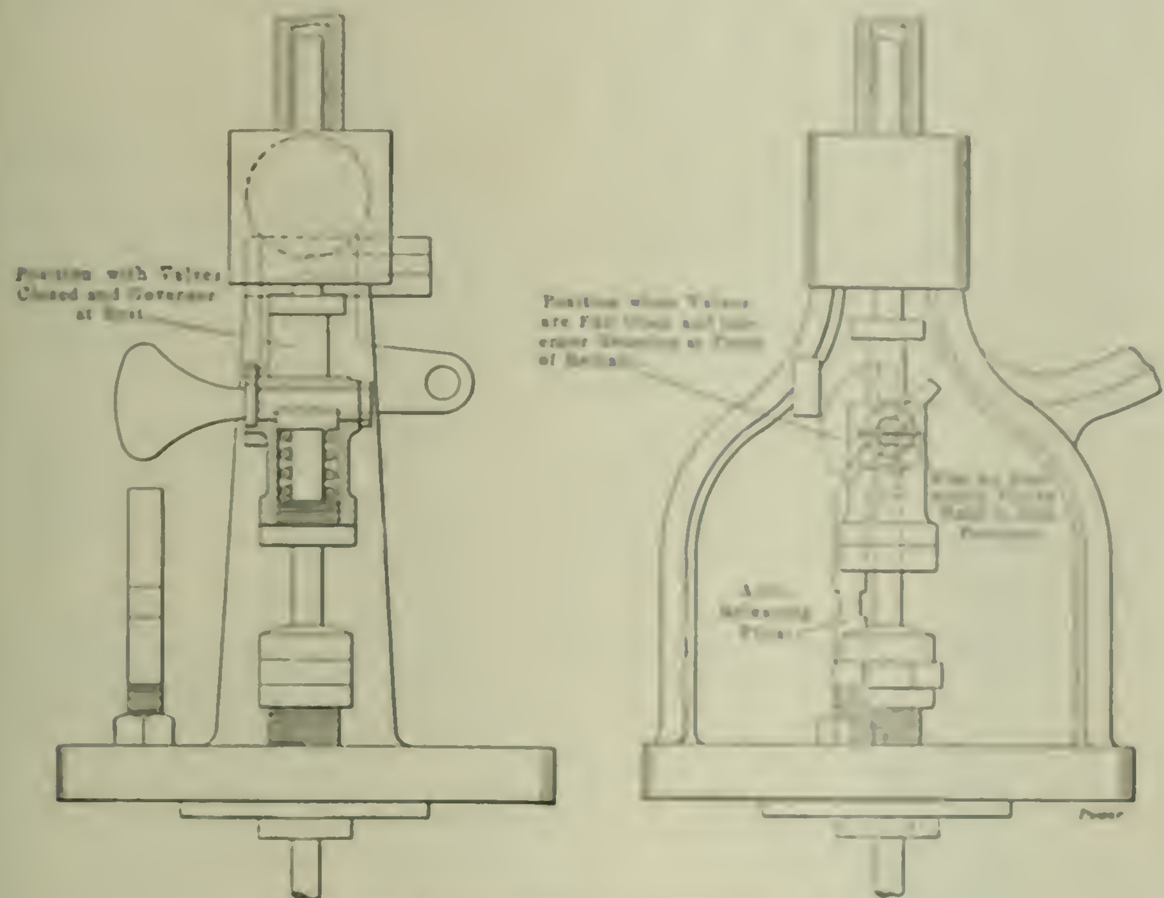


Fig. 4. Attachment for Starting Engine

spindle; and any downward pull of the leaf springs, when the governor is being expanded by an excess of speed, makes the governor less sensitive and interferes with its exact working. The slides, or the pulley slips on the shaft, nor when a pin or key comes out, but only when the belt gives way.

With Smith's patent automatic knockoff gear fitted to the governor, these objections are obviated, and if from any cause the governor stops or slows down, it brings the bottom valve of each pair, the two together constituting an equilibrium valve, into action and shuts off the steam from the engine. These valves are shown in Fig. 3. Neither the action of the governor nor its regulation of speed is interfered with in any way. When the engine is at rest these bottom valves are closed, and, in order to start, a small eccentric is used to open them. This is operated by hand, and its action may be understood by reference to Fig. 4. The eccentric is released automatically by the action of the governor after the engine has been started. This arrangement is simple and it is claimed that it is not liable to get out of order, and has the advantage of utilizing the lifting power of the leaf springs.

Sometimes the governor throttle valve and the stop valve of an engine are combined as shown in Fig. 5, which represents a type of governor largely used for all purposes, and known as the "Acme."

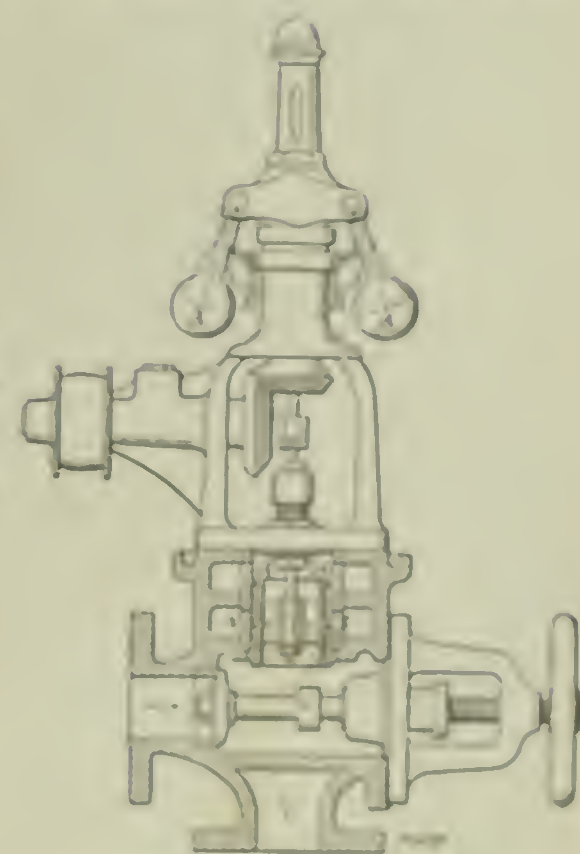


Fig. 6. Soho Governor

Another type of combined governor which is fitted with a safety device is illustrated in Fig. 6; this is known as the Soho safety governor and is manufactured by Messrs. Tangyes, Ltd., of Birmingham. The governor is so designed that if it should stop from any cause, such as breakage of the belt, the throttle valve would automatically close and prevent the engine from racing. The valve is of the equilibrium piston type with double steam ways, thus affording a large area for the passage of the steam with a short travel. To start the engine the balls *A A* must be held up by the supports *B B* as shown in the illustration, and the valve is then full open. When the engine has reached its normal

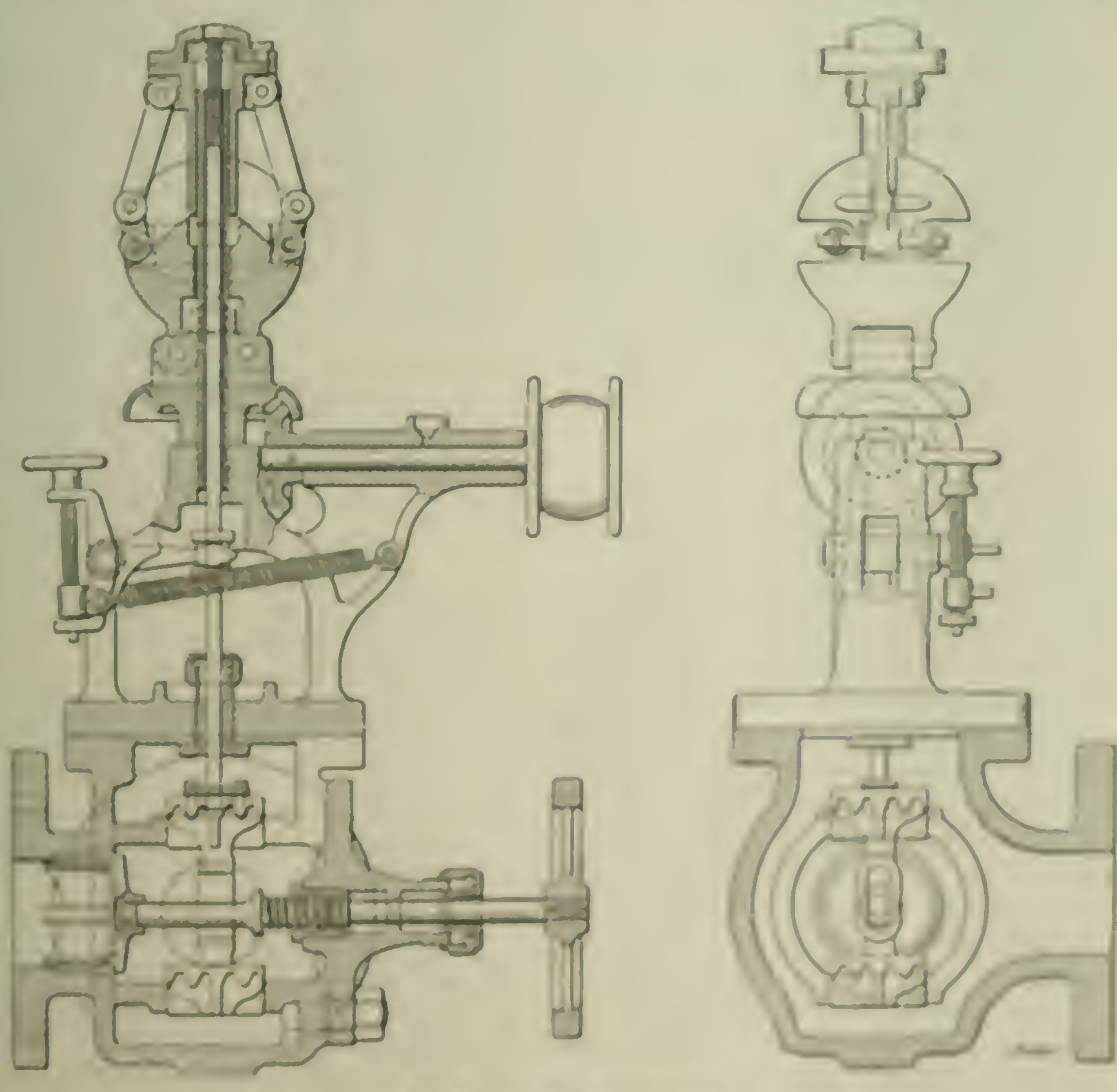


Fig. 5. Acme Governor

speed the balls will have lifted and the supports fallen out of the way, leaving the balls free to drop to their lowest position, closing the valve and preventing the engine from running away in case the

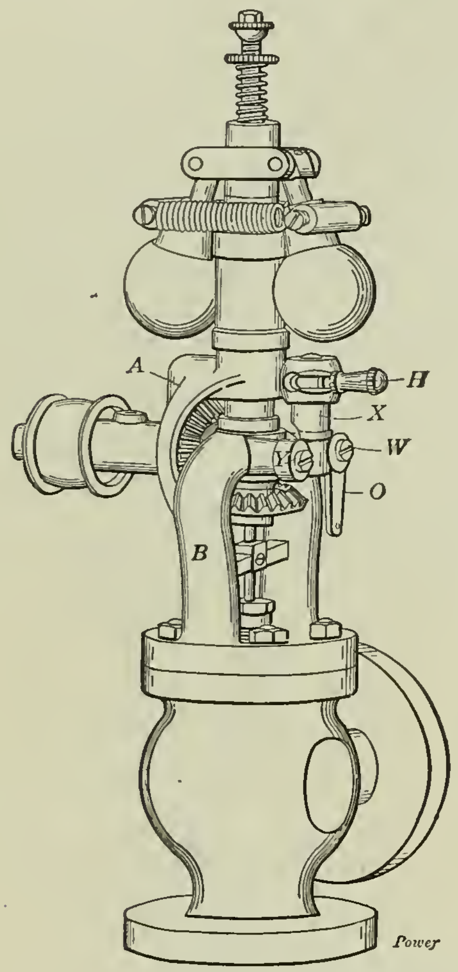


Fig. 7. Precision Governor

governor should cease to run from any cause whatsoever.

In Fig. 7 is shown the Precision spring governor, made by Schaeffer & Budenberg, of London and New York. This governor, although of simple design, is very sensitive, the aim being to reduce friction to a minimum and at the same time to make all parts easily accessible. The governor gear is mounted on a vertical spindle which runs in ball bearings. The tension of the springs increases with the outward swing of the pendulums, the two forces (the tension of the springs and the centrifugal force of the weights) practically balancing each other. The increase in the tension of the springs is practically constant for every equal movement of the weights; consequently the governor is almost astatic. A special type of knockoff gear is fitted which comes into action in case the governor should stop rotating.

The bracket *A*, carrying the governor head and the horizontal spindle with the pulley and bevel wheels, is arranged to slide on and turn round the hollow pillar on the bridge *B*. The bracket *A* is held in the upper position by the collar on the pivot, *X* resting on the rollers *Y* and *W*. In this position the governor acts like any ordinary governor; that is, when the weights are in their "in" position the ports of the valves are full open. If the strap is placed on the pulley, the knock-off motion is put into action by turning the pivot *X* so that the notched portion is opposite the roller *Y;* the bracket *A* is then held in the upper position by the pull of the belt pressing the collar on the pivot *X* against the roller *W*. If the strap breaks, the pivot immediately slides off roller *W*, and bracket *A* with the governor, etc., drops, thus shutting off the valve until the weights fall into their "in" position. By turning the handle *H* on the pivot, the knockoff motion can be adjusted to act for a belt pulley from the opposite direction. The roller *W* is notched and provided with a small lever *O* by which the knockoff motion can be actuated by hand, if necessary, from a distance. If rope or wire connected to the lever *O* is passed under the main belt of the engine, the knockoff motion will be actuated if the belt should slip off the pulley, thus immediately shutting down the engine.

In Figs. 8 and 9 are illustrated a governor, also made by Messrs. Schaeffer &

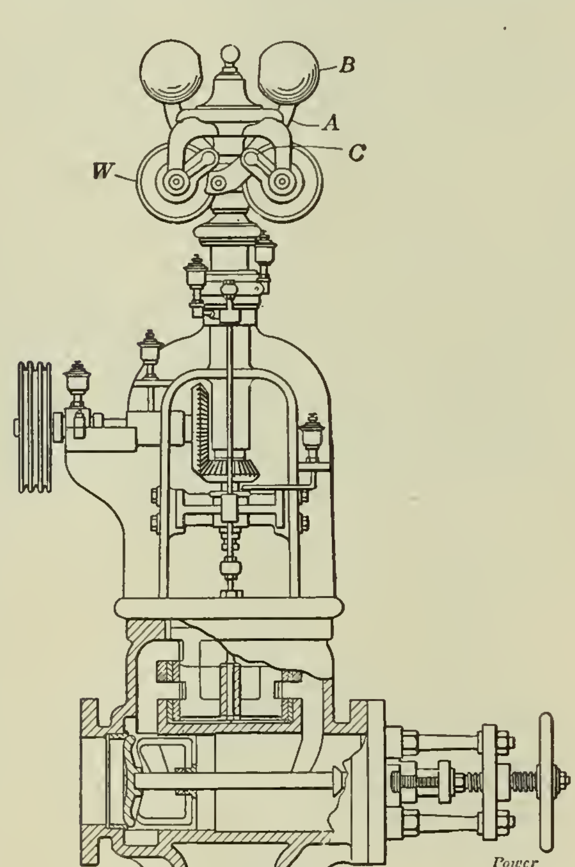


Fig. 8. Buss Governor

Budenberg, and known as the "Buss" type. In this governor a compound pendulum is employed, consisting of a bell crank *A*, one end of which carries a ball *B*, and the other a cylindrical weight *W*. There is one pendulum of this description supported on each side of the rotating axis in such a manner that the arm carrying the cylindrical weight *W* extends across the axis. Each pendulum is fitted with a stud *C*, which engages with and imparts movement to the muff. By a suitable choice of weights the system can be made absolutely isochronous within an angle of oscillation of about twenty degrees; beyond this angle the pendulum is in unstable equilibrium. The condition of equilibrium is such that the resultant of the weights and the centrifugal force must pass through the virtual center, which in this case is the axis of support of the pendulum. That is, in Fig. 9 let *F G* represent the resultant of the weights passing through the center of gravity of the pendulum, and *F K* the direction of the resultant centrifugal force, then *F O* represents the direction of the resultant of these forces, and completing the parallelogram *F G H K F, F K* represents the magnitude of the centrifugal force. In the middle position this acts upon the weight *B* alone, and therefore the speed may be computed as before. In the other positions, the effect of the centrifugal force must be proportionately distributed over the weights *B* and *W* in order to determine the speed. Between the two extreme positions, the governor shows a variation of only 2 per cent., and it could easily be made more sensitive if desired.

If a governor is made extremely sensitive throughout its lift, it is liable to overrun or hunt. This may be checked —at the same time retaining the highest degree of sensitiveness—by making the governor extremely sensitive about its middle position, but less sensitive upon approaching the highest and lowest positions. This is one of the objects aimed at in the construction of the four-pendulum governor shown in Fig. 10. In this there are four pendulums *A* which are suspended in such a manner that under the influence of their own weight alone they would fly apart until they had nearly reached their extreme outer position, corresponding to the highest position of the governor. They are, however, held in the inner position by the weight of the muff *W* which is applied through the pivots *B* of the pendulums. The latter are supported by short links *C* from the spindle *D*, and the sliding weight, which is made in one piece with

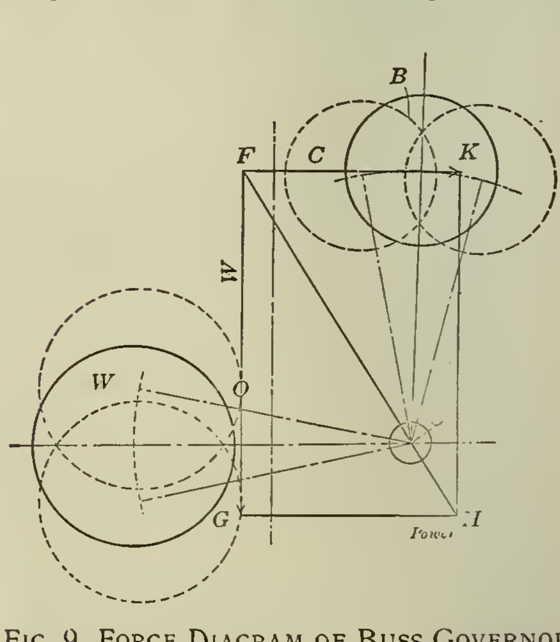


Fig. 9. Force Diagram of Buss Governor

the muff, incloses the whole governor. A light spring *E* is inserted to add to the stability and for adjusting the speed. The small view on the left of the pulley represents an arrangement for varying the speed of the governor while in operation. For this purpose the spindle is elongated and the muff is loaded by means of a spring *S*, which is held down by a nut *F*. By turning the milled wheel *G* the nut is moved on the spindle, and the tension on the spring is varied,

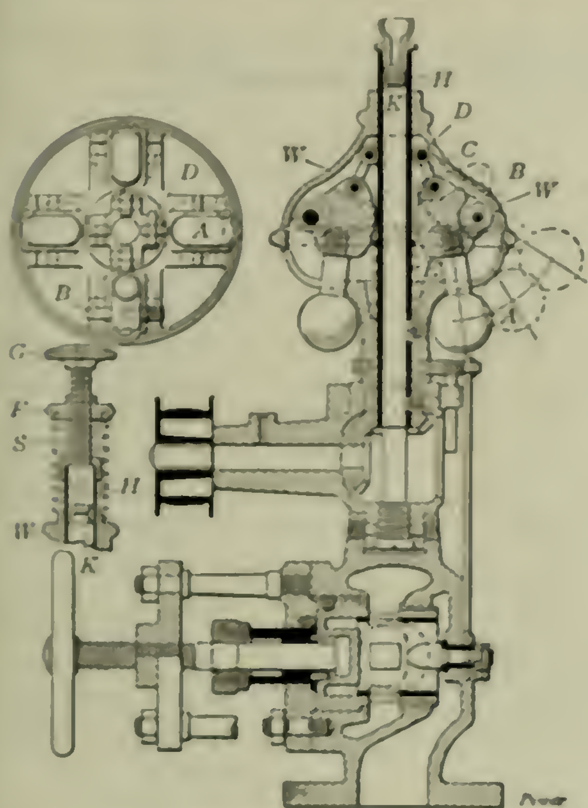


FIG. 10. FOUR-PENDULUM GOVERNOR

which in turn changes the effect of the weight of the muff. By the use of this arrangement the speed of the governor may be varied by about 50 revolutions per minute. This governor is so proportioned that it is almost isochronous about its middle positions, but a velocity difference of 3 per cent. is required to move it from the lowest to the highest position.

A governor constructed in such a manner that the hight of the cone of revolution is constant in all positions of the balls could be in equilibrium only at the one particular speed which corresponds to this hight, and the governor would therefore be absolutely isochronous. This result is obtained if the balls are guided so as to describe a parabola, and supported in a direction normal to the parabola at every point. One possible method of obtaining this consists in hanging the balls from a flexible leaf spring wound upon a base curved to the evolute of a parabola. There are practical difficulties in the way of carrying out this idea, but a feasible approximation to these conditions is found in the Watt governor with crossed arms, if proportioned so that within the range of movement required the arc of a circle described by the balls coincides approximately with an arc of a parabola having its axis in the axis of revolution of the governor.

HIGH-SPEED ENGINE GOVERNORS

As previously stated, the governors of high-speed engines are usually attached directly to the crankshaft and, therefore, revolve at the same speed as the engine. These governors are generally of very simple construction, as illustrated in Fig. 11.

The weights *W W* are pivoted on pins *P P* and by means of extended arms *A A* the motion of the weights is transmitted to the sleeve *B*. One end of the bell crank *C* engages this sleeve and the other end is attached to a throttle-valve spindle. The weights consist of plain steel castings, and adjustment is made by adding weights on either side.

It is now general practice in the case of high-speed, inclosed, forced-lubrication steam engines, to lubricate the main fulcrum pins by oil under pressure. To accomplish this a hole is drilled through

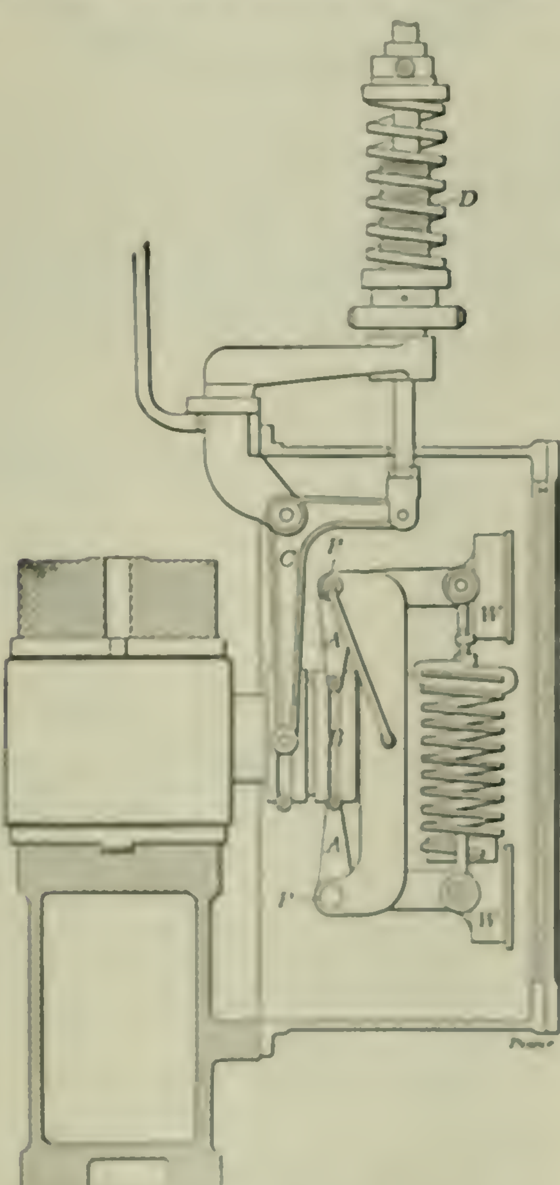


FIG. 11. HIGH-SPEED GOVERNOR

the center of the shaft at the end, connecting with the groove in the nearest end bearing, and from this hole connections are made by means of small pipes to the fulcrum pins.

Referring to Fig. 11 it will be seen that a speeder gear is fitted at *D* just above the casing containing the governor. This consists of a compression spring carried between a bracket fixed to the governor casing and an adjustable collar carried on a screwed bushing attached to the throttle-valve spindle. By means of a handwheel the bushing can be raised or lowered and the compression on the spring modified, thus altering the speed of the engine. As the throttle valve closes upward it will be seen that should the governor break down or become disconnected from the throttle valve, the spring *D* will immediately close the valve and shut down the engine.

The throttle valves used in connection with this class of engines are generally of the double-beat balanced type as shown in Fig. 12. Steam enters at the top and passes out to the cylinder through the two faces shown. The thickness of the metal in the valve and liner is made as nearly uniform as possible, and being cylindrical in form they retain their shape very well, even when subjected to great variations in pressure and temperature. With a view to reducing friction to a minimum, and at the same time preventing the possibility of an engine attendant interfering with the governing, as might be possible if an adjustable type of gland packing were fitted, a plain bush of considerable length is used. This method of preventing leakage of steam has proved very satisfactory, and a bush will remain tight for several years, providing ordinary lubrication is supplied, and as it is usual to feed the cylinder oil into the pipe next to the throttle valve, the spindle easily obtains ample lubrication.

Throttle valves of the piston type have been largely used, as they can be made perfectly balanced and are easy to actuate; but owing to the fact that it is difficult to adjust them when wear takes place, they have been abandoned by most builders of high-speed engines. With a throttle valve of the double-seated type the wear is automatically taken up by the governor itself, for when the weights

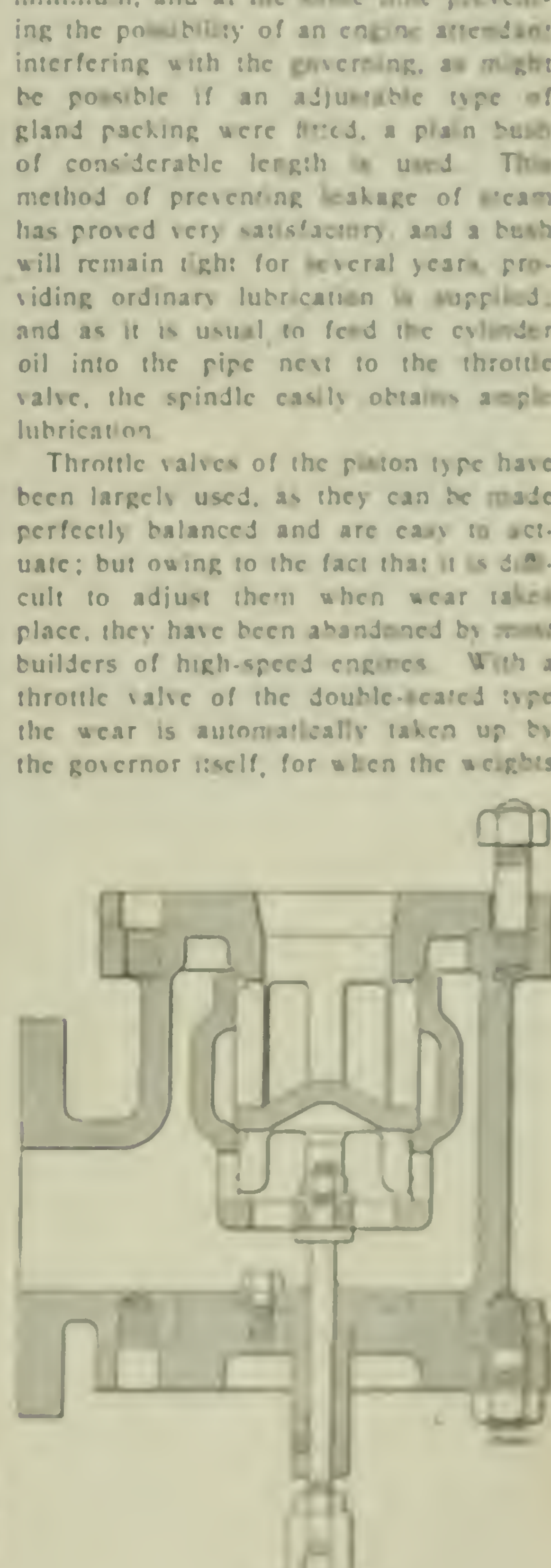


FIG. 12. DOUBLE-SEAT VALVE

are in their out position the throttle valve is forced hard on its seats, and even if it is found necessary to regrind in the valve, the governor will still bring it to its seats.

Other types of governor will be taken up in a subsequent article.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

A Unique Gas Power Pumping Plant

By Osborn Monnett

The city of Toledo, though rated as an important lake port, is situated so far back on the Maumee river that it is impracticable to take advantage of the lake as a means of water supply, and it has therefore gone through all the various processes of evolution common to inland cities which have to depend on river supply, such as Cincinnati, Louisville, St. Louis and others in the Middle West.

The original high-duty pumping station took water from the Maumee river at a point about one mile south of the center of the city. The equipment at this point consists of two 5,000,000-gallon Worthington compound duplex horizontal pumping engines; one 7,000,000-gallon Knowles pump of similar type and two vertical compound duplex Worthington pumping engines of 15,000,000 gallons capacity each, making a total pumping capacity of 47,000,000 gallons in 24 hours. Under ordinary conditions the water at this point in the river is moderately turbid except when it is disturbed by high wind or when the clear water has been displaced by highly turbid water from upper portions of the river. The quality of the water on the whole was not satisfactory and a plan was finally worked out of operating the original pumping station in connection with a filtration plant, using the original station, which had ample capacity, for distributing the purified water, and holding the old intake in reserve.

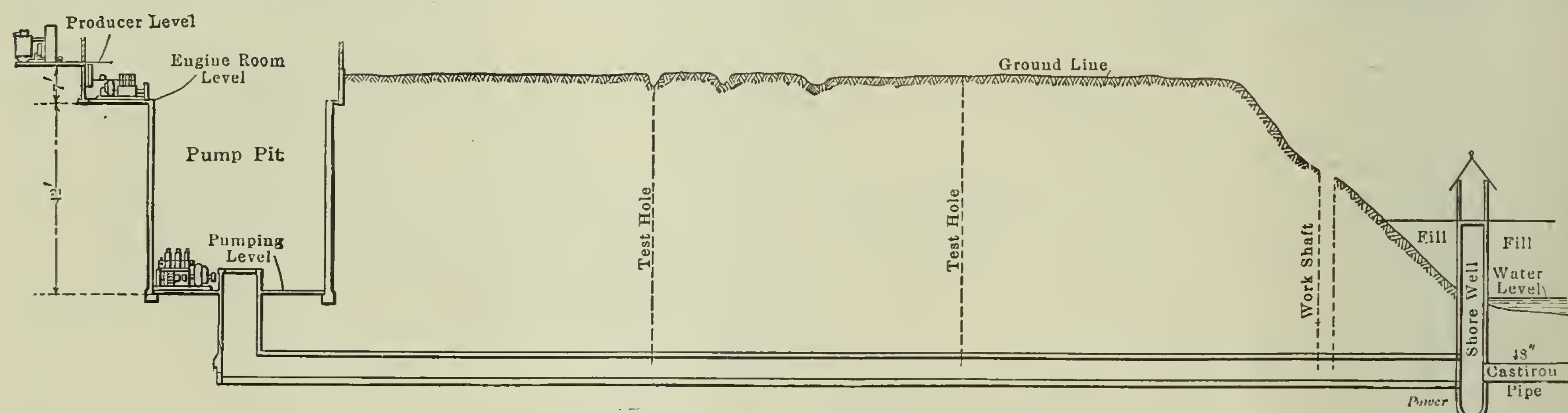


Fig. 1. Sectional Elevation of Pump Pit and Profile of Pipe Route

The filtration plant, as finally built, is located at a point 2½ miles up the river from the original station. The water is supplied to the pumps at this station through a 6-foot concrete tunnel by gravity from the filter beds. In connection with the filter plant a low-service gas-power pumping station has been installed for raising the water up to the point where it is purified. This pumping station was originally intended to be located at the water's edge, but upon investigation it was found that the difficulties of obtaining a satisfactory foundation and the danger from high water and ice gorges were such as to make it advisable to adopt another location. It was therefore decided to build the pumping station at a point about 500 feet nearer the filter plant at a considerable distance from the river, as shown in the profile, Fig. 1.

In order to deliver the water to the pumps in the new location, an intake pier or submerged crib was located approximately 800 feet from the shore toward the channel of the river. From this intake the water flows through a 48-inch cast-iron submerged intake pipe to a concrete shore well 10 feet in diameter; the bottom of this well is 27 feet below mean water level. At a level about 18 feet above mean water level is the pump floor, above which is built a concrete gate house, circular in plan. From the shore well the water flows through a 5-foot brick tunnel, as indicated, 500 feet long, to the suction well in the engine room of the pumping station.

The New Pumping Station

The pumping station proper is a steel and brick structure 65 feet wide and 180 feet long. Fig. 2 gives an idea of the layout as at present installed, with future producer and pumping units indicated in dotted lines. Fig. 3 shows the coaling arrangement. Coal is delivered at the pumping station on a siding elevated some 6 feet above the general ground level. From the cars the coal is either dumped or shoveled into a concrete underground coal bin having a capacity of approximately 250 tons. Underneath this bin is a pit which permits the coal to be drawn from the bin, crushed and delivered to a bucket elevator by which it is deposited in an elevated coal bunker over the stokers, from which point it is spouted by gravity to the charging hoppers. This overhead bin has a capacity of about 70 tons.

Two gas-producer units are in operation but the producer room is planned for a total capacity three times that of the present equipment. Each of the producers now in service is capable of gasifying 300 to 400 pounds of bituminous coal per hour, which will permit each unit to furnish gas for 300 to 350 engine horsepower or to carry a maximum load for two or three hours of 500 horsepower. The generators are of the Wood water-sealed type, 8 feet in internal diameter, with a fire-zone cross-section of 50 square feet. In connection with them are installed two vertical wet scrubbers of the ordinary type and two motor-driven rotary scrubbers which serve also as tar extractors and blowers. The generators are partly shown in Fig. 4 and one of the tar extractors is shown in Fig. 5.

The coal used is Hocking Valley bituminous washed pea, which costs $2.30 per ton delivered at the plant. Up to the present time there has been no attempt to utilize the extracted tar for fuel purposes and considerable thought has been

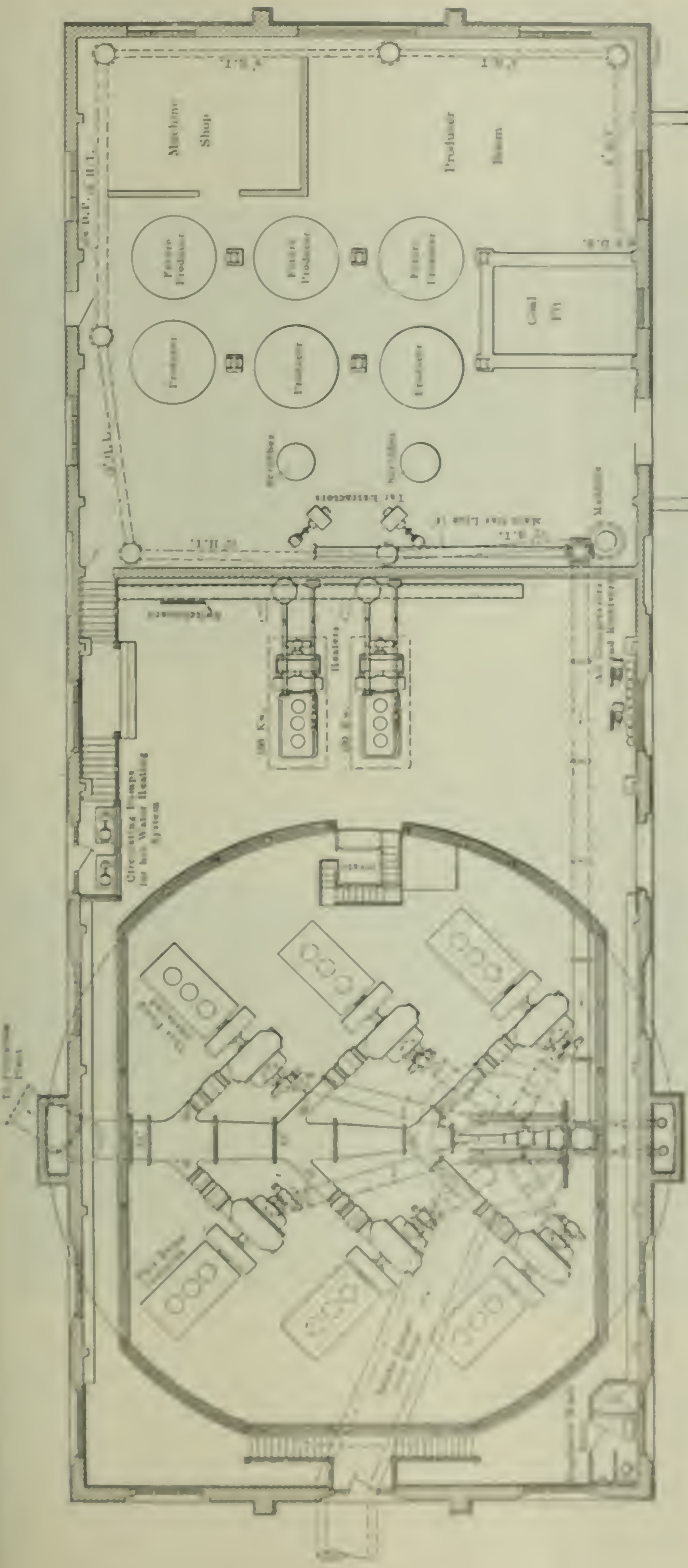


Fig. 2. Layout of the Gas-power Pumping Plant of the Toledo Waterworks

given to the problem of disposing of this byproduct in the most economical way. The method finally adopted and successfully employed at the plant at the present time is to catch the tar discharged from the rotary scrubbers in a water-sealed sump and pump it from there into a storage tank outside the building; from this tank it can be conveniently loaded by gravity into tank cars for shipment. The pump used for transferring the tar from the sump to the tank is a Marsh pump of special design, driven by steam from a small vertical auxiliary boiler. A ready sale for the tar thus produced has been found, its use being principally for paving material. The purified gas passes into a main header 20 inches in diameter which extends out over the pump

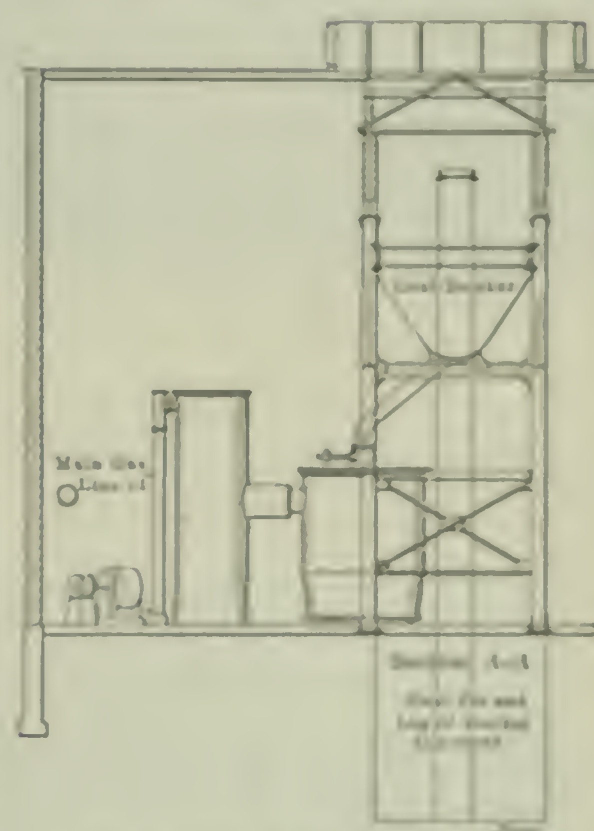


Fig. 3. Coal-handling Scheme

pit on one side and leads to the engines below. In the construction of this header precautions have been taken to provide for the cleaning of any tar deposit, all angles being provided with cross fittings, enabling the pipe to be cleaned from either direction.

The floor of the machinery room, which occupies the easterly 115 feet of the building, is located 7 feet below the level of the producer-room floor and is in part occupied by a circular pump pit 75 feet in diameter and 42 feet deep below the engine-room floor. On the main floor of the machinery room are located two 100-kilowatt generating units consisting of Buckeye three-cylinder vertical gas engines direct connected to General Electric direct-current dynamos which deliver current at 230 to 250 volts (Fig. 6). These units furnish electric current for lighting and a variety of power purposes throughout the pumping plant and the filtering plant, including the operation of the rotary scrubbers and a number of electrically operated valves, in-agent mixers, etc., in the other part of the works, and an electric elevator in the pit.

Waste-gas Heating System

One of the interesting details of this plant is the arrangement for heating it with the exhaust gases of the engine. It

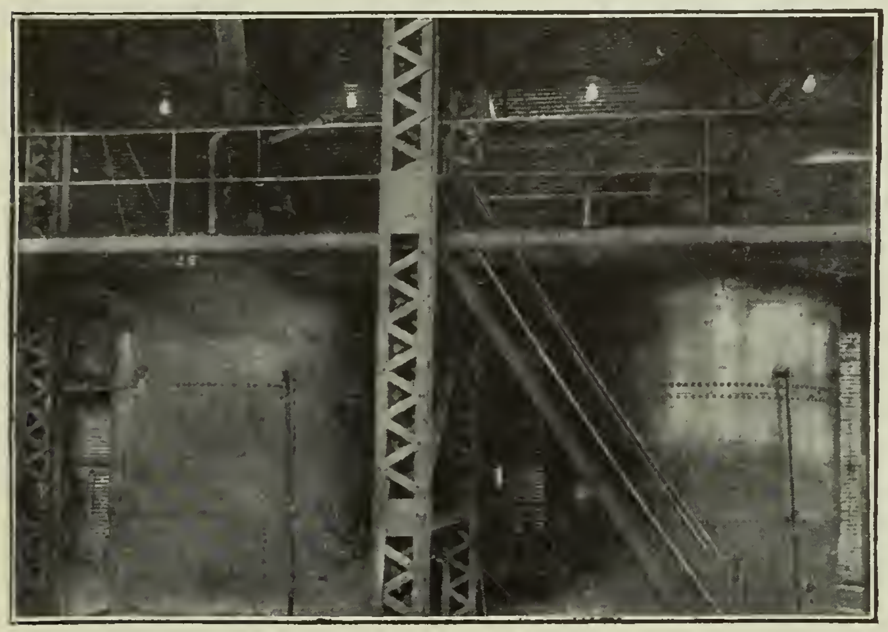


Fig. 4. Upper Part of Gas Generators

Fig. 5. Motor-driven Tar Extractor

was originally intended to install in the pumping station two 80-horsepower horizontal return-tubular boilers to furnish heat for the buildings and steam for operating some of the auxiliaries. On investigation, however, it was found that the waste heat from the gas engines would be more than sufficient to accom-

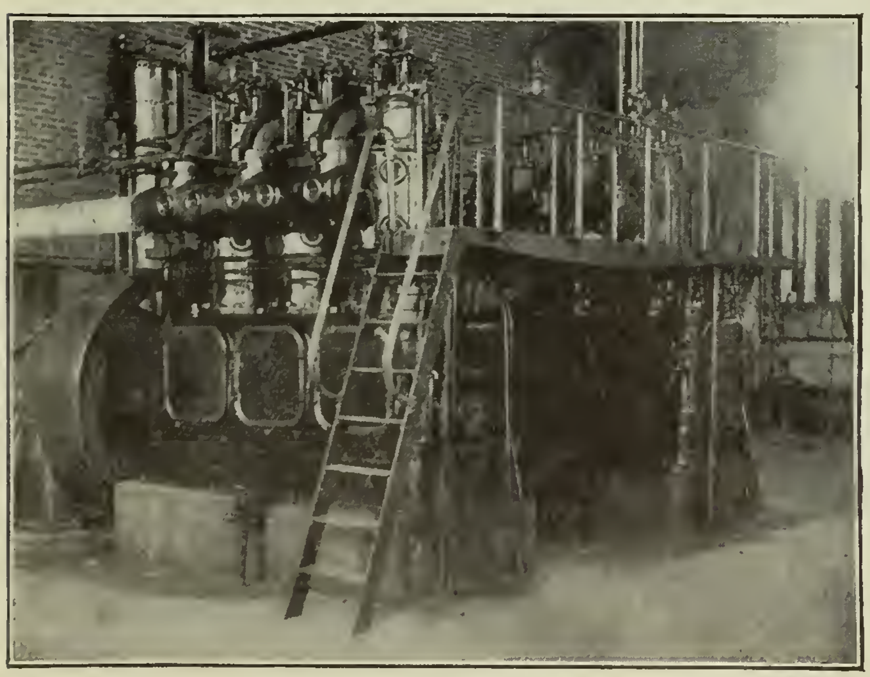


Fig. 6. The Electrical Units

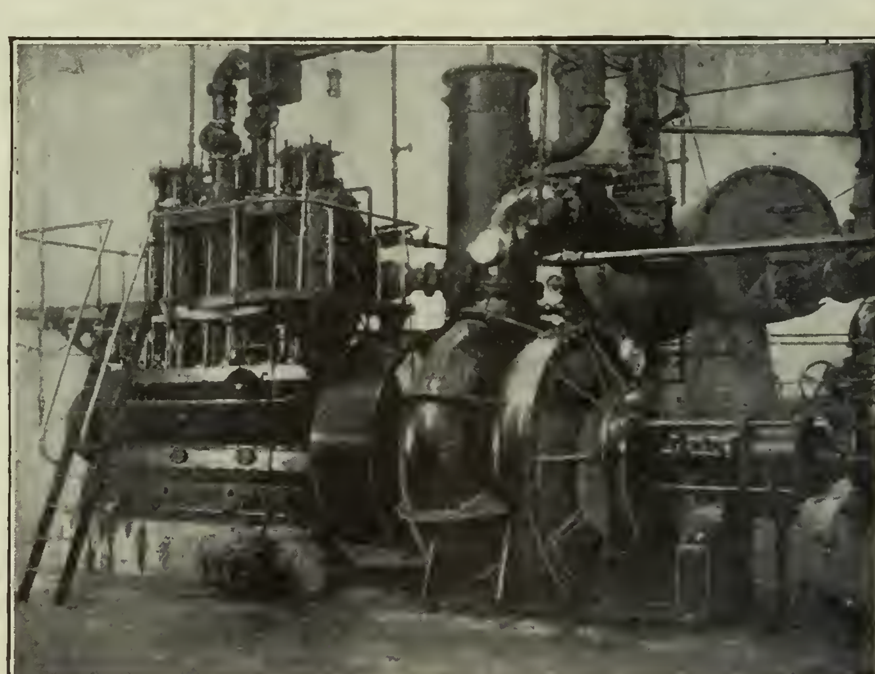


Fig. 7. A Pumping Unit

plish the heating. The method whereby this was accomplished is as follows:

The jacket water from the cylinders of each engine goes to a vertical heater through which the exhaust from the engine is passed. The heaters, one of which is installed for each of the four units, consist of ordinary tubular construction similar to a vertical boiler, with the bottom corresponding to the fire box inclosed to receive the exhaust gases, which pass up through the tubes and out at the top. This muffles the exhaust very effectively and furnishes water at a temperature of 210 degrees Fahrenheit. This water passes through an ordinary system of pipes and radiators heating the different buildings and returns to be again passed through the jackets of the cylinders, heater, etc.

To provide for a proper circulation of the jacket water there have been installed two electrically driven turbine pumps. The water returns to the low-service pumping station from the heating system at a low pressure, which is increased to about 40 pounds by the circulating pumps; this is enough to force it through the jackets, heaters and radiating system and return it to the circulating pumps. The flow is controlled by a hand-operated valve between the circulating pumps and each engine. A thermostat and valve operated by it are located near where the water passes into each jacket and the thermostat is adjusted so that if the temperature of the water entering the jacket should rise above the predetermined temperature, the thermostat valve will open a connection to the mains, where the pressure is about 60 pounds, and admit sufficient water to reduce the temperature of the water entering the jackets to this predetermined temperature. When the heating system is not in use in the summer, water from the mains passes through the jackets and heaters and is wasted.

Pumping Equipment

The main pumping engines, shown in Figs. 7 and 9, are located at the bottom of the pump pit and take their suction from the 12-foot well, as indicated in Fig. 2. These units consist of Rathbun three-cylinder vertical engines, with 20x20-inch cylinders, direct connected to two-stage Wood centrifugal pumps, which have a rated capacity of 15,000,000 gallons of water in 24 hours. There is at this point a maximum variation of about 25 feet in the water level of the river and the intake tunnel is provided with a throttle valve, operated by hand, for preventing the suction well from overflowing. The water from the two pumping units is discharged through a check and hydraulically operated stop valve into a 54-inch main riser, from which it is taken to the filtration plant.

FIG. 8. EXHAUST HEATERS

The engines of these units, as well as those of the electrical units, are of the standard construction regularly used by the builders, but they embody a new valve gear which has not been described in POWER. A lay shaft is located in the crank case and on this shaft are mounted two eccentrics for each cylinder, one to operate the inlet valve and one the exhaust valve. These eccentrics operate, through bored crosshead guides, the push rods which actuate the valve mechanism; the latter is all on top of the cylinders and in plain sight of the operator. Make-and-break ignition is used; the current is supplied from storage batteries which are charged from the dynamos.

In addition to the pumping units there is an auxiliary motor-driven centrifugal pump, having a capacity of 5,000,000 gallons per 24 hours. The motor is arranged to take current from the generators above, enabling them to supply some of the pumping energy in case of necessity.

FUEL ECONOMY OF PLANT

The output of the pumps is measured by means of a venturi meter in the main discharge line and the coal is accurately weighed as it is fed to the producers. Through the courtesy of D. H. Goodwillie, superintendent of filtration, it is possible to present the running results for August and September, 1910, a period of 61 days, under average conditions. The coal consumption was 694,700 pounds and the total output was 560,837 brake horsepower-hours. This gives a record for 61 days of 1.24 pounds of coal per brake horsepower-hour. The coal figures represent the total fuel used for all purposes, including standby losses. The proximate analysis of the coal was as follows: Fixed carbon, 50.25 per cent.; volatile combustible matter, 37.32; sulphur, 0.93; moisture, 5.73, and ash, 6.70 per cent. The heat value was 13,200 B.t.u. per pound of coal as used.

In interpreting the results of this run it must be understood that the volume of water being pumped did not provide full load on both of the pumping units; one of them had to be run on a load considerably below its rating, which would naturally lower the efficiency of operation.

The Diesel Engine in Service

BY EDWARD B. POLLISTER

The article by G. H. Kimball in the January 17 issue, on Diesel engine operation, invites a few pertinent remarks from other operators. The article mentioned is instructive—"disadvantages and drawbacks" are not generally found described in catalogs. But do not judge a Diesel engine too hastily. All engine manufacturers have some installations that prove unsatisfactory. Some recent steam-turbine plants have required a couple of years of manufacturers' nursing to secure acceptance.

Do not forget that combustion, with a Diesel engine, takes place in the cylinder—a running jump from the boiler grates in economy. In the ordinary lighting plant of a town of 5000, clear a space say 8x20 feet in one corner, and install a 100-kilowatt Diesel unit. Close your boiler doors, cut down your force, cut out your fireman, divide your fuel bill by four. Your engineer will have plenty of time to figure out how much cheaper he is manufacturing kilowatt-hours than the city of Boston.

Take good care of the engine; there is good stuff in it. The shaft is nickel steel and probably bears the welding stamp of some expert in the Krupp works in Germany. But run it 24 hours a day except Sunday; then shut it down for five hours—that is plenty of time for inspection and adjustments. You will finally lose your skepticism, say in six or twelve months' time, with uninterrupted service. And then it is time to start the old steam plant for a few days' run. Take the cylinder heads off for the first time, take the piston out, put some new rings if needed, and spend some more maintenance money—there will be plenty in the bank by this time. Ten years of average operation of a Diesel engine should leave enough of a fair depreciation fund to replace all the working parts.

A new plant in southern Illinois, consisting of a single three-cylinder unit, operated during the first six months on 24-hour uninterrupted service, with the exception of regular Sunday shutdowns. It showed a total maintenance expense of $4.50 and a switchboard cost of 7½ mills per kilowatt-hour.

The nice thing about the Diesel engine is that it must be kept up. What percentage of 300-horsepower steam engines are regularly or even frequently indicated? You have got to check up the valves on the internal-combustion engine and even a small knock is a nuisance.

Look about a bit. Visit some Diesel plants five years old and upward. Investigate their prosperity—you will find some that are getting on well. I have done so, and without exception have heard praise of the Diesel.

FIG. 9. LOOKING DOWN INTO THE PUMP PIT

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Primer of Electricity

By Cecil P. Poole

Connections of Compound Field Windings

There are two ways to connect up the field windings of a compound-wound dynamo. Fig. 86 shows the method which is generally used; it is called the "short-shunt" connection. Fig. 87 shows the other one, which is called "long-

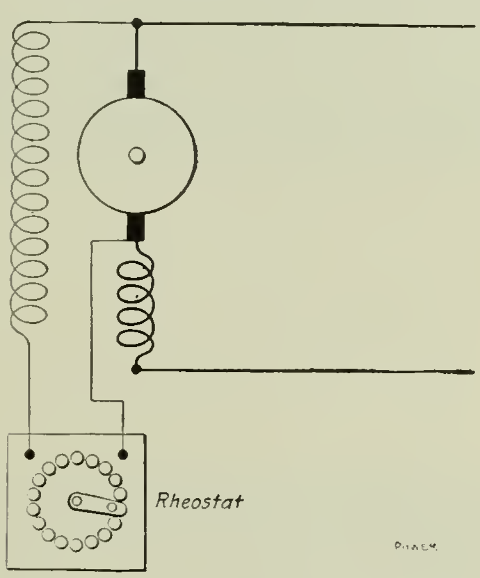


Fig. 86. Short-shunt Connection

shunt" connection. The reason for these names is that the shunt field winding is connected across the armature terminals only in one case and across the entire armature circuit in the other. In other words, the "short-shunt" connection shunts only the armature but the "long-shunt" connection shunts both the armature and the series field winding.

There is practically no preference between the two methods. A dynamo will work just as well with one as with the other if the windings are designed for the method of connection that is used.

If a dynamo built with the "short-shunt" connection (Fig. 86) is changed to the "long-shunt" connection (Fig. 87), it will not compound as it was intended to. If it is flat compounded, the voltage will be slightly less at full load than at no load, instead of being the same. If it is overcompounded, the voltage will not rise as far at full load as it was intended to rise.

The reason for this is that the voltage across the brushes is higher than it is across the brushes and series winding, because of the drop in the series winding. Therefore, with the short-shunt connection the full-load voltage at the terminals of the shunt winding is higher than it is with the long-shunt connection.

For example, suppose the no-load voltage at the brushes is 220, the resistance of the series winding is $\frac{1}{70}$ of an ohm, the full-load current 350 amperes and the full-load voltage at the terminals of the dynamo is 240 volts.

At full load the drop in the series field winding will be

$$\tfrac{1}{70} \times 350 = 5$$

volts, and the voltage at the brushes will be

$$240 + 5 = 245$$

volts. Therefore, if the shunt winding is connected to the brushes, it will get 245 volts, but if connected to the outside terminals of the dynamo, it will get only 240.

For the reason just explained, if a dynamo originally built for long-shunt connection should be changed to the

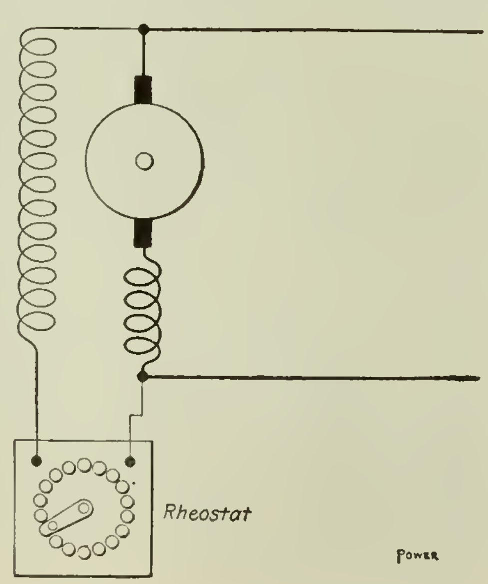


Fig. 87. Long-shunt Connection

short-shunt connection it will give a higher full-load voltage than it was intended to give.

Worse still, if the drop in the series winding is unusually high, changing a compound-wound dynamo from long-shunt to short-shunt may cause the shunt field winding to overheat because of the higher full-load voltage. As a general thing, however, the drop in the series winding is so small that neither the difference in full-load voltage nor that in the heating is of much importance.

Since the full-load voltage at the terminals of the shunt field winding is higher with the short-shunt than with the long-shunt connection, the series field winding does not need to supply as large a proportion of the total field excitation when the short-shunt connection is used.

For example, take the machine described in the last lesson. The no-load voltage was 220; full-load terminal voltage, 232; full-load current, 350 amperes; drop in the armature, 5 volts; drop in the series field winding, 3 volts; no-load ampere-turns per field-magnet pole, 7500;

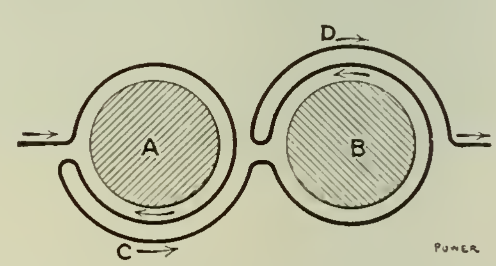


Fig. 88. Effect of Coil Connections

full-load ampere-turns, 8700. These figures supply the following comparison:

	Short-shunt.	Long-shunt.
No-load volts at shunt-winding terminals	220	220
No-load ampere-turns	7500	7500
Full-load volts at shunt-winding terminals	235	232
Full-load ampere-turns in shunt-winding	8011	7909
Total ampere-turns needed	8700	8700
Ampere-turns to be supplied by series winding	689	791

This comparison is not strictly accurate because the resistance of the series field winding would be slightly less in the first case than in the second, but it illustrates the principle well enough.

Adjusting the Compounding

In the comparison just given, the series field winding was expected to give at full load 689 ampere-turns in one case and 791 in the other. Now, these figures were taken from a machine that delivered 350 amperes at full load, so that in order to get exactly 689 ampere-turns from a series coil it would have to be made with

$$\frac{689}{350} = 1.9686$$

turns, which, of course, is absurd. If two turns could be put in the coil, it would have 700 ampere-turns at full load instead of 689. This would be slightly too much, but in practice it would be considered close enough. However, it is impracticable to get a whole number of turns in one coil of a field winding when there are two or more coils in a row, all connected together. You can get 1½ turns, 2½ turns, 3½ turns, and so on, but not 1, 2, 3 or 4 turns per coil, unless an inconvenient method of connection is used, and not always even that way.

The reason that each coil will usually

FIG. 89. MAGNETIC EQUIVALENT OF FIG. 88

have half a turn extra will be made clear by looking at Fig. 88 closely. This shows the arrangement of one-turn coils on two magnet cores, *A* and *B*, and their connections. It is evident that the current in the connection *C* neutralizes the current in that half of the *A* coil next to it. Also, that the current in the connection *D* similarly neutralizes the current in the half of the *B* coil beneath it. The result is exactly the same as though the poles were wound each with a half-turn, as in Fig. 89. This neutralizing of half a turn of the winding by the connecting lead almost always occurs when the coil has a whole number of turns in it. Therefore, the effective number of turns is ½ turn less than the whole number.

Now to return to the problem in hand. With 2½ turns per coil 350 amperes will give

$$2\tfrac{1}{2} \times 350 = 875$$

ampere-turns, which is far too much excitation for either case. The remedy is to reduce the current in the series winding and this is done by means of a "shunt" strip connected across the terminals of the series winding, as shown in Fig. 90, where the shunt strip is represented by the zig-zag line at *S*.

With the machine connected up short-shunt fashion, the series winding is to give 689 ampere-turns per pole. With 2½ turns per pole, therefore, the current in the winding must be reduced to

$$\frac{689}{2\tfrac{1}{2}} = 275.6$$

amperes. To do this, the shunt strip must carry 350 − 275.6 = 74.4 amperes.

Now the relative resistances of two parallel conductors are exactly the same as the relative currents flowing through them, though the larger current flows through the smaller resistance. Since the ratio of currents in this case is

$$\frac{275.6}{74.4} = 3.704$$

the ratio of resistances must be the same, thus:

$$\frac{\textit{Resistance of strip}}{\textit{Resistance of winding}} = 3.704$$

and as the resistance of the winding is 0.0086 of an ohm, the resistance of the strip must be

$$0.0086 \times 3.704 = 0.03185$$

of an ohm.

Let us see how this proves up. With 0.0086 of an ohm resistance in the series winding and 275.6 amperes going through it, the drop at the terminals will be

$$275.6 \times 0.0086 = 2.37$$

volts. And with 0.03185 of an ohm in the shunt strip 2.37 volts at its terminals will cause

$$\frac{2.37}{0.03185} = 74.4$$

amperes to flow through it, which is the required proportion of the total current; 74.4 amperes in the strip and 275.6 in the winding make

$$275.6 + 74.4 = 350$$

amperes, total.

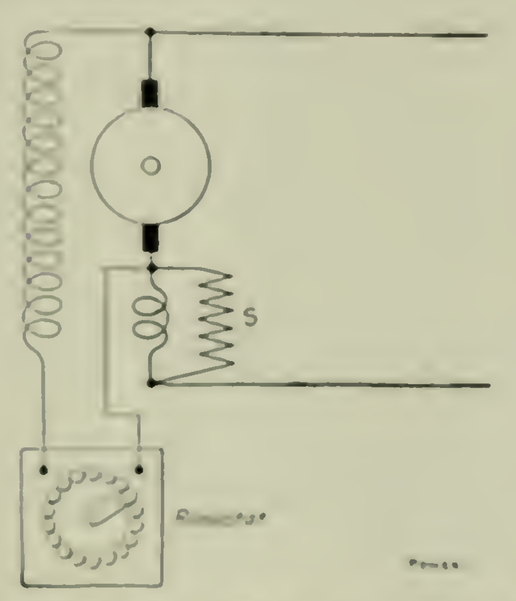


FIG. 90. SHUNT STRIP CONNECTIONS

The case of the long-shunt connection would be figured in the same way, except that the current through the series winding and its shunt strip will be the full load 350 amperes plus the current in the shunt field winding. Thus, to get 791 ampere-turns with 2½ turns in a coil, the current must be

$$\frac{791}{2\tfrac{1}{2}} = 316.4$$

amperes. Suppose the shunt field winding takes 9 amperes; then the total armature current will be 359 amperes, of which 316.4 must go through the series winding, leaving 42.6 to go through the strip.

The ratio of currents is

$$\frac{316.4}{42.6} = 7.43$$

and the ratio of resistances must be the same. The strip, therefore, must have

$$0.0086 \times 7.43 = 0.0639$$

of an ohm resistance. With 42.6 amperes flowing through this resistance the drop would be

$$42.6 \times 0.0639 = 2.72$$

volts, and this voltage at the terminals of the series winding will force through it

$$\frac{2.72}{0.0086} = 316.4$$

amperes, which is the desired current value.

This last case is not presented with strict accuracy because it was assumed that the drop in the series winding would be 3 volts; the calculation shows that it would be only 2.72, and the shunt ampere-turns would therefore be greater, necessitating fewer ampere-turns in the series coil.

In order to make the results check with each other numerically, a good many more decimal places have been used than are necessary in practice. With the actual machine the shunt strip for short-shunt connection would be figured about this way:

Ampere-turns desired, about 700; amperes necessary, about 280, leaving 70 amperes to go through the strip; current ratio about 280 ÷ 70 = 4; strip resistance, about 4 × 0.0086 = 0.034 of an ohm. A strip having about 0.05 of an ohm would be selected and the active length of it would be reduced by attaching one lead to a point within the length of the strip instead of at the end. Fig. 91 illustrates one way in which this is done. One end of the shunt strip is bolted to one terminal block of the series field winding, commonly referred to as the "solid terminal," and the strip is clamped to the other terminal of the series winding at a point which depends on how much resistance is desired.

If more current is needed in the series winding, the clamp is loosened and the end of the strip pushed inward so as to

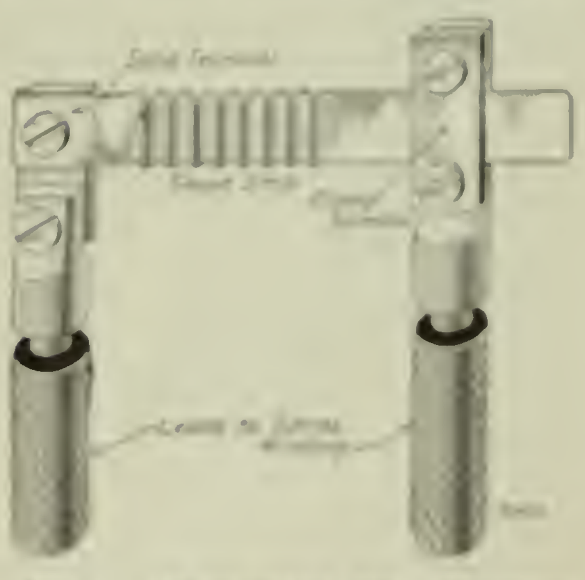


FIG. 91. ARRANGEMENT FOR ADJUSTING SHUNT STRIP

increase the length of strip between the terminal blocks. It is "crimped" to allow this sort of adjustment. Reduced to a few words:

Increasing the active length of the shunt strip increases the effectiveness of the series field winding and, therefore, makes the voltage higher at all loads; this is true for both short-shunt and long-shunt connections.

LETTERS

Static Electricity around Printing Presses

I notice in your January 24 issue an inquiry by A. W. Fish regarding static electricity around printing presses; and I have to offer the following suggestion, which has, in at least two cases, solved the difficulty:

Static electricity is generated usually by friction on the paper and about the press and its parts, and usually during dry, cold weather or cool weather. It is not found to any great extent during damp weather, and this should offer a key to the solution. Most printing establishments are heated either by water or steam, and no arrangement is made for keeping the air moist. My suggestion is to place pans on the steam or hot-water radiators, filled with water, these pans being rather long and deep rather than broad and shallow, so as to hold a considerable amount of water. If the room is a large one, with radiators or coils around the sides, it may be necessary to use artificial means such as small fans for distributing the moisture from the pans around the room. It may require some simple experiment to determine the proper amount of surface to be given to the pans in order to completely eliminate the trouble. The theory of this is that the moisture in the air will allow the dissipation of the frictional or static electricity as fast as it is formed, the moisture acting as a carrier.

I would suggest that it be made the duty of one man to see that these pans are constantly supplied with water, and that the pans are located over coils that are constantly kept in service. If the building is heated by means of hot air from an ordinary furnace, hot-water pans should be installed in the air ducts so that the heated air will pass over them and pick up sufficient moisture to produce the same results.

This expedient has been tried and proved successful in a number of instances. I should be pleased, however, if Mr. Fish would let us know through the columns of POWER what results he obtains if he should try it.

HENRY D. JACKSON.

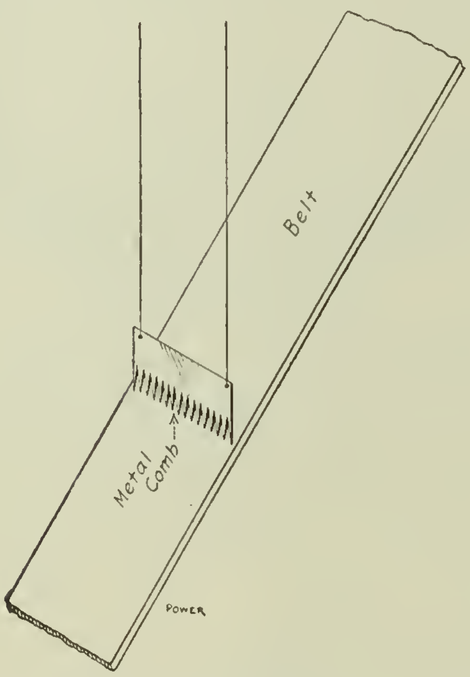
Boston, Mass.

Referring to A. W. Fish's question on how to overcome static electricity around printing presses, I would suggest a method that I found to be of great help to me. Tie one end of a piece of wire to a metal part of the press and attach the other end to any pipe that is grounded, such as a gas or water pipe, preferably the latter. This will enable the electricity to pass off to the ground, just as the ground connection of a lightning arrester takes static discharges off an outdoor line.

EUGENE M. HILBERT.

East Rutherford, N. J.

A simple and efficient method of overcoming static electricity in belts or other moving devices that cannot be easily grounded is to suspend a strip of metal, one edge of which has been cut to form a number of points somewhat like the teeth of a coarse comb, a short distance above and crosswise of the belt; the comb is hung on wires which are grounded to any convenient object, such



TAKING STATIC ELECTRICITY OUT OF A BELT

as a water pipe. I should think this would work also with the paper on a printing press.

EARL F. POTTER.

Urbana, Ill.

A homemade "neutralizer" which I have used with success consisted of an automobile induction coil with one secondary terminal grounded and the other terminal connected to a homemade "comb" mounted with its teeth close to the paper passing from the press; the coil was supplied with primary current from a low-voltage "Mazda" transformer connected to the 110-volt alternating-current lighting mains. I short-circuited the vibrator of the induction coil because with alternating current it was not needed and the coil worked better without it. The grounded secondary terminal of the coil was connected to the water pipe and the frame of the press was similarly grounded. High-tension cable of the kind used on automobiles was used to connect the other secondary terminal to the comb.

The comb consisted of a piece of ½-inch brass pipe to which were soldered brass pin points in a single straight line, spacing them about ½ inch apart along the pipe. The comb was mounted on brackets attached to the press frame in such a way that the comb extended at right angles across the sheet of paper, the pin points projecting to within ¼ inch of its surface. Heavy fiber sleeves and washers were used to insulate the comb from its supports. If the discharge from the points is visible, it is liable to set fire to the paper, and the voltage applied to the primary of the coil should be reduced until no sparks can be seen.

S. H. HARVEY.

Hamilton, O.

Static electricity in printing presses may be partially removed by grounding the frame of the press and stretching copper wires along the side of the fly-sticks upon which the paper travels after leaving the cylinder. If the press has automatic jogger boards they may be lined with metal and grounded. This practice proved more successful in my experience than the electric neutralizer, which is expensive and hard to maintain. The draw sheet may be frequently wiped with a rag wet with glycerin, although some pressmen prefer a "dope" made of glycerin two parts and nitric acid one part, which is rubbed over the draw sheet after the mixture has cooled.

It is claimed that this mixture does not swell the packing as much as pure glycerin. In any method so far in use, the electricity is removed only on the press, the sheets again being charged when fed into the folders, where we have no means of removing the electricity

THOMAS H. WATSON.

Chicago, Ill.

Tinsel cord so placed that each sheet of paper is brushed by it as it passes into the press and another piece of cord where the paper comes out will carry off the static charge. This cord must be connected to the metal frame of the press or to some other good ground. When the static manifestations are particularly troublesome it may be necessary to discharge both sides of the sheet of paper in this manner.

This method of getting rid of the static charge is an old one. It operates upon the same principle as the copper comb so often used in drawing the static charge from moving belts, and if desired a comb may be made for use on the printing press. The easiest way to do this is to take a piece of heavy copper wire sufficiently long to reach across the press and fasten to the frame; strip the insulation from a piece of old lamp cord and cut it into lengths of about four inches or less, as required; solder these to the heavy wire and spread the free ends to form "combs," arranging them so that the sheet of paper passes under them.

A. D. WILLIAMS.

Cleveland, O.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

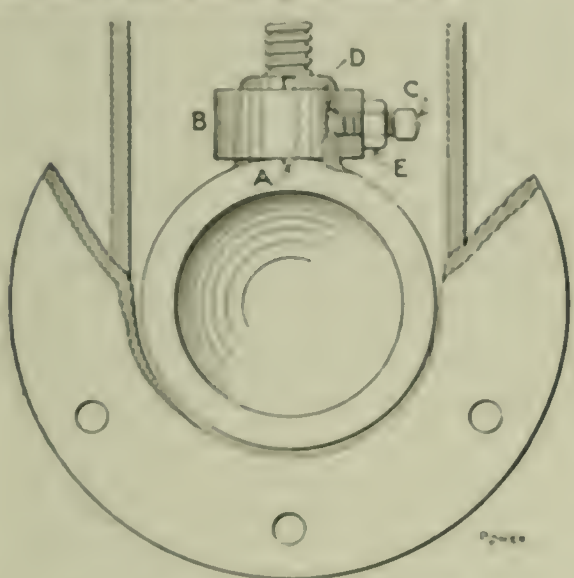
Gate Valves of the Inside Screw Spindle Type

One evening when shutting an 8-inch injection valve connected to a jet, I found that the valve spindle turned without coming to a stop.

This valve was of the straightway inside-screw spindle type and was located so that the spindle stood upright.

I removed the valve cap and found the threads on the spindle and in the plug so worn that the plug would slide over the threads on the spindle.

As the valve had to be in condition to use the next morning in order to regulate the supply of water to the pump, I made a temporary repair about as shown in the accompanying illustration.



SECTION OF GATE VALVE

With a back saw I cut a slot *A*, inserted pieces of sheet iron in the opening and then sawed down through the hub again until the cut was of the desired width.

In a box of odds and ends a collar *B* with a set screw was found. With a half-round file I tapered the hole in the collar to fit the hub on the plug or gate, and also filed a flat place *D*, on the hub, for the set screw to seat against.

After slipping the spindle into the plug, I tightened the set screw *C* against the hub, which closed it around the spindle, and to prevent the set screw from turning after being adjusted the check nut *E* was used.

When assembled, some pulverized glass and oil was put on the spindle and the plug was screwed back and forth a few times to fit the thread. This was then cleaned off and the spindle coated with graphite and cylinder oil. The valve was then put together and used until a new plug came from the manufacturers.

Experience has taught me that a valve of the outside-screw and yoke type is preferable in such places, because the thread on the spindle can be readily cleaned and oiled.

Another instance where I had trouble with a 3-inch inside-screw straightway valve was where the collar on the spindle roughed up and it was impossible to open or shut the valve. This valve was in a direct steam line, so that there was no chance for lubrication.

I took the valve apart, put the spindle in the lathe and smoothed up the collar and coated it with cylinder oil and graphite before putting it together; but fearing a recurrence of the trouble, I replaced it with one of the outside-screw and yoke type at the first opportunity.

J. W. PARKER.

Clinton, Mass.

Low Water Causes Leaks

I had the day shift in a small steam plant at a mine a little over a year ago and the way that boiler was handled by the night engineer was outrageous. In the first place, the boiler was not large enough to run the mine machinery, being of 45 horsepower and furnishing steam for a 35-horsepower single drum, direct-motion hoisting engine and an air compressor of the same horsepower.

One night I went up to the engine room and found no water showing in the glass, and the engineer was at the hoist with the throttle wide open, hoisting from the shaft. He said he could keep up steam better with low water in the gage glass. A few days later we had to shut down to expand all of the tubes in the three upper rows, and one week after I counted 27 leaky rivets.

I left soon after as I would rather run chances with men using dynamite with care than with a bad boiler and a man working in ignorance and with carelessness.

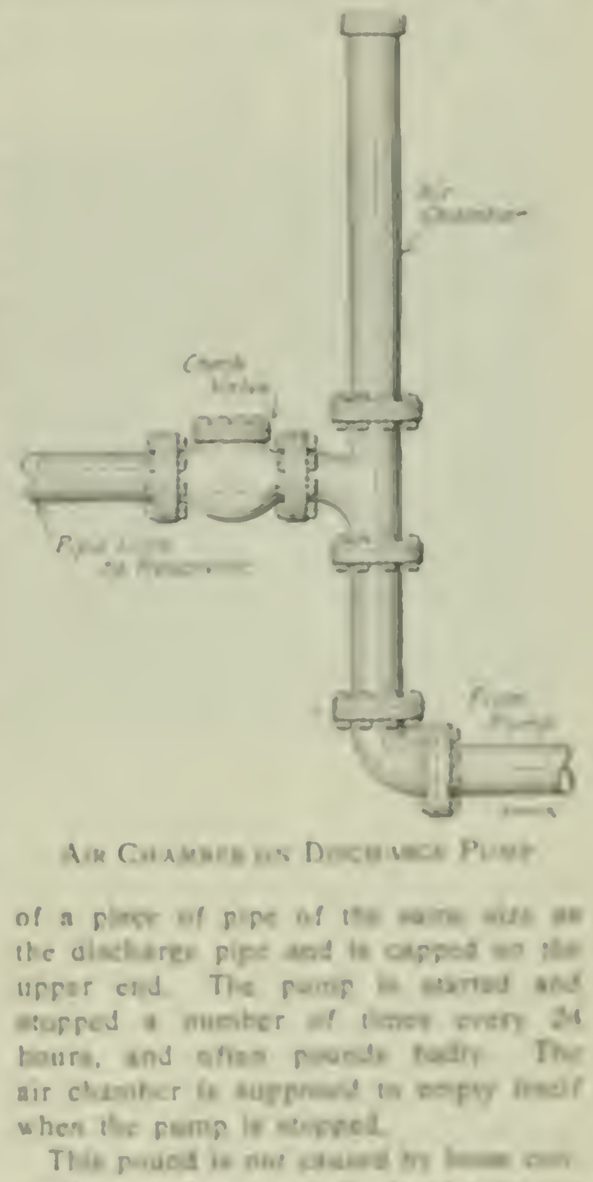
C. F. PINKNEY.

Grass Valley, Cal.

Size of Air Chamber

Can some of the readers of POWER give me any information on the comparative effects of long or short air chambers on the discharge line of a pump?

The accompanying sketch shows the discharge of a deep-well power pump, located in a pit. The discharge-pipe line runs to a reservoir on top of a hill 200 feet high and 1100 feet from the pump. The 8-inch by 8-foot air chamber is made



AIR CHAMBER ON DISCHARGE PUMP

of a piece of pipe of the same size as the discharge pipe and is capped on the upper end. The pump is started and stopped a number of times every 24 hours, and often pounds badly. The air chamber is supposed to empty itself when the pump is stopped.

This pound is not caused by loose connections, and some of the local wiseacres say the air chamber is too short; others say it is too long, and one thinks an air pump is required to force air into the top of the chamber.

Does good practice fix any definite relation between the diameter of the discharge pipe and diameter of the air chamber; between the diameter and length of the chamber, or between the length of chamber and the pressure in the pipe line? Has a long air chamber any advantage over a short one? What is the effect of a small inlet, as usually seen in cast-iron chambers?

F. A. DOW.

Niles, Cal.

Steam Plant Repairs

Some years ago I was called upon to repair an old whale-back Corliss engine that had a very bad pound, apparently in the crank. The valves had been reset a short time before in an attempt to stop it, but to no purpose. A new cylinder had been put on a year before, so I looked for trouble there. Upon lining up, it was found that the cylinder was ¼ inch too thick from the center line to the side where the bed bolted on, and although the crosshead and crank were in

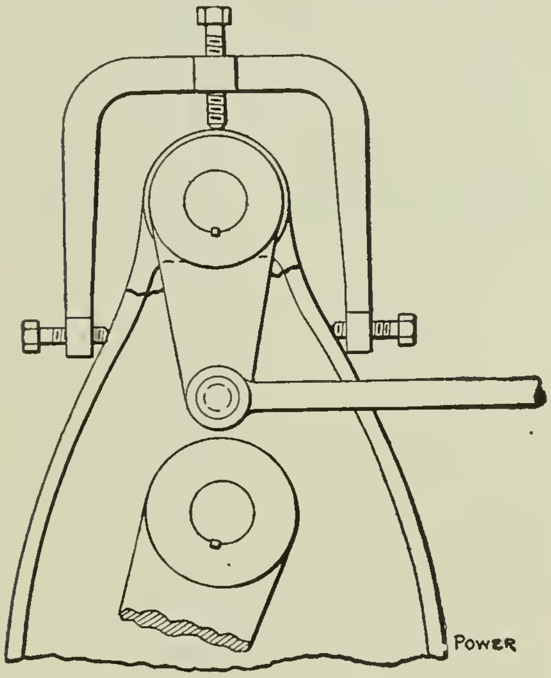


Fig. 1.

line the cylinder was out. This was one of the get out of it cheap cases, so ¼ inch was taken off the front side of the crank-pin box in a lathe and a like amount pinned on the back.

To bring the crosshead in line was more work, but was done by taking the babbitt out of the shoes, and putting the parts all in place, then pouring the new shoes with the crosshead in position. This made the babbitt thicker on the back than on the front, but put the engine perfectly in line.

A boiler feed pump in a central station was repaired as follows. This was a broken rocker-arm stand, and in looking

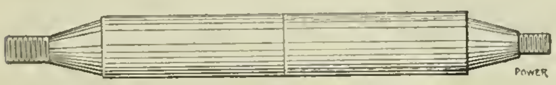


Fig. 2.

over the stock room a clamp was found with which a very good repair job was made and permitted the pump to be kept in service for some time. The two bottom set screws of the clamp, Fig. 1, were set into the casting solid before the top set screw was tightened. These three set screws held the broken part in place until a new part was secured.

In one case a large duplex pump gave a good deal of trouble with leaky packing. The rods of the water end were of steel and badly pitted on the surface. To save the expense of brass rods, I had the steel rods turned down to a forced fit for 2-inch brass tubing, Fig. 2, which was pushed on over white lead that had been smeared on the steel rods. This made a rod as good as if made of solid brass.

W. E. Holt.

Medford, Mass.

Economy in the Boiler Room

A problem which every electrical-power station engineer has before him is to deliver a kilowatt-hour of electrical energy to the busbars with the least possible consumption of fuel. This may sound easy, but many times it is a problem difficult to solve.

Before an engineer is in a position to deliver electrical energy to the switchboard at a low cost, it is absolutely necessary that the installation in its entirety shall be in its best possible condition, and every precaution taken against losses which are always occurring.

In order to know just what is being done, a record should be kept as to the output of each unit and also of the coal and water used. With this in hand the engineer is in a position to seek out the losses that are taking place and determine whether they are due to low boiler efficiency, steam losses or wasteful engines, etc.

There are many electric-light and power plants operating at small profits, and there is a great field for improvement in their economical operation. A mistake made by engineers is that of letting what they think is "well enough" alone, instead of making tests and determining whether a certain performance cannot be bettered.

It is a fact that the greatest loss in all steam-generating plants is found in the boiler room; therefore, that is the place to begin an investigation as to the cause for losses.

One matter which should first engage the attention is the analysis of the fuel and also fuel gases, and a general supervision as to the condition of auxiliary apparatus, radiation, feed-water apparatus, method of firing, superheating of steam, if any, and the load factor.

A fireman, to get the best results, must know his fuel. The best results cannot be obtained, however, if frequent changing of the quality of the coal is made, and the engineer should insist that the coal from one mine should be delivered and not accept a cargo of coal from several mines. This applies, of course, where coal is bought in carload lots. It is not a bad idea to ascertain the quality of the coal by repeated tests of these carload lots. When the character of the coal has been determined in a satisfactory manner, the engineer's next duty is to make a complete analysis of the gas from the boiler, keeping a record of the temperature, draft and chemical constituents.

With this information at hand, the chimney losses may be reduced to a minimum; and a greater loss occurs right here than might be imagined. If the maximum efficiency is to be obtained, the quantity of excess air must be as small as possible, and this can only be determined by frequent tests, and generally depends upon the quality of the fuel and on the available draft. Enough oxygen should be combined with the carbon to produce CO_2, which in everyday practice with reasonable attention will be about 12 per cent. with a stack temperature of 600 degrees Fahrenheit or less. In order that this may be known, a recording apparatus should be installed for ascertaining the percentage of CO_2. Without such an apparatus it is impossible to detect air leakage, while with the device the result will be such as to more than repay for the cost. Even with a supposedly tight boiler setting, there will be air leakages which are not detected, and which may become excessive unless constantly attended to.

Any steam boiler should be kept free from scale. The scale question has been discussed so often and so thoroughly that there is little call for any extended remarks upon the subject.

After the engineer has been over his boiler plant and checked all the leakages in the brickwork, has a record of the CO_2 and has secured a good grade of coal at the lowest possible cost, it is then up to the fireman to produce better results and it is a case where the engineer must give his personal attention to the matter and see that the fireman follows out his instructions.

A desirable saving can be made if the load-factor conditions are studied. If it is such as to require banked fires, the load factor should be improved, because the effect is more pronounced in the boiler room than in the engine room, as a banked fire wastes coal. A saving can be made by reducing the number of boilers under steam and increasing the draft by some method to help out at peak loads.

All radiation should be reduced by covering all heat-radiating surfaces with some good nonconductor. In larger plants this will be found to be already accomplished, but in small power stations there is room for considerable improvement.

L. Holder.

Ouimet, Can.

Piping a Lubricator to a Reservoir

I would be pleased to see a discussion and illustration of the best method of piping up a lubricator to an oil reservoir published in Power.

L. J. Pierce.

Ottens, N. J.

Deplorable Steam Plant Conditions

About one year ago I took charge of the mechanical department of a mill engaged in the manufacture of tin plate. The condition of the machinery of this plant had become such that the continuous operation of it was utterly impossible. Shutdowns in various departments were of hourly occurrence, due, not to the incapacity of the machinery, but to the man in charge.

The accompanying illustration shows two views of a lead gasket that had been placed in an 8-inch steam line directly over the throttle of a 30x60-inch engine. The steam line at this point made a quarter bend, and had been made too short on the end, not meeting the throttle valve by several inches.

To overcome this, the entire line had been sprung down, and the bend stretched out to meet, causing the flanges on the pipe and valve when touching on one side to stand open 5/16 inch on the other. This lead gasket had been made to fill this irregular opening. The inside has not been cut out, but a narrow slit cut through with the idea, perhaps, that the steam would cause it to bend away and leave a free opening, which it did only in part, and the cutting of the steam, as it was wire drawn through it, is shown. Full power could not be obtained from this engine, and the cause was not discovered until leakage required the removal of this gasket. A steel filler faced on each side at a proper angle made this defect right.

On this same engine the valve gear was in very bad shape, and after the valves had been set and the valve rods adjusted to length, the eccentrics were found to be keyed to the shaft (having been done since the engine was erected), and the steam eccentric was so late that the valves did not open until the piston had traveled 4½ inches. The exhaust valves were late in opening, the piston having traveled 2½ inches before this event occurred.

Alongside of this engine is another of a different make, but of the same dimensions, which worked very badly as regards steam consumption and output. The application of the indicator demonstrated the cause, and the eccentric was found, as in the other case, keyed to the shaft and was 5½ inches of the stroke late. The valve stems and bonnets showed excessive wear, although the superintendent stated that they had been bushed only a short time previous. When taken down for repairs they were found to have been bushed with steel pipe cut to length and forced in.

All steam lines leaked in every joint from the boiler drums to the engines, and in many places there was as much as 2 inches of gasket blown out. One of the flanges were found to be cracked entirely through. Upon inquiry, I ascertained that it had been the custom to sling a chain block from the steam lines to remove the engine-cylinder heads, and on at least two occasions to remove the piston and rod.

It was impossible to make the boilers develop enough steam to run the engines, consequently the management was getting quotations on a new boiler. The boilers were fired with natural gas, using one of the very best designs of burner. They had been formerly fired with coal, but it had been abandoned, as under the conditions it was impossible to keep up steam.

Gas was burned with a pressure of 16 ounces, and at times was raised as high as 45 ounces. The battery consisted of two water-tube boilers rated at 300 horsepower and one boiler rated at 250 horsepower.

All of the boiler settings were cracked, frames and castings were loose, the

Two Views of Lead Gasket

dampers were entirely removed and lying on the bottom of the connections to the stacks, bridgewalls had fallen down and were lying in the combustion chambers, checker work for breaking up the gas flames had fallen and were useless, and the feed-water discharge pipes were disconnected and lying in the steam drums.

In the larger boilers a covering of baffle brick 2 feet wide had been laid over the first row of tubes in front of the bridgewall. This was filled up by a deposit of dust and ashes solid to the top row of tubes; the baffle plates and brick linings were in a ruinous state.

In the small boiler the same condition existed in regard to bridgewall and checker work. The baffle brick had been removed over the first row of tubes for 16 inches in front of where the bridgewall should have been. The top course was more than half gone. All blowoff valves were leaking a stream as thick as one's finger. Of the three safety valves, one was in working condition, but the others were corroded fast. The steam gages registered from 10 pounds heavy to 20 pounds light. With the exhaust from 1000-horsepower engines blowing into the air, water was fed to the boilers at from 100 to 120 degrees Fahrenheit.

Included in the power equipment was a 50-horsepower gas engine. This engine was running about three-fourths of the time, the balance being taken up in starting and tinkering.

The exhaust-valve stem had worn the adjusting screw down and almost half way through the lever, causing compression of the spent gases during almost one-fourth of the exhaust stroke. The body of the gas cam was cast integral with the bevel gear for operating the governor, the hardened-steel cam being recessed into this. Probably on account of a stripped gear, at some time this cam had been replaced by a new one. The cam was keyed to the shaft, and the new cam, having its keyway planed, was put on as received and was so located that the gas valve was open on the compression stroke, and all the gas that the engine could get was by having the adjustment so that the valve continually leaked. A new exhaust valve had been made, which was only 1/8 inch larger than the seat, but this valve was worn down to within 1/16 inch of being through the seat. Making a new valve, boring out the seat and driving in a new seat ring remedied this trouble.

These are the most prominent examples among the hundreds which could be told of the conditions existing in this plant at that time.

F. E. Cannon.

Washington, Penn.

Removing Kink from Pipe

In case a length of pipe becomes kinked, heat the pipe to a bright red where the kink shows and then roll the pipe on a perfectly level floor or plate.

E. H. Marble.

Bellaire, O.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Connecting High Pressure Drips to Heating Mains

In the issue of December 27 appears a letter from W. T. Meinzer, describing how "one of our boys" hit on a plan that worked successfully and eliminated the trouble of digging up the lawn and driveways, also the cost of 500 feet of pipe that would have been necessary to return to the boiler room the condensed water from about 15 high-pressure traps in the adjoining buildings.

I think that if he had made the high-pressure traps perform their function, there would not have been very much heating done in the sewers, no more than there would be now to help the low-pressure heating system.

Mr. Meinzer gave us a sketch showing how the pipe connections were made to accomplish the saving of the vapor from the drips. He says "This line was connected to a water seal about 4 feet deep, from the top of the seal in the inlet side. A 2-inch vapor or equalizing pipe was run to the low-pressure heating main to prevent any steam or pressure blowing the seal out into the return to cause water hammer."

I wonder why he did not think of putting in a back-pressure valve. This would undoubtedly have been more effective in preventing back pressure from blowing the seal back into the drip return. Also, it would have been more simple.

As it is now, according to his sketch, both sides of the seal are of the same hight; the slightest amount of back pressure will force the seal back into the return, it being lower than the low-pressure heating main, to which it is connected by the "vapor or equalizing pipe."

This same "vapor or equalizing pipe" will also cause a lot of heat to be wasted through condensation, or, if there be sufficient pressure in the low-pressure main, live steam will blow right through into the returns, not doing any work at all.

Mr. Meinzer fails to state for what purpose they wanted to return the waste from the drips to the boiler room. By returning the water, two purposes might be served. First, the price of the water so returned is saved; second, if the returned water is used for feeding the boiler, and the feed water be heated with live steam, a saving will be made due to the difference between the temperature of the returned water and that taken from the city main, river or well, as the case may be. In any event, I do not think that the saving in this case would justify the expenses incurred by laying a 500-foot return line and tearing up the lawn and driveways.

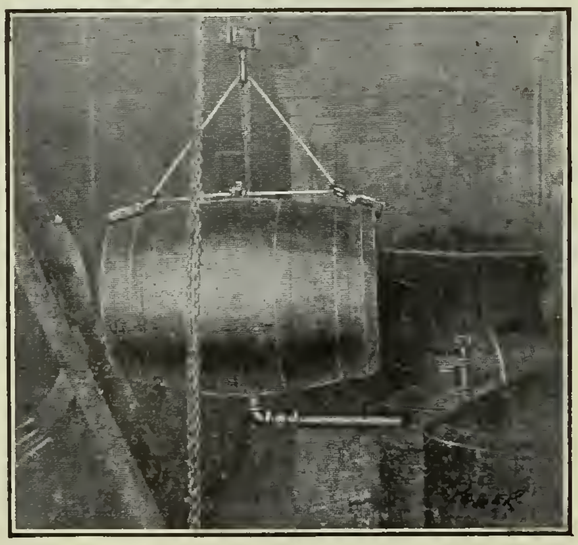
I think that if the high-pressure traps had been put in good working order, there would not have been any loss to speak of on account of letting the drips run into the sewer.

New York City. VICTOR BORM.

Barrel Emptying Device

In a recent issue of POWER there was described a device for emptying liquids from a barrel.

The idea is not a new one, similar schemes have been described before. About four years ago I tried a device like the one described on a barrel of heavy crank-case oil with unfavorable results. The discharge pipe was 1 inch and the air pipe was ¼ inch. The barrel was placed in an alleyway beside the oil tank, about 30 feet from the front of one of the boilers.



ARRANGEMENT FOR DRAINING BARREL

The air was turned on and I stepped to the tank to see if the oil was flowing. Suddenly, I heard a loud crack and a sort of slopping sound. Turning around, I quickly discovered what had happened. The air had fed into the barrel faster than the heavy, thick oil could flow out and the result was that one of the barrel heads broke. The barrel head hit the front of the boiler. Between the point where it hit and the barrel was distributed the greater part of the oil, slopped all over everything.

After that, I devised the scheme shown in the figure herewith. I had two grab hooks made with a clevis in each one. Then I ran a piece of ½-inch steel cable through them and fastened the ends. I threaded a piece of tapered pipe to fit the bunghole of the barrel. To this I fitted a 1½-inch elbow and on that a valve.

After this piping arrangement was screwed into the barrel, the barrel would be hoisted up with the chain blocks, and a piece of pipe of the right length screwed into the valve. After being hung up, the barrel required no more attention until drained out. While I do not in any way condemn the air-lift device, I think that it should be used with good judgment. The air must be admitted to the barrel very slowly, especially at the start, or the gain in pressure will burst the barrel as in the instance I described.

Glenfield, Penn. L. M. JOHNSON.

Trouble with a Heating Plant

That was interesting reading, the account of his troubles by T. H. De Saussure in the issue of January 10. I know that it must be wearing on the brain and a menace to health to have a problem like his bothering a person.

There is a question I would like to ask him, how did this water that at times filled the boilers up to the top of the water glasses get into the system? If a contractor did a job of piping for me like the one shown, I would have the law on him.

Judged as a heating system that will not work successfully, that shown in his Fig. 1 is a success. Why in the name of "Mike" did he want to have the water pocket in the return from the coils or radiators marked *X*? If he would like to know what change is necessary at the point he writes about to make the system work O. K., I can tell him. All that is necessary is to remove the pipe from the main to the return at the point *A* and take out the pocket in the return, leaving it straight.

The secret of all of his trouble is that the steam pipe has access to the return pipe above the water level in the receiver; the pocket or water seal, as he calls it, only aggravates the trouble.

GERALD GRIFFIN.

Hartford, Conn.

Belt Lacing

I read in the January 10 issue William L. Kiel's article, "Two Methods of Lacing Belts," and, while I admit that the lacings shown have a neat, finished appearance, and are fairly satisfactory when the work the belt has to do is only moderate in proportion to the size of the belt, they are anything but reliable when there is a heavy load on the belt, or where belts have to be run extremely tight, and I have found from my own experience that a much more reliable method is the hinge type of lacing.

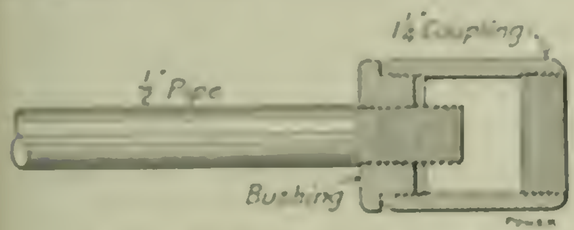
R. R. FORD.

Nemours, W. Va.

Soot Blowers

I have recently read in POWER the articles by W. O. Rogers on soot blowers and suckers and I believe that a little discussion on this subject may be of interest. Mr. Rogers makes a statement that "the simplest form of soot blower is a piece of ½- or 1-inch pipe attached to a hose, and that while such a device will partly clean a tube, an excessive amount of air is drawn into the tube and that soot is blown about the room."

While the objection to having soot blown about the room is well founded, according to my understanding of the principles of soot blowers the air is not



THE HOMEMADE SOOT BLOWER

objectionable as the end in view is to secure the greatest velocity of steam and air through the tube. Therefore, there can be no excessive air; in fact, some of the blowers are so designed as to draw all the air possible into the tube and thus increase the efficiency of the blower.

A fallacy (so it seems to me) expressed in some of the designs is the apparent effort to make the steam travel along the tube surface with a greater velocity than it does in the center. This is impossible; in fact, the opposite is really the case owing to friction.

Referring to the description of the blower shown in Fig. 25, page 2145 of the issue for December 6, in the last paragraph, it is stated: "The air and steam current is directed by the inverted cone at the front end of the cleaner against the inner wall of the tube for its entire length." I believe that this cleaner would be improved if the cone were removed as the steam and air would then have a free passage to the tube surface, thus insuring the greatest possible velocity. A blower should have a steam nozzle so designed as to convert pressure into velocity and be efficient in drawing air into the tube.

I recall an experience I had with a flue blower when I was running a small plant (my first). The manager asked the engineer of a larger plant to rig up a blower for me. He made one as shown in the sketch. I tried it and not being satisfied with the results I removed the bushing and coupling and got better results; the tubes were 2 inches in diameter.

The statement by Mr. Rogers that the tubes are only partially cleaned is very true, for the blower will only remove the loose matter in the tubes and should be used as an aid to the tube scraper, not as the only means of cleaning them.

I do not agree with his statement in the instalment for December 20 that blowers fixed in the wall are as efficient as the hand blowers, because with the hand blower the steam jet is in the most favorable position to produce a strong blast through the tube, while with the fixed blower the effect is comparatively weak, owing to the distance from the tubes or to the large area of steam opening necessary to take in a number of tubes.

EARL JUBBE.

Cedar Rapids, Ia.

Climbing the Ladder

There have been many salary-raising and encouraging articles in POWER. None has been much superior to the leading editorial in the January 10 issue.

This feeble effort of mine is intended to help some brother engineer or fireman who is discouraged so that he will take a fresh hold of things and keep trying to "climb the ladder," the rungs of which might represent positions in the following order: Laborer, coal passer, fireman, head fireman, oiler, fourth-, third-, second-, first-assistant engineer, chief engineer, consulting engineer, superintendent, general manager and, lastly, president, who is on the top rung.

Not a few men have started from the first and attained the last position. How? The answer is given in the following, which was written by one who knew:

"Heights by great men reached and kept
Were not attained by sudden flight,
But they, while their companions slept,
Were toiling upward in the night.
Standing on what too long we bore
With shoulders bent and downcast eyes,
We may discern—unseen before—
A path to higher destinies."

What chief engineer who has come up from the ranks cannot look down along the rungs and feel that this experience or that experience has made him a better chief engineer and a better man? Who cannot remember the times he has helped other fellows solve some knotty problem in engineering or lifted other men to better positions by saying to employers, "Mr. A is just the man you want"?

WILLIAM M. GLASS.

Pasadena, Cal.

Selection and Use of Packing

I was very much interested in the communication on the "Selection and Use of Packing" in the January 3 issue of POWER by Charles H. Taylor.

I am what is considered an "old timer." When I was an apprentice, we plaited hemp for packing and with a liberal use of tallow and beeswax it answered very well. However, in these days of high-pressure and superheated steam this kind of packing would not last long. At present I am using a metallic packing and find it to be quite satisfactory. Of course, there will never be a packing to suit all engineers, for there are as many different kinds of engineers as there are packings.

J. A. EVERLY.

Thomasville, Ga.

Driving Keys

Mr. Stewart, in the January 3 number, in trying to criticize Mr. Taylor on the subject of driving keys has made the matter worse than Mr. Taylor left it.

I believe that Mr. Stewart's method of driving a key is the correct one, but his idea of the effect that the "driving" has on the connecting rod is wrong unless he refers to a type of rod with which I am not familiar.

The accompanying figure shows one

CRANK-PIN BOX WITH KEY ADJUSTMENT

type of rod in which adjustment is made with a key. It is plain that driving the key will draw the strap back on the rod. This may be continued until the box next to the key is worn in two or the key fills the space in the strap or rod.

Mr. Stewart's statement that a liner placed on the key side of the rod, that is, between the brass and the end of the rod, would have the same effect as driving the key, is incorrect for this is the best and simplest means of lengthening the rod.

I think that Mr. Stewart must have in mind a "wedge" instead of a key, but even then he is wrong in his assertion that an engine with a crank-pin key or adjusting wedge on the opposite side of the pin from the connecting rod, and the crosshead key next to the rod, has a tendency to keep the clearance equal, for a wedge has an effect opposite to that of a key.

T. K. HASSART.

Mease, Ky.

What Causes the Engine to Run?

Since Mr. Teer's puzzle appeared in the November 1 issue, I have been waiting for someone to solve it successfully.

Both Mr. Dunlap and Mr. Libby, in the January 3 issue, seem to have overlooked the fact that the bleeder is connected directly to the exhaust pipe. It does not look reasonable to me that the steam would turn three 90-degree angles and create a greater pressure in the end of the cylinder which is closed than it does in the exhaust unless the velocity which it attains in expanding into the exhaust pipe causes a partial vacuum, thereby creating an unbalanced condition of the piston having a partial vacuum on one side and a slight pressure from the cylinder drain on the other. In this case the vacuum created in the exhaust would have to be greater than the drain pipe which is connected to the end of the cylinder, which is open to the exhaust, would supply.

S. Scarth.

Newark, N. Y.

The Double Entasis

Referring to the article entitled "A Handsome Chimney," which was illustrated in the January 3 number, it is, perhaps, to be regretted that most industrial plants evidence so little of the "esthetic" or the beautiful in their construction, and, therefore, it may be that no word other than praise should be spoken of this present effort in the right direction. Still, it may be questioned whether or not a chimney top is just the place for a display of elaborate ornamentation. Do not too many frills around the mouth of a smoke vent jar upon one's sense of the eternal fitness of things, much as do the Ionic and Corinthian columns of some old-time engines and machines?

The top of a chimney seems to require some relief from straight-line severity, but the more simply its lines can be given a graceful termination the more correct will be the design. The base of such a structure being removed from the vicinity of the smoke offers a more fitting place for ornamentation than the top. Formerly, the smokestacks of most river steamboats were surmounted by a crown of pointed iron plates shaped like slender leaves of a plant; but latterly these "ornaments" are being relegated to the limbo of things that used to be, and the so called astragals which afford additional surface for the wind to blow against at the top of many steel smokestacks might well be made to follow them.

Whatever is right, looks right; therefore, anything in the nature of a sail on a chimney top must look wrong.

Wonderful people, those Greeks! And it does seem strange that after more than two thousand years we are not able to produce designs so entirely to our credit as their designs were to their credit. In the use of the double entasis the Greeks were right, as usual. In the case of a column supporting a superimposed load it is right and, of course, it looks right. But is not the building of a chimney a problem of another kind? A chimney, exposed to the wind, must act as a cantilever beam uniformly loaded, and such a beam, weaker at the point of support than at other points, is at once recognized as being faulty in design. In the trunk of a tree nature shows the proper form of structure to resist the wind; it spreads out at the base and is firmly secured to the earth upon which it stands.

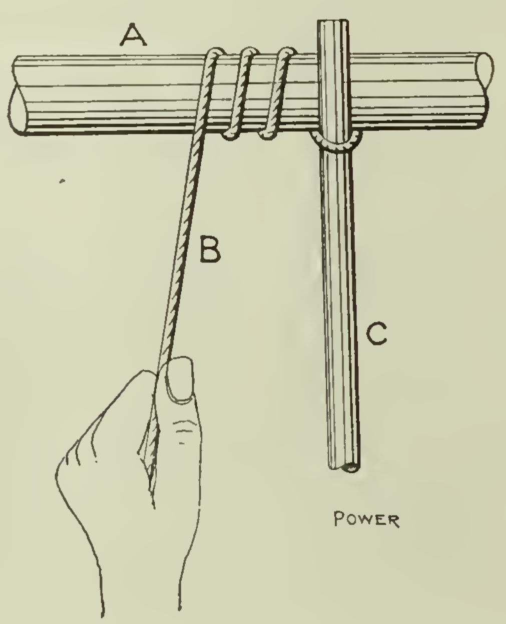
R. E. Nelitnac.

Pittsburg, Penn.

Piston Rod Clamp

In Power for January 3 I saw a suggestion for keeping a pump rod from turning while tightening or loosening the jamb nuts. I think that the set screw would have a tendency to mar the rod if not bend it.

The accompanying figure illustrates a method which I learned in California 30 years ago. The pipe or rod to be held or turned is represented at *A*; *B* is a rope and *C* is a lever. The rope has a loop at one end. The end with the loop is lapped around the pipe two or three times, or more, if need be, in the direction that the strain of the lever will be made and the end of the lever is passed through the loop as shown. The rope will grip the pipe without injuring it in any way. The fewer turns of rope there are the easier it will be to slack off to get a fresh bite with the lever. A piece of iron pipe or a hammer handle does for a lever. For polished brass or nickel-plated pipe, use webbing such as suspenders are made of or strong cloth instead of rope and a piece of cloth wrapped around the pipe where the lever touches.



Arrangement for Gripping Pipe

Daniel Ashworth.

Wappingers Falls, N. Y.

Causes of Boiler Explosions

A writer in a recent number of Power does not believe that a sudden reduction of pressure in a boiler will cause a lifting of the water with dire possibilities. He endeavors to substantiate his opinion by saying that boilers do not explode from a reduction of pressure due to the opening of the safety valve. I take exception to this statement. Anyone who will stop to think, will see that the opening of a safety valve does not reduce the pressure, except the amount of its pop, but prevents it from rising any higher. The safety valve allows the steam to escape only as fast as it is made, while a quickly opened stop valve lets it out faster than it is being made with a drop in pressure in the boiler if there is enough difference between the pressures of the boiler and the main. The greater the variation, the greater the danger.

I believe that the water-lifting action in a boiler under the above conditions has not reached the limit of study. I think it very possible that sheets and joints have been ruptured immediately upon the opening of a large valve, but I consider that more damage has been caused by a surging similar to that so often found in water pipes.

To understand what I mean, consider a possible case. Assume that we cut in a boiler whose pressure is 20 pounds above that of the main. The drop in pressure causes a lifting of the water. This in itself is serious. If the boiler holds, the pressure is soon equalized and the water is thrown down with greater force as it has the assistance of gravity. In this way there are produced a number of hard blows which may rupture sheets, joints or pipe connections or loosen the setting. A broken pipe connection of any considerable size would without doubt be the proverbial last straw, as it would produce a drop in pressure that could not be equalized with safety. A boiler might be "punished" by a water hammer of this nature many times before it let go or it might go the first time, depending on the severity of the "punishment" and the condition of the boiler.

H. K. Wilson.

New Bedford, Mass.

Trouble With Steam Radiator

The reason why E. L. Morris is having trouble with the heating system described in the January 17 number is probably because the feed pipe under the floor should be falling *from* the riser tee to the second radiator. At this point a tee should be used instead of an elbow, and a bleeder or drip connected into it. The drip could be run directly to the cellar and there connected into the boiler return, or it could be run back and connected into the return riser below the ceiling. I assume that the system is for low-pressure steam.

Another mistake in the work is that only one valve is used at each radiator. In all two-pipe systems two valves should be used at each radiator. An air cock should also be placed on each radiator.

JAMES E. NOBLE.

Toronto, Ont.

If E. L. Morris will put an air-vent valve on the outlet end of the cold radiator, the steam will circulate. The cause of the trouble is that the steam drives the air to the furthest end where it is held by the supply and return pressure.

As a rule, all outlet sections of radiators are tapped for a ⅛-inch air vent.

W. H. PLOWMAN.

Philadelphia, Penn.

I noticed Mr. Morris' letter in the January 17 issue concerning a cold radiator. In his diagram, which is reproduced herewith, it will be noticed that the tee at the top of the riser is put on "bull headed," as steamfitters express it. This tee should be put on in the vertical position, that is, as shown in Fig. 2 herewith. I made such an alteration in a system of which I had charge and overcame thereby a difficulty similar to that described by Mr. Morris.

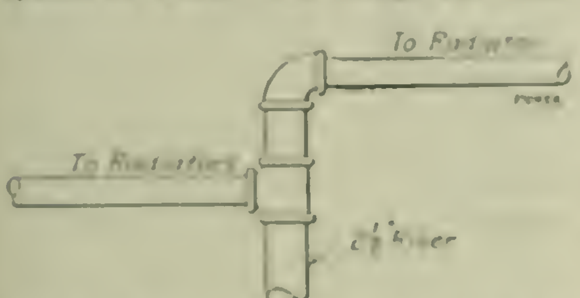


FIG. 2. REARRANGEMENT OF CONNECTIONS AT TOP OF RISER

FRANK MCCOTTIN.

Newport, Ky.

The trouble with E. L. Morris' heating system, as illustrated in the January 17 issue, is that the horizontal leads to the three radiators on the third floor are not large enough.

The central radiator evidently consumes the greater portion of the steam conveyed through the short 1¼-inch horizontal length leading thereto, while the remaining quantity, continuing along through the long lead to the left-hand radiator, condenses on the way and is practically all reduced to water by the time the valve is reached, the returning flow acting to cut down further the already insufficient capacity of the 1¼-inch horizontal pipe.

To make a serviceable job of this part of the system, both the supply and return horizontals should be run 2 inches from the 2" risers to the middle radiator, and thence 1½ inch to the left-hand radiator, with 1¼-inch vertical connecting branches to each radiator. Likewise, the leads from the risers to the right-hand radiator should be changed to 1½-inch size, with 1¼-inch branches to connect with the radiator.

A. J. DIXON.

Chicago, Ill.

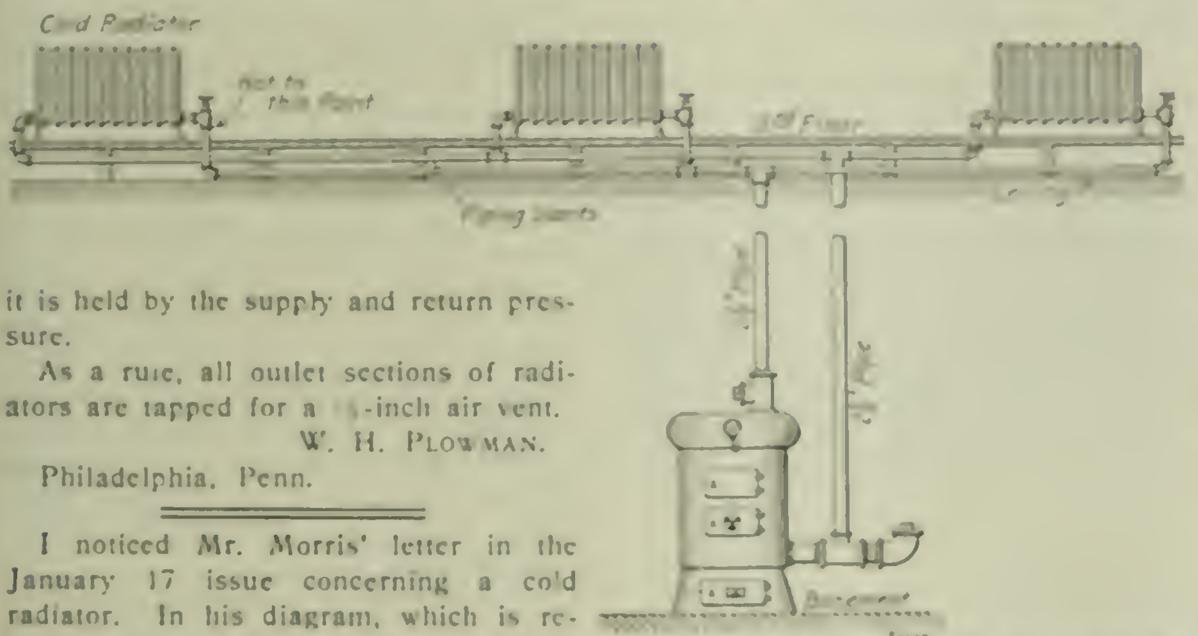


FIG. 1. REPRODUCTION OF MR. MORRIS' DIAGRAM

Cornell Fuel Economizer

I noticed the editorial in the January 17 issue regarding "Impossible Boiler Performances" supposed to have been brought about by means of a Cornell H_2O fuel economizer; and, as I have had some experience with this apparatus, I will recite some of it for the benefit of any engineer who may be curious about this device.

I once took charge of a large building having two 125-horsepower return-tubular boilers, both of which had been fitted with the Cornell apparatus just a little while before I took charge.

The apparatus was supposed to consume the smoke, giving smokeless combustion. All that it did in this line was to whiten the smoke a little by mixing steam with it. I made tests with the apparatus working and also when it was shut off and could see but little difference in the smoke from each fire.

We were instructed to stop or check the flow of steam through the jets. When we did this, condensation would gather and as soon as we opened up the jets again the jets or tuyeres would burst from the sudden rush of water. I tried draining the pipes but it did not help much. Then I removed them altogether from one boiler. We used each boiler alternate weeks. The one boiler used 200 pounds less coal in 24 hours than the one to which the "economizer" still remained, and we had no more smoke than when the apparatus was working, so I threw out the other set also. We then carried the full load, the same as before, on 200 pounds less coal per day. Hence we decided that the apparatus required 200 pounds of coal per day to supply the steam to operate it, besides the cost of renewing the tuyeres or jets, which was considerable.

ALLAN A. BLANCHARD.

Frostproof, Fla.

Fixing Receiver Pressure

I see a great many letters in POWER about receiver pressure. I have found it to be good practice to increase the receiver pressure until it causes the governor to start to drop. Then, to reduce the pressure so that the governor revolves in its highest position.

This rule is convenient for use by those who have not the use of a steam-engine indicator.

J. J. JACKSON.

Waynesburg, Penn.

Water Hammer and Boiler Explosions

I read with interest Mr. Clark's article on "Water Hammer and Boiler Explosions" in the January 10 issue.

I once had serious trouble with water hammer at a mill where there was an installation of four 60-inch by 16-foot return-tubular boilers.

The boilers were connected by a 10-inch header, out of the center of which a 4½-inch pipe led to the engine. This pipe connected into the bottom of the header, dropped about 2 feet and then ran 30 feet to the engine. Of course, this pipe drained the header and came near being the cause of wrecking the plant.

On going to the plant one morning, I found that the night watchman had closed the valve on the 4-inch header that connected into the pipe above the throttle. The pipe was cold and evidently full of water. The steam pressure was well up, ready for starting, but the safety valves were not blowing.

The first move of the header valve caused such a commotion that the fireman and one or two other persons in the plant ran out. Three or four times the violence of the surges and blows threw the safety valves off of their seats. Every time one of those heavy hammer blows came I could see the elbow on the pipe above the throttle move back and forth and quiver.

If a water hammer can cause a safety valve to rise and reset as these did, I believe it might easily cause a boiler explosion, to say nothing of pipe and fitting breakage.

JAMES W. LITTLE.

Portland, Wash.

Handling Men

We have been invited to give our views on handling men. There is nothing to it except giving them a square deal, a smile instead of a frown, when possible, maintaining discipline and firing shirks and grouches. I think that this covers the field or subject, though I could fill pages in elaboration of the above and still reserve the privilege of saying more.

J. O. BENEFIEL.

Anderson, Ind.

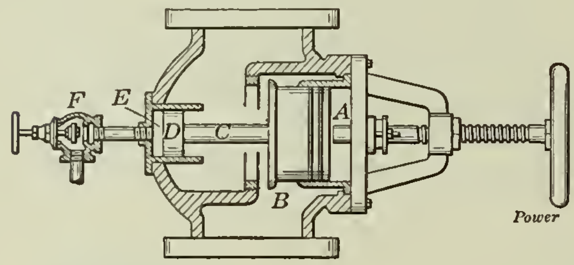
Safety Stops for Steam Engines

Under the above heading some time ago, Mr. Wakeman made some statements that according to his drawings were incorrect. For instance, he had the following to say concerning one of the numerous designs of valve described:

"Pressure acting on *B*, Fig. 3 (which is reproduced herewith), holds the valve open because the full area on the outer face is exposed to pressure, while the rod occupies a portion of the inner face, thus reducing the effective area. Etc."

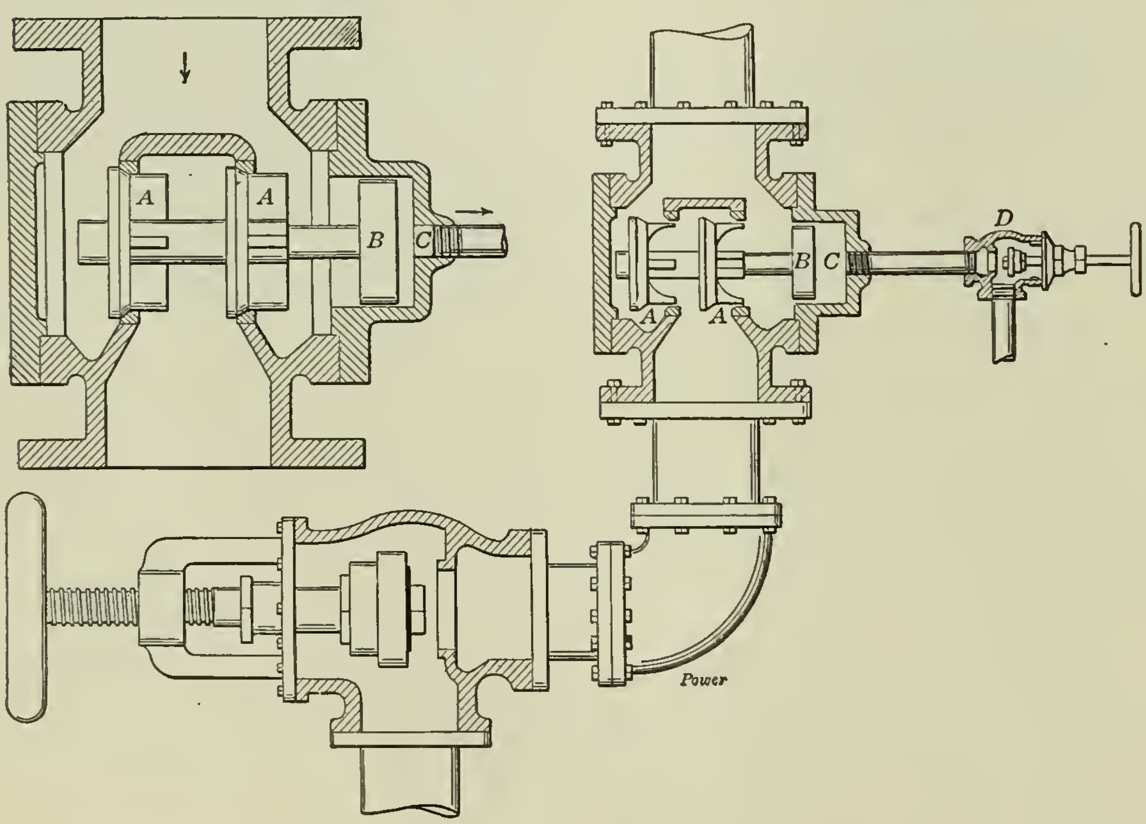
This would be the case if the stem of mechanical device has not been provided, the valve cannot be opened.

In the case of another device, shown in Fig. 7 (also reproduced herewith), he reverses the ideas worked out in Fig. 3. He says that piston *D* is in equilibrium, but the figure indicates that there is full pressure in *E* and that the stem terminates in the disk *B*, on the right side of which



REPRODUCTION OF FIG. 7.

there is no pressure at all. This arrangement gives a greater effective area at the left of *D*, than at the right. Suppose that the disk *B* is closed, pressure acts on it and *D* alike. But, as the area of *B* is greater than that of *D*, it (*B*) will follow the stem *A* to the right should the handwheel be turned from right to left. When the trip releases the pressure in *E*, the



REPRODUCTION OF FIG. 3 OF MR. WAKEMAN'S ARTICLE

the valve extended through the bonnet to the left, but the drawing shows it inclosed and therefore the end of the stem is subjected to the steam pressure. This would give equal pressure on both sides of the piston *B*, and as the main valve is balanced it would remain in any position so long as pressure was maintained in *C*. Should the electrical device act and release the pressure in *C*, the valve would close, but if there is no way of creating a greater pressure in *C* than there is in the steam main, or if some piston *D* is supposed to move to the left and close *B*.

But, as *B* is unbalanced and has to close against pressure, the piston *D* would have to be of greater area, while the figure shows that the opposite is the case and, therefore, the valve will not close. In the case of these two valves it would be interesting to hear from Mr. Wakeman as to whether the drawings or his explanation are at fault.

JOSEPH STEWART.

Hamilton, Ohio.

Weighing Small Parts Accurately

Mr. Kirlin, in the issue of January 17, describes a way of accurately weighing small parts without the use of a delicate balance. It certainly is simple and yet a method which one would be unlikely to originate himself in an emergency.

There are one or two places where I believe his method will stand simplification. In regard to the scale ratio, which is 100 to 1, I would like to ask Mr. Kirlin if he generally has his revolver handy to test the scales with. I hope not, for the sake of the poor man who might happen to dispute his weights. Also, does he generally carry a pound of tobacco around with him? Even had he the pound, or any other known weight of it with him, how many times would he find it unsampled, when he wanted to test his scales with it? I think I am safe in saying that all scale weights are marked with both their actual weight and the weight which they will balance on the scales. This, of course, gives the ratio and should be sufficient even if a man is "from Missouri." As an example, a 200-pound balance weight, with the above ratio, would have the numeral 2 under the 200 mark upon it.

With regard to weighing, assume that the ratio is 100 to 1. Suppose the article weighed approximately one pound. By Mr. Kirlin's method this would mean that we would have to hunt around for some thing or things which would weigh about 100 pounds to just balance the article. Quite a little work. And then we would still have the junk to get rid of when finished.

My method would be as follows: I would first step on the scales and find my own weight accurately, say it was 175 pounds. I would then place the article on the tray and repeat, finding my weight then to be, say, 90 pounds. Now, 175 minus 90 equals 85 pounds, which is the weight balancing my article. Then, 85 divided by the scale ratio gives me 85/100 pound as the weight of the article. Of course, if the article had been more than 1¾ pounds, my own weight would not have been enough and I would have had to have a helper or two on the platform with me.

The points I bring out are that it is not necessary to have an *exact* weight to balance the article, the balancing being done by the sliding weight on the arm, and that it is better to have a self-propelled balancing weight in these times of flying machines and automobiles.

JOHN BAILEY.

Milwaukee, Wis.

Cracking noises in steam pipes indicate that they contain water and that an explosion may occur at any moment. Such cases should be carefully inquired into.

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POWER

The Pabst Boiler Explosion Decision

In the suit of the Pabst Brewing Company versus the Hartford Steam Boiler Inspection and Insurance Company, there are two important points at issue.

Does a company which undertakes insurance of apparatus, like boilers, flywheels, elevators, etc., incur liability in excess of that assumed in the controlling policy or contract, for damage from a defective condition which, it is afterward claimed, should have been discovered by the insurance company's inspector?

When several boilers explode at sensibly the same time, is it one explosion or several explosions?

The brewing company claimed that, relying upon the inspections of the insurance company, it had continued to run boilers which were defective until they exploded, and sought to collect from the insurance company, not only the damages resulting directly from such explosions, but such indirect damages as loss of business, increased cost of manufacture, etc.

Against this contention the insurance company urged that they had contracted to pay to the insured damages of specified kinds up to a certain amount, directly resulting from an explosion of one or more of the boilers covered by the policy. They had made no contract to inspect the boilers, were not obliged to inspect them, and if they did inspect them, it was only to protect their own risk, and they were not obliged to report the results of such inspection to the insured, nor liable beyond the terms of the policy for any damage resulting from their failure to make such inspections and report the results.

The court held that the liability of the underwriter was limited by the terms of the contract, or policy, and ruled out any claim based upon the alleged negligence of the company in the matter of inspections.

Any other decision would have thrown consternation into insurance companies of all kinds that maintain inspection service; for if a company making inspection of apparatus or buildings be liable, upon the establishment of negligence, for any damage which may result from the failure of such apparatus or the destruction of the buildings, one might with a $500 policy purchase immunity for any amount, and involve the entire capital of a strong underwriting corporation.

Many patrons of the boiler-insurance companies value the supervision of their boilers by the expert inspectors more than, or as much as, the guaranteed immunity from financial loss. The contention of the insurance company that it need not make such inspections unless it wants to, and is not obliged to report them to the insured, need cause no uneasiness in this respect. It was the logical reply to the contention of the plaintiff. But the only way that a boiler-insurance company can afford to take a risk is by diminishing by inspection the probability of explosion, and the insured are very sure to know the results of such inspection, especially if anything is discovered which is not just right.

The other question—what is "one explosion"—has not been so satisfactorily determined. The Pabst policy covered a battery of six Munoz boilers and was for $150,000 for three years. There had, however, been attached to the policy a "rider" or agreement, supplementary to the main form, providing that "the total liability of the company for loss or damage resulting from any one explosion shall not exceed the sum of $50,000, and in case of more than one explosion the entire liability of the company shall not exceed the sum insured by this company; viz., $150,000."

At the Pabst plant four Munoz boilers exploded at sensibly the same instant. Was it one explosion or four within the meaning of the policy?

The meaning of the policy is, or ought to be, the meaning which was attributed to it by the covenanting parties when it was drawn up and signed.

Did the man who accepted this policy for the Pabst Brewing Company understand at that time that the failure of each particular boiler constituted a separate explosion, notwithstanding a number of them should fail simultaneously and from a common cause? Do the many business men who hold policies containing this agreement (for it is by no means uncommon) consider that a single accident, involving more than one boiler, constitutes more than one explosion within the meaning of the policy?

If so, they had better have an understanding with the underwriters, for the underwriters' understanding of it is not that way.

The attachment of this rider, or agreement, to the policy very materially lessens the premium. The underwriter can take the risk for considerably less money when his liability for any one accident is limited to one-third the face of the policy. The probability of three destructive explosions within three years in the same plant is so remote that it is difficult to understand the attitude of a man who pays for such a chance, even at a reduced rate. If he is satisfied that $50,000 will cover any single loss, he would apparently be better off to take a straight policy for $50,000, and renew it, in the remote probability of his collecting it up, than to pay even a reduced premium on a $150,000 policy, upon which he can realize the face value only if he has, within the three-year period of the policy, say three to thirty explosions or tube ruptures in his battery of boilers, each causing direct damage of $5000 to $50,000 or more to persons or property. It was perhaps inability on the part of the jury to understand why a man should pay for such a policy, unless he understood the failure of each individual boiler to be a separate explosion, that led them to find for the plaintiff on this count. Notwithstanding their verdict, we think that the average disinterested engineer would regard the occurrence at the Pabst brewery as "a boiler explosion," that the underwriter has in mind in attaching the rider quoted, that he is limiting his liability for any one occurrence to the sum stipulated, and that the average business man in accepting this modified policy, at a materially reduced rate, recognizes that the stipulated sum fixes the limit of the loss which he can collect at any one time, or for any one occurrence.

Central Station Service in Public Buildings of New York City

The attitude of POWER in the strife between the central station and the isolated plant embraces neither antagonism nor sentiment; it accepts the facts purely upon an engineering basis, and as such recognizes that there is a field in which central-station service possesses advantages over the isolated plant. Nevertheless, when the agents of the former overstep the boundaries of this field and attempt to extend their business through misrepresentation of facts and juggling of figures, we feel it our duty to protest. The recent invasion of the central station upon the public buildings and plants of the city of New York calls for a careful investigation of the facts.

A consulting engineer, employed at a salary of seventy-five hundred dollars per year, to give the city expert advice, made a report—based presumably upon careful tests—relative to the cost of operating the isolated plant at the Harlem hospital. This report showed the plant to be operating uneconomically, and was accompanied by the recommendation that it be shut down and central-station service substituted. Fortunately, the report fell into the hands of those able to analyze power-plant costs and it was discovered that the consulting engineer, in his efforts to present an accurate statement of facts, had included the cost of two hundred and eighty thousand cubic feet of feed water, which, however, if based upon the amount of coal used, would have shown an evaporation of over fifty-five pounds of water per pound of coal, a rather startling figure. On the other hand, his coal consumption was estimated upon the abnormal basis of twelve and a half pounds of coal per kilowatt-hour. Needless to say, this particular recommendation was not heeded; but the fact remains that a number of other city plants have since been shut down upon the advice of this same engineer. That the city officials are beginning to awaken to this condition of affairs is shown by the resolution passed by the Board of Estimate on February 2; this was as follows:

"Resolved: That hereafter no contracts involving electric light or power equipment of any kind in the city of New York shall be advertised for or let by any branch of the city government unless the approval, in writing, of the Department of Water Supply, Gas and Electricity, of the plans and specifications for the work shall have been first obtained, and no alterations to the work as contracted for shall be ordered or approved without the written approval of said department.

"This resolution shall not, however, be deemed to authorize the commissioner of the Department of Water Supply, Gas and Electricity to prohibit or prevent the installation of generating or other electrical apparatus, provided the specifications therefor conform to the established requirements of the said department, nor shall this resolution confer upon the water commissioner any other right or power not specifiedly vested in him by the charter of the city of New York with respect to the use of electricity in any of the public buildings of the city of New York."

The Draft Gage

An instrument whose possibilities seem to have been greatly overlooked is the draft gage. Operating engineers and others who have to do with power-plant design and management will usually encourage the purchase of practically all kinds of instruments except those which will serve to make the fireman's work less a matter of guess work and judgment. And yet, beyond all other operations in the plant, the management of the boiler furnace depends on the personal element.

With a draft gage connected into the breeching at the base of the stack or beyond the damper and another connected with the furnace or first pass, and encouraged to watch the variations in the draft, the fireman should soon learn the importance of keeping the fires clean and the damper suitably adjusted.

Federal Inspection for Locomotive Boilers

The locomotive boiler-inspection bill, mentioned some time ago in these columns, has now passed both houses and will soon become a law.

The effect of the bill will be to put the inspection of locomotive boilers under the charge of the Interstate Commerce Commission. A chief inspector at $4000 a year, with two assistants at $3000 a year each, will have actual charge of the inspection service. Fifty inspectors will do the work of inspecting boilers in the field. Every locomotive boiler will be minutely and carefully examined at least once a year and also at such other times as is deemed advisable. The limit of cost of the service is fixed at $300,000 a year.

Another mysterious boiler explosion was avoided when the fireman of the boiler at the Empire laundry at Poughkeepsie, N. Y., discovered a dynamite bomb in a shovelful of coal which he was about to toss into the furnace. It consisted of a stick of dynamite wrapped in black paper with a percussion cap and fuse. If this was a gentle joke, the perpetrator ought to be dealt with under the impelling force of a conception of the possible results to the thirty-odd employees of the laundry, to say nothing of the neighbors and passers by.

There appears to be a change of policy with respect to the large gas engine. The Tennessee Coal and Iron Company, with a large amount of coke-oven gas available at its Ensley plant, has decided to burn the gas under boilers and use steam turbines rather than to use the gas in large gas engines; and the Cambria Steel Works is installing a 15,000-kilowatt turbine, the steam for which will be made in boilers fired with blast-furnace gas.

A few of us manage to carve our names on the tablet of fame, but some of us never carve them on anything more important than the plank siding of the coal bin.

Every small boy delights to blow a whistle, but that is no excuse for the engineer to play a rag-time tune every time he starts up or shuts down his engine.

"Whenever you see a head, hit it" is a good practice to follow in regard to the little leaks and irregularities in steam-plant operation.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Safe Speed for Flywheel

How can I calculate the safe speed for a flywheel?

B. C. M.

The safe limit of rim speed of a well designed cast-iron wheel is 100 feet per second. The maximum diameter for a given number of revolutions is determined by the formula

$$D = \frac{1910}{R}$$

in which

D = Diameter in feet;
R = Revolutions per minute.

Conversely,

$$R = \frac{1910}{D}$$

High- and Low-pressure Pumps

What is the difference between a high-pressure and a low-pressure pump?

H. L. P.

A high-pressure pump is one that is used to pump against a pressure as high or higher than that of the boiler which furnishes the steam. A low-pressure or light-service pump, as it is sometimes called, is one designed for pumping against pressures below that in the boiler and the water cylinder is of a greater diameter than the steam cylinder.

Thickness of Cylinder Walls

Please give me a formula by which I can calculate the proper thickness of a steam-engine cylinder.

E. H. B.

For a good quality of cast iron

$$Thickness = 0.0004 \times Diameter \times Pressure + 0.3\ inch.$$

The 0.3 inch is added for reboring.

Hight of Suction Lift

In a well the water level is 25 feet below the surface. Will a 1½x2¾x4-inch duplex pump operate satisfactorily at this lift and discharge water 10 feet above the pump?

A. L. B.

With the pump in good working order there is no reason why the pump will not work well. The piston and the valves must be tight, as slight leaks past either will interfere with the operation. A foot valve should be placed at the lower end of the suction pipe to facilitate priming when it becomes necessary.

Compounding Separate Engines

Can two simple engines, each having the same length of stroke, running at the same speed, and both connected to the same line of shafting be run as a cross-compound engine?

C. S. E.

Yes. The cylinder diameters will, however, have a great influence on the practicability of the scheme.

Cause of Increased Receiver Pressure

In a cross-compound engine with a separate governor for each cylinder with a varying load the receiver pressure rises with a light load and falls with a heavy one. What is the cause of this and what is the remedy?

I. R. P.

The range of cutoff on the low-pressure cylinder is too long. The cutoff is too short on light loads and may be too long for heavy ones. The cutoff on the low-pressure cylinder should vary the same as that on the high. Then the receiver pressure will be constant and the load evenly distributed.

Evaporation from and at 212 Degrees

Please explain what is meant by the expression "from and at 212 degrees."

R. A. S.

When water is fed to the boiler at a temperature of 212 degrees and evaporated into steam at atmospheric pressure, the steam has a temperature of 212 degrees and the evaporation is said to have taken place from and at 212 degrees. As this requires a definite amount of heat, it has been adopted as a standard to which all boiler performances are referred when tests or comparisons are made.

Cutoff on Low-Pressure Cylinder

If the point of cutoff in the low-pressure cylinder makes no difference in the number of expansions, of what use is a cutoff on this cylinder?

L. C. O.

It is used for controlling the receiver pressure and distributing the work between the cylinders.

Effects of Bag on Boiler Safety

On the front sheet of a boiler over the fire a small bag about 2 inches deep has formed. Is it dangerous?

B. B. S.

It is not necessarily dangerous. The sheet at the thinnest part of the bag is probably stronger than the seam, and if kept free from scale or deposits of mud is not unsafe. However, the matter should be referred to an experienced boiler inspector.

Draft Regulation

What is considered the best practice to regulate the amount of air supplied to the furnace: by the damper or by opening and closing the draft doors?

H. E. H.

The draft should be regulated by the damper.

Air Receiver Explosion

I am using an old return-tubular boiler in a cellar as a receiver for compressed air at 100 pounds pressure. If it should explode, would the results be disastrous?

E. A. R.

Probably not. It would be a case of simple rupture, which, if it occurred at the side, would move the receiver a few feet from its position.

Water Hammer in Open Pipe

What is water hammer, and is it possible to get a water hammer in the exhaust pipe of a steam engine?

J. I. W.

Water hammer is the violent projection of a body of water against some part of the interior surface of the containing vessel or pipe. It is possible to get a water hammer in an open-ended exhaust pipe if there are water pockets.

Effect of Clearance

How is the ratio of expansion found when the clearance is known?

F. D. C.

The ratio of expansion is found by dividing the final volume by the initial, or volume at cutoff. When the clearance is considered, the percentage of piston displacement represented by the clearance is added to both the initial and final volumes. If the piston displacement be represented by 1, the final volume will be 1 + per cent. of clearance, and the ratio of expansion will be

$$\frac{1 + \text{clearance}}{\text{Cutoff} + \text{clearance}} = \text{Ratio of expansion}$$

Sizes of Turbine Steam and Exhaust Pipes

The accompanying curves were prepared by W. J. A. London, chief engineer, of the Terry Steam Turbine Company, Hartford, Conn., to save the necessity of working out the size of steam and exhaust piping for each individual calculation.

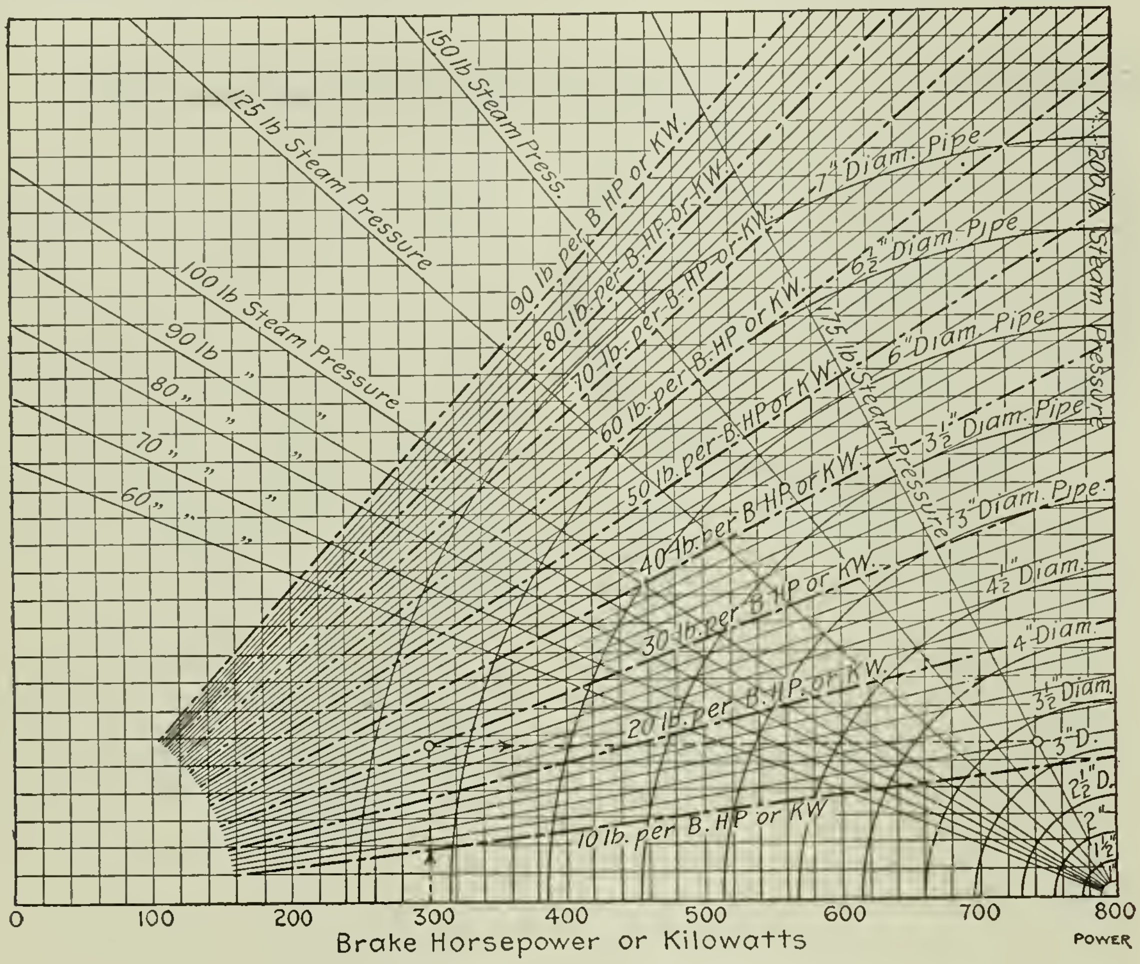


Fig. 1. Size of Steam Pipe to Turbine

Having given the power, water rate and steam pressure, the size of the steam pipe is obtained as shown in the example relating to Fig. 1. Thus: Assume 300 horsepower at 30 pounds water rate, with 175 pounds initial pressure. Follow up the 300 line to the 30 pounds water rate, and from the intersection run to the right to the initial-pressure line, and in the example this is between 3- and 3½-inch pipe, and will therefore take the larger size.

For determining the exhaust outlet when given the power, water rate and back pressure or vacuum, use Fig. 2 and in exactly the same way.

The steam-pipe sizes are based on the standard steam velocity of 100 feet per second or 6000 feet per minute, using dry saturated steam. The exhaust curves are based on a velocity of steam of 400 feet per second or 24,000 feet per minute for all vacuum curves; 100 feet per second, 6000 feet per minute, for the atmospheric-exhaust curve is allowed.

In all these curves steam has been taken as expanding from 150 pounds gage, and from Peabody's steam tables, which have been used throughout the calculation; this gives an entropy of 1.56. In cases where the initial pressure is different from that stated, a small correction should theoretically be made for the difference in moisture, but the percentage difference in ordinary work in expanding from 200 pounds to 1 pound absolute, and from 100 pounds to 1 pound absolute, is so small that the curves will be found sufficiently close for all practical purposes.

All pipe diameters given are based on net internal areas. As the net areas of extra-heavy pipe and double extra-heavy pipe are very often considerably less than the normal diameter of pipe, corresponding allowances should be made.

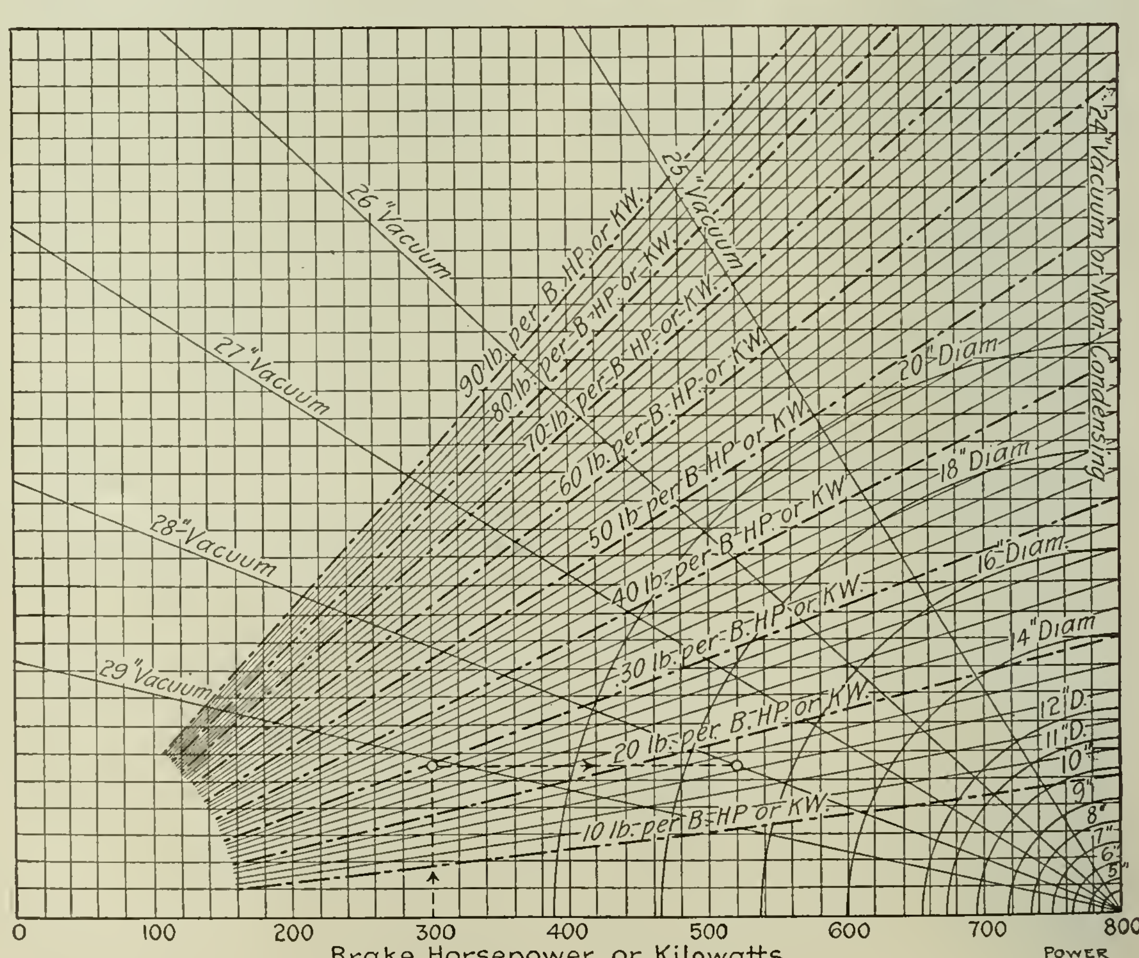


Fig. 2. Size of Exhaust Pipe

General Electric Centrifugal Air Compressors

A score of men connected with blast-furnace operation were the guests of the General Electric Company at the River Works, Lynn, Mass., on February 4, to inspect the design and construction of the three new turbine-driven, constant-volume centrifugal air compressors which are to be delivered to the Iroquois Iron Company at South Chicago, Ill.

One of these compressors is completed and erected on the testing floor; an actual demonstration of its operation was made.

These machines will constitute the third installation in the United States of this type of compressor. The first machine to be installed was that at the Oxford Furnace of the Empire Steel and Iron Company, Oxford Furnace, N. J.

The Cambridge Scientific Instrument Company showed several novel instruments at the recent exhibition held by the Physical Society of London. The first of these was the bi-meter carbon-dioxide recorder, which contains no glass nor liquid, the CO_2 being absorbed by lime and being recorded by the aid of a differential gearing between two cylinders, through which the flue gas is drawn. The second, the recalescence curve tracer of H. Brearley, of the Firth Laboratory, of Sheffield, gives recalescence curves on a very open scale of rectangular coordinates, connecting time and temperature with the aid of a thermo-couple and a galvanometer. One clock drives the whole mechanism. The observer has to turn a handwheel in such a way as to keep the pointer coincident with the light spot of the galvanometer mirror.—*Ex.*

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Tools for Placing Baffle Brick

This set of two tools has been designed for the purpose of removing and replacing baffle walls of Babcock & Wilcox boilers.

Ordinarily when removing baffle bricks it is necessary to break them before they can be taken from between the tubes. When replacing new baffle walls, using old methods, it is necessary to chip the edges on two sides of each brick before it can be put in place between the tubes. With the new method the brick are put in place whole and set up snug against the tubes.

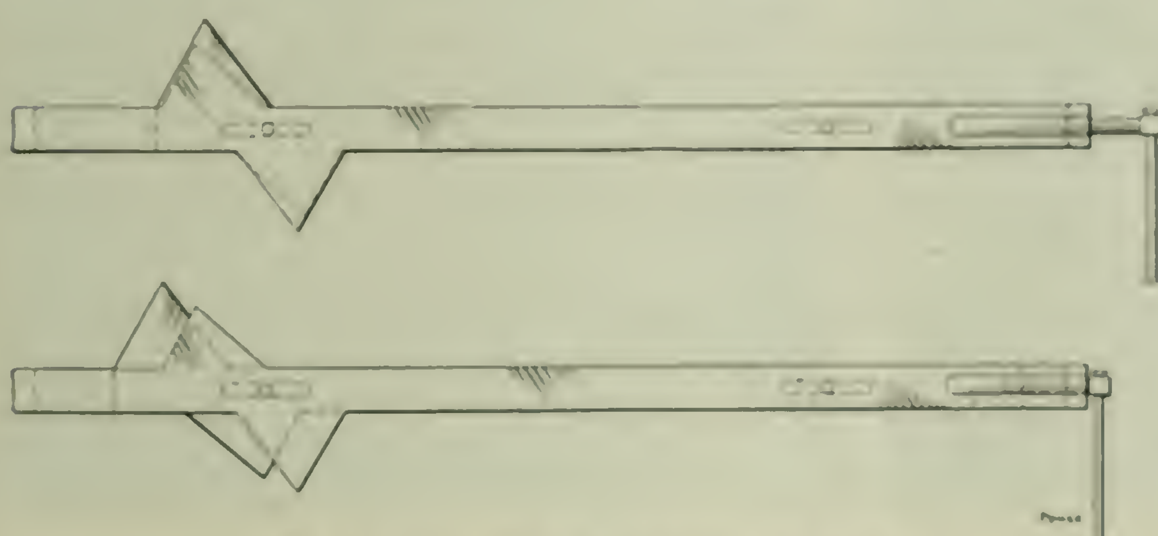


FIG. 1. TOOL USED FOR SPRINGING THE TUBES

In Fig. 1 is shown the tool used for springing the tubes. It is made with an adjustable spreader head. The movable part is operated by a threaded stem that screws into a nut on the inside of the handle, and is operated by the rod on the end. The upper view shows the tool in a contracted position; the lower view as it appears when the tubes are sprung.

By referring to Fig. 3 it will be seen that four tubes are sprung as the head is expanded; that is, tubes *A* and *B*, which bear against the stationary portion of the head are sprung away from the tubes *C* and *D* which bear against the movable part of the head. With the tubes sprung in this manner, it is a simple operation to remove an old baffle wall and replace it with new baffle bricks.

Fig. 2 illustrates the tool used for placing the baffle brick in position. The upper view shows the brick as it is placed in the tool; the lower view shows the brick gripped by the jaws of the tool. The gripping member is adjusted by a threaded rod which passes through a nut on the inside of the handle. The knurled end of the handle is turned, which tightens or loosens the jaws of the tool on the brick. The stationary member is so made that it fits the end of the baffle brick.

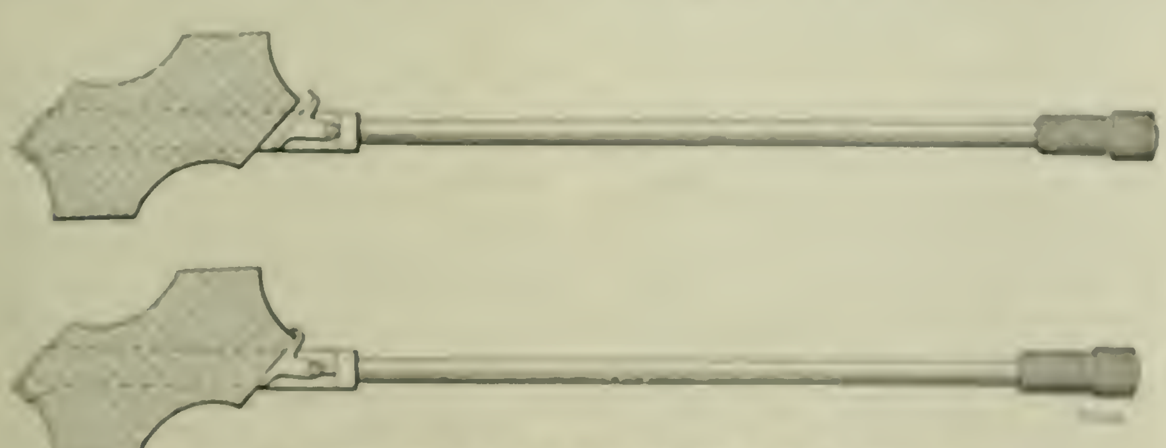


FIG. 2. TOOL FOR PLACING BAFFLE BRICK IN POSITION

With the brick gripped in the jaws, the tool is inserted between the boiler tubes and when in place the movable jaw is drawn back and the tool removed.

By using these instruments the baffle brick can be replaced whole and thus their efficiency is not impaired.

These tools are made by J. Keers, 224 Eighty-first street, Brooklyn, N. Y.

Albee Crude Oil Burner

This device has been designed for use in the furnace of steam boilers, forges or wherever crude oil can be utilized as a fuel.

It consists of a main body *A* which has an air and oil inlet and a discharge outlet. Oil is discharged into the burner through the plug *B*, in which is screwed a nozzle *C*. This plug has a wire screen *D* that is held in place by the cap *E*.

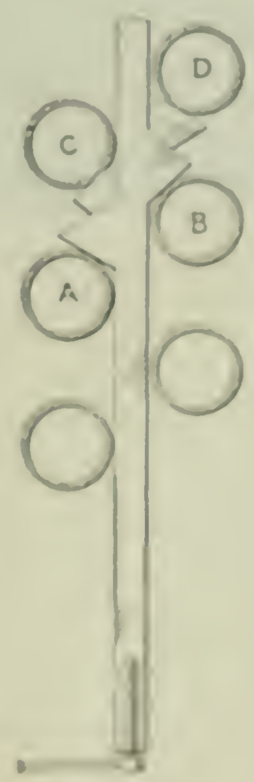


FIG. 3.

FIG. 4.

To the discharge end of the burner is screwed a cast-iron pipe having an outlet formed as shown in the illustration. This extension piece passes through the brick wall of the furnace front and is the only part of the burner that is exposed to the furnace heat. When it does become burned, it is easily renewed at a small cost.

When in operation the furnace works as follows: Oil is forced through a supply pipe to the inlet of the burner and out through the small discharge hole in the nozzle *C*. Air, under a three-pound pressure, is admitted to the body of the burner through the top opening and

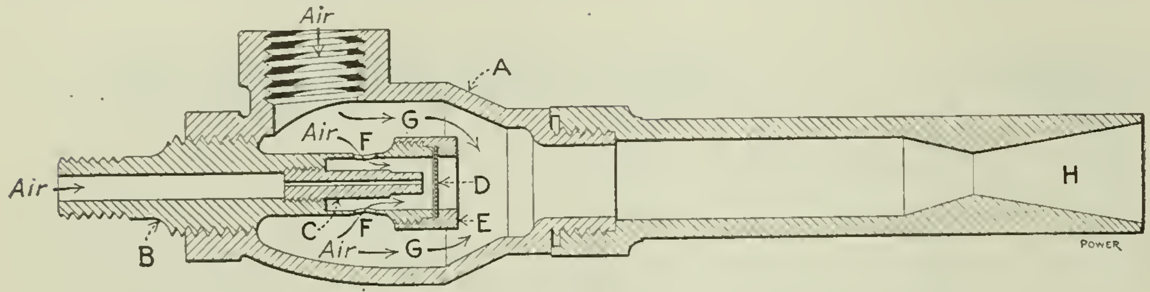


Fig. 1. Sectional View of the Albee Crude-oil Burner

travels along two paths before it is expelled at the discharge end. That is, a portion of the air supply passes to the interior of the plug *B* through a series of holes as shown at *F F*. This air mingles with the incoming oil from the nozzle *C*

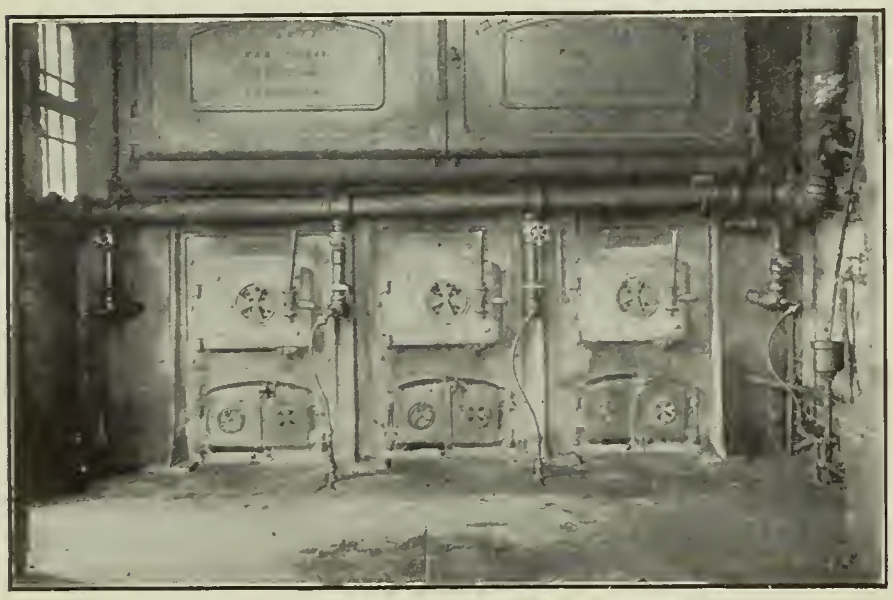


Fig. 2. Burner in Place Ready to Supply Oil as a Fuel

Fig. 3. Burner Pulled Out Ready to Burn Coal in the Furnace

and passes through the wire screen *D* in a partially atomized state, the current of air and oil passing diagonally from one side of the burner to the other from all points of the discharge cap *E*.

As this current of air, indicated by the arrows *G G*, strikes the oil and air being discharged through the cap *E*, the mixture is blown through the expanding tube and is discharged at the end *H* in a vapor, and is then ignited in the furnace of the boiler.

An oil connection is made to the supply pipe by means of a flexible hose, in order that the burner can easily be disengaged from the air line and withdrawn from the furnace. This is accomplished by a sliding coupling on the air connection. Fig. 3 shows the burner connected to and withdrawn from the supply pipe.

This arrangement permits of changing from coal to oil fuel, or *vice versa*, which makes it possible to burn oil during the day and coal during the night when the fires are banked.

This burner is manufactured by H. L. Albee, East Douglas, Mass.

First Monthly Meeting of the Institute

On Tuesday evening, February 9, the first of the series of regular monthly educational meetings inaugurated by the executive committeee of the Institute of Operating Engineers was held at the Engineering Societies' building, 29 West Thirty-ninth street, New York City.

Hubert E. Collins acted as chairman and after briefly outlining the objects of the institute and giving the reasons for holding the meetings, he introduced Prof. F. H. Sykes, director of Teachers College, Columbia University, who gave a half-hour talk on the necessity for industrial education as is exemplified by the scarcity of trained workers in all cases of modern industry.

Professor Sykes has made a careful study of the systems of industrial education in vogue in all the countries of Europe in which the industrial arts are most highly developed, and his address on this occasion was greatly enforced by statements of the changes in certain industries which in many cases have been wrought in a few years by the influence of the industrial schools, in some instances the school saving the industry from complete decline and the people who engaged in it from financial and industrial ruin.

He was followed by C. H. A. Bjerregaard, librarian of the Astor library, who dwelt on the ethical phases of the subject.

Mr. Jurgensen then presented a paper pointing out the weak spots in the present system of education for the engineering profession and outlining the institute's plans to provide him a balanced and competent system of professional education.

Professor Lorentzen, of New York University, in a few well chosen words emphasized what had been said by the preceding speakers.

He was followed briefly by F. L. Johnson, Timothy Healy and H. M. Elder, all of whom spoke of the significance to the operating engineer of industrial education as proposed by the institute.

San Francisco Exposition

San Francisco is to have the exposition to be held in 1915 in commemoration of the completion of the Panama canal. A joint resolution to this effect has already passed the House and is sure to pass Congress. California has promised $17,500,000 for the proposed exposition and no pecuniary aid has been asked of the national Government. New Orleans has put up a hard fight for the honor, but the location chosen will have the advantage of giving many of the visitors an opportunity to view the canal.

PERSONAL

Dr. F. R. Hutton, late of Columbia University and honorary secretary of the American Society of Mechanical Engineers, has been appointed consulting engineer of the Department of Water Supply, Gas and Electricity of New York City, vice George W. Birdsall, deceased.

On the evening of January 25, Melville W. Mix, president of the Dodge Manufacturing Company, celebrated the twenty-fifth anniversary of his connection with the company by giving a splendid nine-course dinner to stockholders and directors. At the close of the dinner, Mr. Mix was presented with a silver gold-lined loving cup by First Vice-president W. B. Hosford as a token of the company's esteem and confidence.

Mr. Mix began as office man and at one time was wrapper of *Power and Transmission*, the company's official organ. He became shipping clerk and also went to New Orleans, where he assisted in the Dodge exhibit at the exposition. In 1890 he went to Chicago, where he became Chicago manager of the company. In 1894 he was returned to Mishawaka and became general manager and in 1895 he was elected president and general manager, and has occupied that position since that time.

BOOKS RECEIVED

THE SLIDE RULE. By Frank C. Hinckley and William W. Ramsay. Engineering Text Book Company, Boston, Mass. Leather; 104 pages, 4x6¼ inches. Price, $1.75.

APPLIED THERMODYNAMICS FOR ENGINEERS. By Prof. William D. Ennis. D. Van Nostrand Company, New York. Cloth; 438 pages, 6x9¼ inches; 316 illustrations; indexed. Price, $4.50.

THE DOTINGTON MULTIPLE BOILER EXPLOSION AND OTHER MULTIPLE BOILER EXPLOSIONS. By Edward G. Hiller. Taylor, Garnett, Evans & Co., Ltd., Manchester, Eng.; 60 pages, 5½x8½ inches; illustrated; plates. Price, one shilling.

THE PRACTICAL ENGINEER ELECTRICAL POCKET BOOK. The Technical Publishing Company, London, Eng. Cloth; 567 pages, with diary additional, 3½x5¼ inches; illustrated; tables; indexed. Price, one shilling and sixpence.

NEW INVENTIONS

[illegible]

PRIME MOVERS

INTERNAL COMBUSTION STEAM MOTOR. [illegible]

WAVE MOTOR. [illegible]

TURBINE. [illegible]

ROTARY MOTOR. [illegible]

MOTOR. [illegible]

INTERNAL COMBUSTION ENGINE. [illegible]

INTERNAL COMBUSTION ENGINE. [illegible]

ROTARY ENGINE. [illegible]

BOILERS, FURNACES AND GAS PRODUCERS

LIQUID FUEL BURNER. [illegible]

SMOKE CONSUMER. [illegible]

WATER-TUBE BOILER. [illegible] a Corporation of New Jersey. [illegible]

STEAM BOILER. [illegible] a Corporation of New Jersey. [illegible]

STEAM BOILER. [illegible]

POWER PLANT AUXILIARIES AND APPLIANCES

VALVE. [illegible]

MIXING VALVE FOR HYDROCARBON ENGINES. [illegible] a Corporation of New York. [illegible]

MIXING VALVE FOR INTERNAL COMBUSTION ENGINES. [illegible] a Corporation of New York. [illegible]

AUTOMATIC PUMP. [illegible]

ROTARY PUMP. [illegible]

LUBRICATION APPARATUS. [illegible]

COMBINED THROTTLE VALVE AND OILER. [illegible]

FLUE CUTTING DEVICE. [illegible]

STEAM ACTUATED WATER TRAP. [illegible]

PISTON ROD. [illegible]

VALVE GEAR FOR STATIONARY ENGINES. [illegible]

AUTOMATIC GOVERNOR AND REVERSING GEAR. [illegible]

LUBRICATOR. [illegible]

CENTRIFUGAL PUMP. [illegible]

STEAM BOILER SAFETY DEVICE. [illegible]

ENGINE GOVERNOR. [illegible]

METALLIC PACKING. [illegible]

SUCTION PUMP. [illegible]

ELECTRICAL INVENTIONS AND APPLICATIONS

DYNAMO ELECTRIC MACHINE. [illegible]

ELECTROMAGNETIC POWER TRANSMITTING MECHANISM. [illegible]

DYNAMO ELECTRIC MACHINE. [illegible]

DYNAMO ELECTRIC MACHINE. [illegible]

ELECTRIC SWITCH. [illegible]

ELECTRIC SIGNALING DEVICE. [illegible]

ELECTRIC CASH REGISTER. [illegible]

METHOD OF SUPPLYING ELECTRIC FURNACES WITH POLYPHASE CURRENTS. [illegible]

POWER PLANT TOOLS

WRENCH. [illegible]

VALVE REAMER. [illegible]

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS [illegible]

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS [illegible]

NATIONAL ELECTRIC LIGHT ASSOCIATION [illegible]

AMERICAN SOCIETY OF NAVAL ENGINEERS [illegible]

AMERICAN BOILER MANUFACTURERS ASSOCIATION [illegible]

WESTERN SOCIETY OF ENGINEERS [illegible]

ENGINEERS SOCIETY OF WESTERN PENNSYLVANIA [illegible]

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS [illegible]

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS [illegible]

AMERICAN ORDER OF STEAM ENGINEERS [illegible]

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATION [illegible]

INTERNAL COMBUSTION ENGINEERS ASSOCIATION [illegible]

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS [illegible]

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS [illegible]

INTERNATIONAL MASTER BOILER MAKERS ASSOCIATION [illegible]

INTERNATIONAL UNION OF STEAM ENGINEERS [illegible]

NATIONAL DISTRICT HEATING ASSOCIATION [illegible]

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

There was once a young Shepherd Boy who tended his sheep at the foot of a mountain near a dark forest. It was rather lonely for him all day, so he thought upon a plan by which he could get a little company and some excitement. He rushed down toward the village, calling out, "Wolf, Wolf!" and the villagers came out to meet him. This pleased the Boy so much that a few days afterward he tried the same trick, and again the villagers came to his help. But shortly after this a wolf actually did come out from the forest, and began to worry the sheep, and the Boy of course cried out, "Wolf, Wolf!" But this time the villagers, who had been fooled twice before, thought the Boy was again deceiving them, and nobody went to his aid. The wolf made a good meal off the Boy's flock and when the Boy complained, the wise man of the village said: "*A liar will not be believed, even when he speaks the truth.*"

While reading this one of Aesop's Fables, written some twenty-five centuries ago, we couldn't help wondering whether there was not advertising in some crude form even in those days.

The moral so exactly illustrates the reason why an advertiser who advertises regularly in reputable papers must back up his claims with bona fide goods!

And why an advertiser whose goods do not meet the claims made for them will not appear on the pages of reputable papers for any length of time.

We recently met a man who had been selling patent medicines. He told how in the last five years he had advertised and sold six different brands.

That is to say, *different* in name. The mixture was exactly the same each time, being advertised only as long as the new name and new claims would fool people into buying.

However, patent medicines and other articles which are put out to fool the public are now practically eliminated from the better grade weeklies and monthlies, and even the dailies are closing the door on them.

This change of attitude on the part of publishers is due to the ever increasing recognition of Advertising Ethics. That advertisers have come to a realization of their responsibility is shown by this report from one of our solicitors.

He says: "This concern is manufacturing a new design of gas engine. They are not yet in a position to advertise it because it has not been tested long enough to know whether it will 'stand up' or not. In fact, they refuse to make any sales until they are absolutely certain that it will be right in every particular."

In the same mail we get a letter from a subscriber, who, in renewing his subscription, says: "You may be interested to know that after reading the advertisements of the —————— Indicator, I bought one and found it to be all they claim for it."

This is the beginning and the ending of the story of modern advertising.

It begins with the advertiser who knows it will not pay him to advertise any but tested and proved machinery—

And ends with the buyer who finds the goods "all that is claimed for them."

Back of it is a conscientious publisher who will not insert the advertisement of the man trying to pull off something in the nature of a fake deal.

The publisher may be doing it from a sense of honesty, who knows? Give him credit for it, anyway.

In any event he knows it's poor business in the long run to do anything else.

The up-to-date buyer comes pretty close to knowing who's who and what's what.

And if he happens to be a power-plant man, he knows what supplies, equipment, money- or time-saving appliances he wants.

He *knows* because he reads the advertising pages of his technical paper and sees what goods are advertised regularly for which certain claims are made, backed up by convincing "reason why" copy.

The maker of a good article *can* advertise regularly and convincingly.

The maker of an inferior one can only raise the cry of "Wolf!" until the people get used to it and no longer answer the call.

POWER

NEW YORK, FEBRUARY 28, 1911

AN ancient allegory deals with certain six blind men who went once to "view" an elephant. After the manner of the blind, their "viewing" was done through the sense of touch.

It so happened that each came in contact with a different part of the pachyderm; one touched its trunk, one took hold of a tusk, one felt an ear, another touched a foreleg, another felt its side and the sixth caught hold of the elephant's tail.

When asked to give his "views" on elephants, the first man intimated that an elephant was long and round in form and coiled up toward the end, very similar to a huge snake.

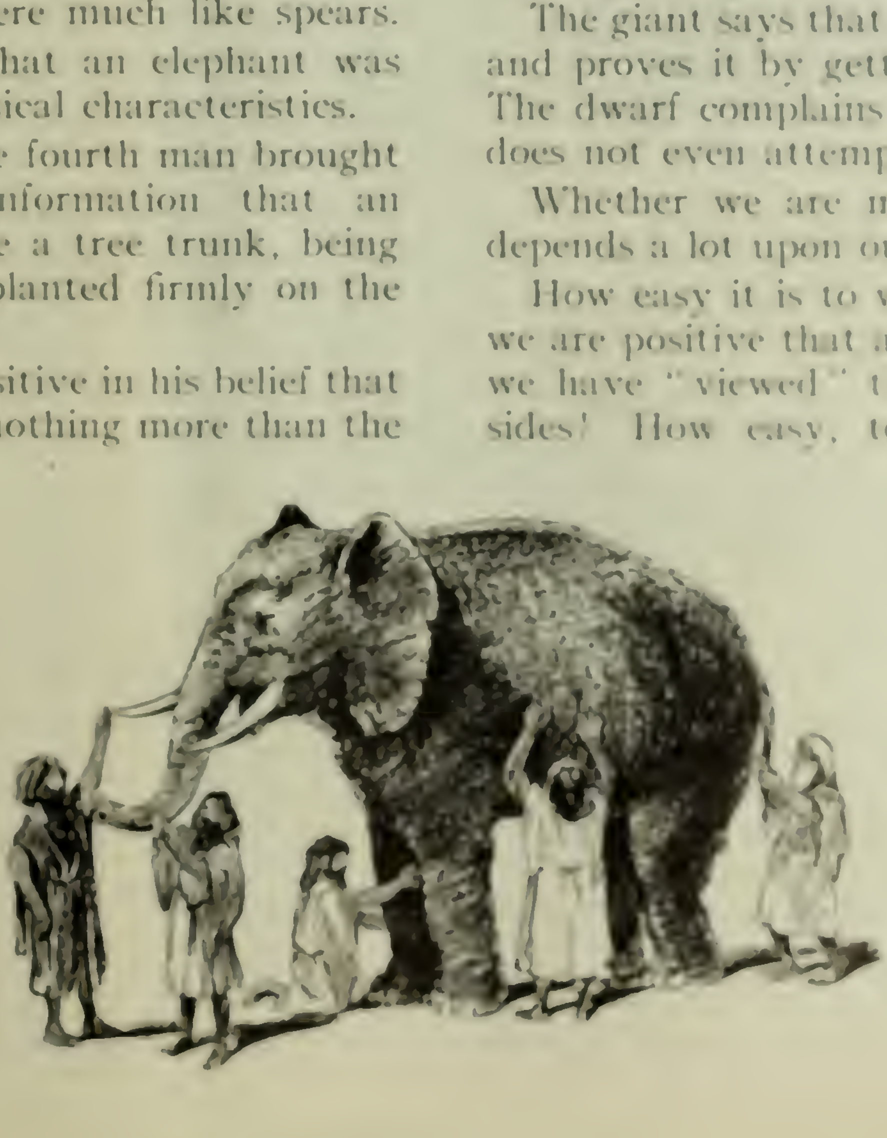
The second man went on record to the effect that elephants were much like spears.

The third thought that an elephant was much like a fan in physical characteristics.

An interview with the fourth man brought out the interesting information that an elephant was not unlike a tree trunk, being thick and strong and planted firmly on the ground.

The fifth man was positive in his belief that an elephant resembled nothing more than the side of a barn, being flat and broad.

While the sixth man did not wish to contradict anything which his companions had said, he felt justified in maintaining that an elephant was merely thin and long, just like a piece of ordinary rope.



Thus it was that the term "nature faker" came into vogue, although none of these blind men really was one, for the term faker implies deliberate deception while these men were entirely sincere in their misstatements.

*   *   *

The fable, a synopsis of which has just been given, was designed to show how easily a wrong opinion may be formed if limited observations are used as a basis.

All of us form wrong opinions; sometimes, because we form them too hastily, before all of the facts are in; sometimes, because the question is too large for us to view the whole of it at once and, like the blind men, we are led astray by our limited observations.

The giant says that the wall is easy to scale, and proves it by getting over in "jig time." The dwarf complains that it is too high and does not even attempt to climb it.

Whether we are mental giants or dwarfs depends a lot upon ourselves.

How easy it is to withhold judgment until we are positive that all the facts are in—that we have "viewed" the "elephant" from all sides! How easy, to measure our "wall" by true standards, not by self made, dwarfish units of measurement!

First, get the right point of view and, second, size things up at their true values.

Let's not underestimate our faults and overestimate our hardships.

Additions to Hartford Power Plant

By H. R. Callaway

The Dutch Point station, which carries the greater part of the lighting and power load for Hartford and the surrounding districts, has recently been equipped with two additional 1250-horsepower Bigelow-Hornsby boilers. These are served by the largest automatic stokers ever built.

The Dutch Point station of the Hartford Electric Light Company, at Hartford, Conn., has been a gradual growth from a small auxiliary to the water-power installations of this company to its present status as the main generating station of the Hartford system. When the company first began business its current output was the product of two small hydro-electric developments having a total output of not more than 2400 kilowatts. As the load became greater it became necessary to build a small steam station to serve as an auxiliary in the time of low water, and a location on what is known as Dutch point, on the Connecticut river, was chosen as the site. A small creek runs into the river at this spot, and the station is located on the point of land between the creek and the river, thus making it a handy site for the delivery of coal and other supplies.

As the load on the company's system increased, the development has been along the line of additional steam power, so that now the water powers furnish a rather insignificant proportion of the total electricity. So rapidly has the sale of electricity increased that the Dutch Point station has been added to several times, and the company has just recently completed the latest of these additions to the equipment.

FIG. 1. STOKER ASSEMBLED IN SHOP

The power-house building, including the recent additions, is about 250 feet long by 135 feet wide. It is of steel frame and brick construction throughout, with a brick dividing wall running lengthwise of the building and separating the boiler room from the turbine room. On the side of the building opposite the boiler house is an extra bay slightly lower than the rest of the building which houses the switchboard and the gallery containing the electrical equipment and the circulating pumps for the condensers.

The original boiler-house equipment consisted of six 550-horsepower Aultman-Taylor boilers. These are arranged in a single row with the horizontal firing aisle next to the building wall. Later it was decided to add 2500 boiler horsepower, and two 1250-horsepower Bigelow-Hornsby boilers were installed, these being set beyond the Aultman-Taylor boilers and transversely with the boiler house. The latest addition to the boiler equipment has been two more 1250-horsepower Bigelow-Hornsby boilers placed in an addition built onto the end of the boiler house next to that part occupied by the transverse boilers. The unusual size of the four latest additions to the boiler room is one of the notable features of this station, and not only are the boilers themselves of unprecedented size, but they are equipped with the largest automatic stokers ever built. These are fourteen retort Taylor gravity underfeed stokers, shown in Fig. 1. The first installation of these mammoth stokers was on the two latest of the Bigelow-Hornsby boilers. Afterward it was decided to change over the two original 1250-horsepower boilers from hand firing to automatic stoker firing, and these are now being equipped with Taylor stokers. The main reasons for using such large boiler units at this station were concentration of power, economy of floor space and increased economy in operation due to a smaller amount of radiation.

The Bigelow-Hornsby boilers which are shown in Fig. 2 measure 27 feet 6 inches across the front and stand 21 feet 6½ inches from the floor line to the center of the steam drum. The latter is 4 feet in diameter and extends the entire width of the top of the setting. This drum connects with forty sections of 3¼-inch water tubes, 21 tubes to a section, or in all 840 tubes, each section of water tubes terminating at either end in a cylindrical header. The front sections are inclined at a steep angle, while the rear sections are vertical. In this type of boiler the depth of the furnace is necessarily somewhat limited; therefore the extreme width of grate and a high rate of combustion are depended upon to develop the rated horsepower. All the boilers in the station are equipped with Foster superheaters. Three 10-foot steel stacks serve the various batteries, two of these discharging the gases from the Aultman-Taylor boilers and the two oldest Bigelow-Hornsby boilers, and the third, a new 50-foot stack, serving the two latest units. The stokers operate on about 4 inches draft, but as yet there is no information available as to the performance of these huge units. Tests, however, will be made before long, the results of which are awaited with interest, owing to their unusual size.

One of the principal reasons for the installation of automatic stokers in this station was economy in labor, 2500 horsepower of boilers being operated by three men per day of 24 hours. When this same battery of boilers was operated with hand firing it took 12 men per day for the same capacity.

FIG. 2. FRONT OF BOILERS SHOWING STOKER

There are in all six main units: one 3000-kilowatt, one 2000-kilowatt and two 1000-kilowatt Westinghouse turbo-generators and two 4000-kilowatt General Electric horizontal turbo-generators, the latter being the latest additions. The six machines all operate in parallel and generate two-phase, 60-cycle current at 2400 volts.

The turbines receive steam at 150 pounds pressure and 100 degrees superheat from a single 12-inch main running alongside the boiler-room wall and behind the batteries. The leads taken off to the various turbines are of 6-inch, 8-inch and 10-inch pipe; 6-inch to the two small units; 8-inch to the 2000-kilowatt Westinghouse turbine and to the new General Electric machines; and a 10-inch to the 3000-kilowatt machine.

Situated in the basement directly below their respective turbines are the condensers and their auxiliaries. The largest of the Westinghouse turbines exhausts into two condensers operated in parallel, each containing 6000 square feet of surface. By a suitable arrangement of valves this machine can operate singly on either condenser if required. Although the 12,000 square feet of surface available for this machine is much larger than is necessary, this arrangement enabled the company to make use of an old 6000-square foot condenser instead of scrapping it and buying a new one of 10,000 square feet. The two 1000-kilowatt turbines are served by a single 6000 square foot condenser and the 2000-kilowatt machine by one of 6000 square feet. The four Westinghouse units are all provided with similar circulating-pump installations, each pump being driven through a long vertical shaft by an induction motor situated in a gallery alongside the switchboard. Each pump is provided with a separate intake from the river, but the discharges of all are joined into one pipe line which ends at a point somewhat downstream from the intakes.

Very little condenser-tube trouble has developed at this station, due probably to the fact that there are few acids in the water of the Connecticut river. Instead of the pitting so often found in condenser tubes of large power stations, the main trouble here seems to be the wear at the ends of the tubes due to expansion and contraction in the heating and cooling of the condenser. Naturally this trouble is not as serious as is the case of poor water, the tubes merely becoming loose at the heads. A rather ingenious method is used for saving the tubes worn in this manner, by cutting them off just inside the condenser heads and inserting a short length of smaller tubing, which is extended just inside the cutoff ends and then sweated on. This method results in cutting down the area somewhat, which, however, matters very little in this particular case because the condensers are altogether too large for the turbines.

Each of the two new General Electric turbo-alternators is equipped with a 20,000-square foot condenser having 1-inch tubes. The auxiliaries for these machines are rather unique and exceedingly compact. They consist of a centrifugal pump for circulating water and another for the hotwell water placed on the same shaft, both pumps being driven direct by a steam turbine; these are shown in Fig. 3. The dry-air pumps for all the condensers are set on the turbine-room floor between the machines, and the vacuum maintained is unusually high, the average during the winter being 28.75 inches, based on a 30-inch barometer.

As already stated, the coal is usually received by water, it being brought up the river in barges and unloaded at the company's dock beside the power station. In addition to the facilities for receiving

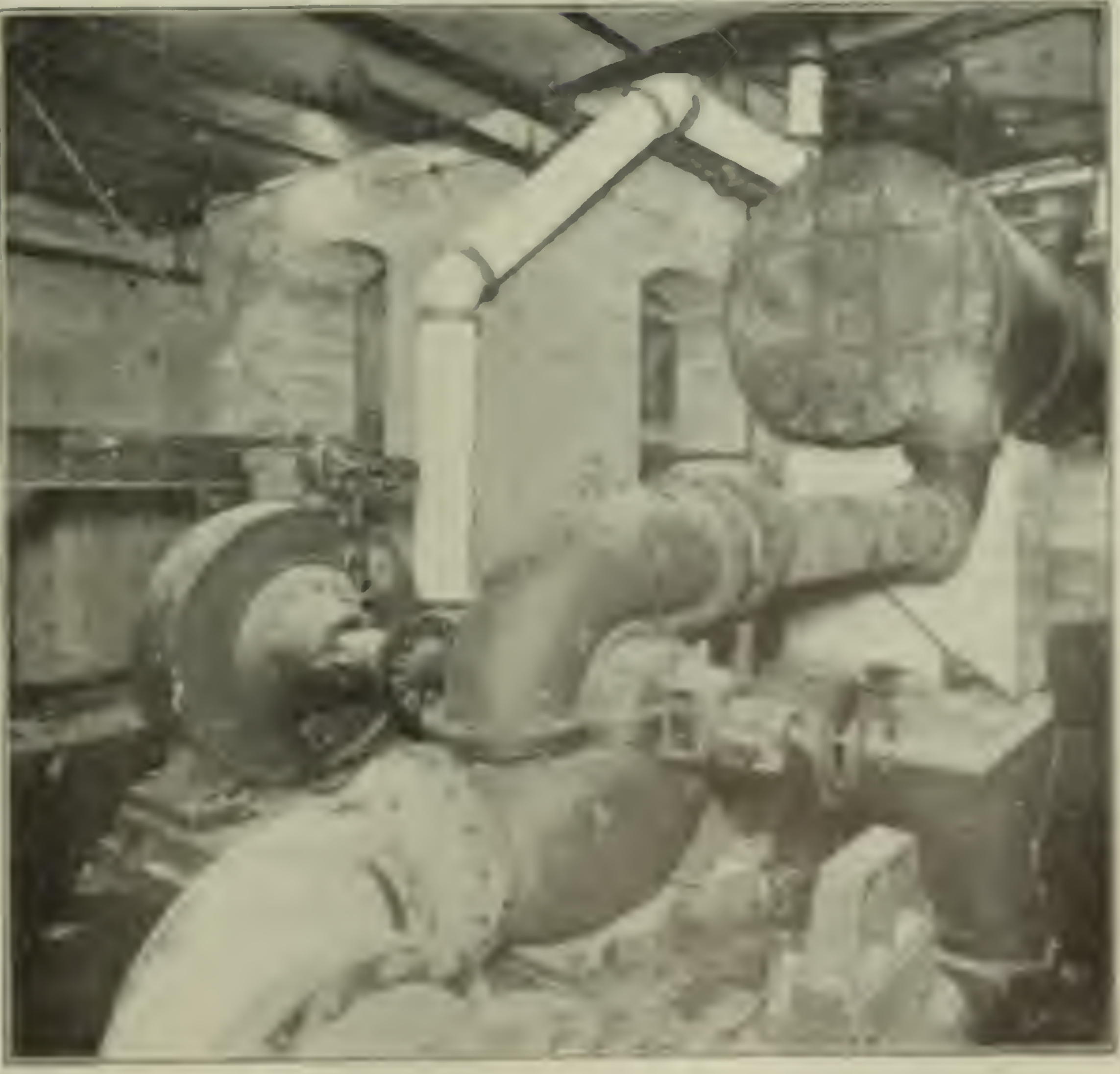


FIG. 3. CONDENSING OUTFIT

coal and other supplies by water, a spur track runs alongside the station on the boiler-room side. This is utilized for obtaining coal by rail during the winter months when the river is frozen and a sufficient supply has not been stored in the fall, although the 18,000-ton capacity of the storage bins usually proves adequate for this period. The approximate yearly coal consumption is 40,000 long tons.

The system of handling the coal is unusual. In addition to the spur track, already mentioned, which runs on the boiler-room side of the station, another spur runs on the river side along the unloading piers. Two derricks mounted on railroad trucks are used for unloading and loading the coal cars on these tracks. One derrick hoists coal from the barges and deposits it into the coal cars which are then shunted around onto the other track, and there unloaded into bins from which the coal falls by gravity to the boiler-room floor. In the case of the new stoker-fired boilers the coal goes from the bins into the hopper over the firing aisle, from which it is fed through chutes into the retorts of the stokers. Where the coal is brought by rail the cars are simply run in on the spur next to the storage bins and unloaded by means of the derrick hoists. It is said that 3 cents per long ton covers all unloading charges for coal. The hand-fired boilers burn a mixture of 75 per cent. No. 3 buckwheat and 25 per cent. bituminous coal. This mixture is the result of a large number of experiments on the most efficient and economical coal for use under the hand-fired boilers, and marks the point where the pounds of steam per unit cost is a maximum.

The Taylor stokers are supplied entirely with soft coal averaging about 14,600 B.t.u. per pound. The buckwheat averages 11,400 B.t.u. per pound. Although the mixture has proved to be the most economical fuel for average conditions on the hand-fired boilers, it has been found that under peak loads it is impossible to get sufficient capacity out of the boilers. Accordingly at the time of heaviest loads it is customary to burn straight soft coal on the hand-fired boilers as well as on the stokers. In the case of the former, this practice gives rise to considerable smoke and poor efficiency, which was another reason for the installation of the mechanical stokers under the new boilers.

The present system is to carry the steady load of the station on the stoker-fired boilers and handle the peak loads with the hand-fired boilers.

The ashes are dumped from hoppers under the boilers into ash cars in the basement. These discharge into a bucket hoist at one end of the boiler house, which dumps the ashes into carts. The ashes are then carted away by contractors who take all the ashes from the station without charge, so that the ash-disposal problem is very simple.

The station contains no fire pumps whatever; the construction being practically fireproof throughout and the coal-storage bins being outside the station walls, the chances of fire are exceedingly small. Located as it is on an isolated point between two bodies of water it would be impossible for a fire in the station to do harm outside the premises.

Buckwheat No. 3, delivered by water,

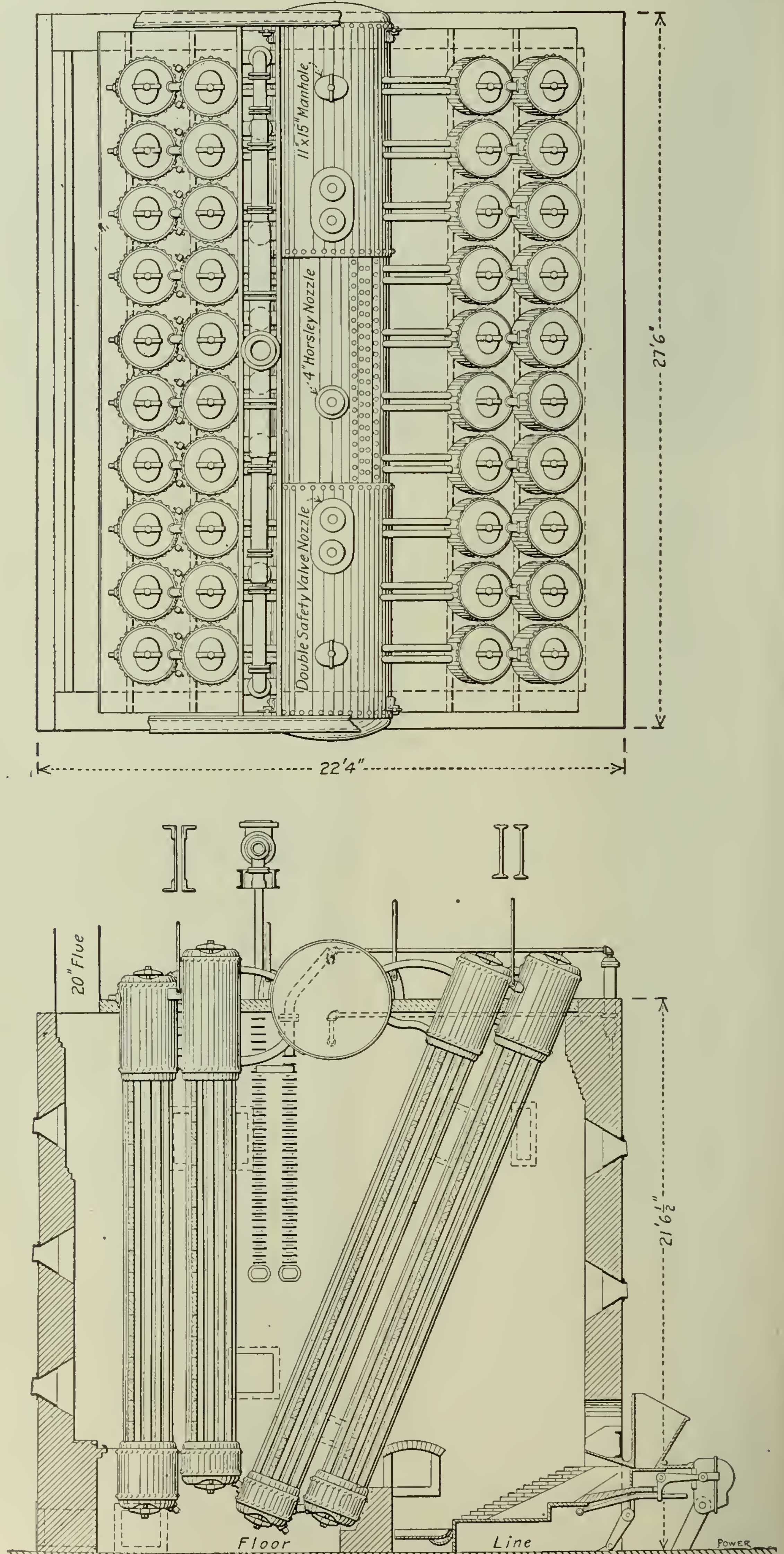


Fig. 4. Sectional Elevation and Plan of Bigelow-Hornsby Boiler

costs $2.05 per ton; by rail, $2.72. The bituminous coal costs $3.35 and $3.65 respectively.

The electrical distribution is divided up into two separate systems. For the city proper the current is not transformed but is transmitted at the generator voltage of 2400 to two substations, where it is stepped down to 220 volts and changed to direct current by means of rotary converters.

The lighting distribution from these two substations is on the Edison three-wire system, 220 volts outside and 110 volts between the outside and the grounded neutral. In the case of large power consumers, such as mills and factories, separate feeders go direct from the power house to transformers located on poles at the mill end of the feeders; this current is alternating.

There is a second system of distribution in use for the outlying districts; transformers located in the basement of the station step up the voltage from 2400 volts two-phase to 11,000 volts three-phase. In this system there are no converters, alternating current being distributed and stepped down by pole transformers.

The winter load on the system averages 140,000 kilowatt-hours per day and the load factor is unusually high for a lighting installation, approximating 65 per cent. Because of the large number of induction motors operating during the day in the various factories, the power factor during the day time is only 85 per cent. As soon as the motor load goes off in the evening the power factor rises to 95 per cent. It is understood, however, that rotary condensers are to be installed in order to counterbalance the lagging effect of the induction motors and to bring up the load factor during the day to somewhat near unity. It would not be necessary to operate them during the night.

The designing engineers of this plant, who also had charge of the erection, are Westinghouse, Church, Kerr & Co., of New York City.

Making, Use and Care of Belting

By Chas. A. Schieren, Jr.*

> *The tanning of hides for belt leather by the old, long-time, oak-bark process and the operations in making belts.*
>
> *Belt specifications fair to both buyer and seller, and belting factors that have been tested by long experience. How to get maximum belt service per dollar of investment.*

*Treasurer, Charles A. Schieren Company.

With the bark and the hides at hand the process of tanning to produce leather for belting may be taken up.

The hides are first soaked in pure spring water until all the dirt is thoroughly washed out of them. They are then placed in a vat of weak lime water, which is gradually strengthened until the sixth day, when the hair has been loosened sufficiently to allow the skin to be laid on a beam and the hair scraped off with a blunt knife.

The bare hides are then placed in an alkaline solution called the "bate," for the purpose of removing the lime which may have remained from the previous bath; this liming and "bating," done in a building known as the "beam house" or "lime house," is a very important step in the making of good, solid belt leather.

Cleansed from hair, flesh and lime, the hides are taken from the "bate" to the "handlers," where they receive their first bath of weak tanning liquor.

Preparing the Tanning Liquor

This liquor is prepared from oak bark. Ten years ago this bark was ground in something like an overgrown coffee mill, but our tannery has been equipped for five years past with an improved crushing machine which does the work quicker and more effectively, and as the crushed bark leaves this machine it is blown by means of a rotary fan through large metal pipes to the leach tubs.

These are 12 feet in diameter, eight feet deep, and hold fully eight tons of ground bark.

To this ground bark water is added by means of rotary brass sprinklers and filtering through the mass, takes up and carries downward the tannic acid.

There is a false bottom in each leaching tub, and the liquor is collected beneath it and pumped away to the storing and supply tanks for use when needed. It is from these tanks that the liquor is drawn for the handler vats in which the hides are put after the "liming" and "bating."

Tanning

The hides are placed in the handler vats across sticks side by side, packed as closely as possible, and are left here for about 10 or 12 days, during which the hide swells, opening the pores and increasing both in thickness and firmness.

When the hides are taken from these vats the bellies and heads are trimmed off and tanned separately for shoe purposes. The butt portions intended for belting are then stowed in vats called "lay-aways." Here they are laid flat, one on top of the other, about a hundred in each vat. Loose bark is spread between the layers, and they are covered with strong tanning liquor.

Hides intended for belting are given five successive layers or treatment of bark. The first layer remains 10 days, and the process is graded up to 40 days for the last layer.

In this way oak tanned belt leather is submitted to a tanning which takes 120 days for the attainment of the best results.

Drying and Finishing the Belt Centers

When the hides have thus been thoroughly tanned they are taken from the vats, washed, so as to remove every particle of tan bark, and then oiled on the grain side, hung up to dry in a darkened loft, where they are kept at an even temperature with very little heat, and gain a beautiful clear russet color. The leather, as such, is now completed, and each hide is cut into widths according to its grade and weight.

The bellies, shoulders and all flabby or imperfect parts are thrown out for shoe purposes, and the central portion or heart of the hide is reserved for belting.

This solid leather is carefully shaved on the flesh side in huge machines, operating somewhat on the principle of a milling machine, and is then scoured by other machinery. The object of this is to open up the pores for the reception of the stuffing of cod oil and pure beef tallow by which the leather is preserved and made suitable for the transmission of power.

Many hours are devoted to this stuffing, and the thoroughness with which it is done lends to belting one of its most prominent features—long life. When the stuffing is accomplished the leather is smoothed and stretched so that the fibers will be made uniform.

Nothing now remains to be done at the tanneries but to allow the leather to dry, brush it off, pack it in bundles and ship it to the belt factory.

The capacity of the Dixie Tannery, of Bristol, Tennessee, owned by the Charles A. Schieren Company, is [illegible] hides a year, and its equipment is used solely for tanning and finishing prime oak leather for belting.

The leather centers and sides, when they reach the belting factory, are from [illegible] feet to [illegible] feet long. At the facnery, after the leather is taken out of the vats, and before the currying process, the shoulders are removed from all of the hides, and each hide is measured four feet from the butt end of the tail to the shoulder, and the shoulder cut straight across so that no piece of shoulder or flanky leather is left on the hide.

After the severe stretching which these pieces undergo during the currying process and in the stretching frames the pieces elongate from four inches to six inches, making each piece four feet to four feet six inches in length, and all of the pieces solid leather.

Operations in Making a Leather Belt

The first process at the belting factory is to select the centers and sides for thickness and weight, and cut them up into various widths for which the stock is most suitable; this is one of the most important processes in the making of leather belting.

After the leather has been cut to width it is transfered to the matching tables, where the pieces are matched in pairs and marked for the scarfing machine; this machine scarfs the laps to a length already indicated by the matcher.

From the scarfer the stock is taken to the feathering-machine operator, who feathers the edges of the laps prior to their going to the pressman to be cemented. The cement used is either our improved belt cement for regular belts to run under dry conditions, or our waterproof cement for waterproof belting. Perfect joints can be and are made with no other fastening than cement, and in most cases riveting or sewing the laps is superfluous; joints that are cemented only have the advantage of running smoother and with less vibration than belts fastened in any other way.

The belt next goes to the finishing department, where it is inspected and where the edges are finished either round or square as the case may be. During the finishing of the edges the belt passes through a stretching device which eliminates all of the stretch or surplus elasticity that may be necessary for good running.

The belt is next turned over to the final finishing table, where the edges are burnished and the roll made up ready for shipment and sent to the shipping department.

Every center-made belt six inches in width and over takes the central portion of one steer hide for every four feet of length single ply, and two steer hides for every four feet of length double ply. A large main-drive belt made by us was 243 feet long and 72 inches wide, three ply thick. It took the best or central portion of the hides of a herd of 549 steers to make this belt. The average area of a steer hide when it reaches our tannery is 40 square feet. The head, shoulders and bellies are trimmed off and tanned separately for shoe purposes, and only 14 square feet, or the central back portion of each hide, is used for first-class belting. This indicates one reason why good belting is expensive.

Belt Specifications

It is hard to suggest a belt specification which would be acceptable to every buyer and every seller, and there is a great divergence of opinion regarding such specifications. From my standpoint the following is reasonable in all respects:

1. The belting shall be short lap, cut from centers of the best oak-bark tanned belting butts, tanned with oak bark by the old slow and long-time process.

2. No piece of leather in the belt shall be more than 54 inches in length, including laps. The leather shall be cut lengthwise from the extreme end of the butt, eliminating shoulder, and offal of every description. No piece of leather in the belt shall be cut from a portion of the hide further away than 18 inches from the side of the backbone of the animal which shows through the center of the butt.

3. The weights shall be as follows: Single belts, 1 to 2 inches in width, 14 ounces to the square foot. Two and one-fourth to 5½ inches in width, 15 ounces to the square foot. Six inches and over in width, 16 ounces to the square foot. Double belts, 1 to 2 inches in width, 28 ounces to the square foot. Two and one-fourth to 5½ inches in width, 30 ounces to the square foot. Six inches and over in width, 32 ounces to the square foot.

The above weights are for the very best brands of heavy oak-bark tanned leather belting. Of course, belts lighter than these weights can be made and are lower in price. The quality of the leather is just as good but the substance of the belt is thinner. A second weight would be one ounce per square foot under the weights above enumerated, and for a very light-weight solid-stock belt the weights would be two ounces less per square foot than the weights above enumerated.

4. Laps. In single leather belts six inches wide or less, no laps shall exceed seven inches in length, or be less than 3½ inches in length. On all wider sizes of single belts no laps shall exceed nine inches in length or be less than five inches in length. In double leather belts, no lap shall exceed six inches in length, nor be less than 3½ inches in length.

5. Cement. All laps of leather belting shall hold securely in every part, and when pulled apart the surfaces then exposed shall show no resinous, vitreous, oily, or watery condition.

6. Tests. Belts must show an elongation of not more than 15 per cent. for single belts, and not more than 13 per cent. for double belts when subjected to a stress of 1500 pounds per square inch; the elongation to be measured under stress. The breaking strain should be about 3200 to 3500 pounds per square inch of unstressed cross-section, both single and double ply.

Belting Factors

Regarding belting factors there are many rules and regulations that are published and talked about. In Europe they use single belts for everything, whereas in America most of our belts above five or six inches in width are double ply. They carry the single-belt theory to an extreme and use single belts a meter wide. Their idea is that a single belt runs better and will transmit much more power than the same amount of leather put into a double belt; this, however, is not true because the transverse strain on a wide single belt weakens it, and a double belt over eight inches is a good investment for any service and is really necessary as a reserve power. In general they figure too close on the power-transmission proposition in Europe and the belt gets the worst of it. Some of these ideas are coming more and more into vogue here. My opinion is that the old rules that have been used for the past 40 or 50 years are the best.

Regarding the length of belts, it is generally safe to figure that the minimum distance between centers should be three and one-half times the diameter of the largest or driving pulley.

A good transmission rule, and one that leaves sufficient reserve power in the belt, is to divide the number of feet that the belt travels per minute by 800; the result is the number of horsepower that a 1-inch single belt will transmit; in other words, if a belt travels 2400 feet per minute, according to this rule a 1-inch single belt under this condition would transmit three horsepower, a 10-inch belt 30 horsepower, and so on.

A good rule for double belts is to divide the number of feet that the belt runs per minute by 500; the result is the number of horsepower that a 1-inch double belt will transmit; in other words, a double belt 1-inch wide running 2500 feet per minute will transmit 5 horsepower, and wider belts in direct proportion.

These are both old rules but they are safe.

It is impossible to give a hard and fast rule in regard to shortening a new belt before it is placed on its pulleys, and in regard to taking up belts that are in use. The factors for such shortening would vary with the different tannages of the belt leather. The old long-time process of tanning gives a long-fibered leather with more elasticity, more life and more staying power than the shorter-tanned leather. A shorter-fibered leather does not stretch as much as the longer fiber, and while it may have a greater tensile strength in the beginning it lacks the durability of the old-style long-fibered oak-bark tannages.

Thus, while it is impossible to lay down an exact rule regarding how much shorter belts should be cut than the actual tape-line measurement around the pulleys, it is safe to say that the average leather belt in the market today should be cut two inches short for each 10 feet of tape-line measurement; thus a belt that is to be 30 feet long when in place on its pulleys should be cut 6 inches short and this 6 inches stretched out of the belt when it is put in place.

By following this method a belt properly selected for the work it is to do should not have to be taken up at frequent intervals.

In regard to a factor for shortening belts in use the same conditions confront us as regards the different tannages of leather as have been mentioned above, that is, the short-fibered leather stretches less and has less elasticity and a shorter life. Two per cent. of the length should be the maximum that a belt will stretch unless it is severely overstrained. Any belt that stretches over 2 per cent. of its length is overstrained, and is liable to break if stretched to a much greater degree.

Care of Belts in Service

Regarding the care of belts in service, belts which are subjected to extreme heat or dryness need a good belt dressing applied perhaps once every six months, in some cases oftener than this, but once every six months will harm no belt if it is properly done, and this treatment has a tendency to preserve the wearing quality of the belt.

For special service leather link belts are made for drives that have short centers, and are the only belts that we guarantee to run quarter turn; their usefulness, therefore, is limited.

Belt Efficiency

The most efficient belt can perhaps be defined as the one that will give the maximum number of horsepower-hours of service per dollar of belt investment. Sometimes engineers tell us that they wish to put in a temporary drive and that they do not expect the belt to last over three months or one year, or two years, as the case may be. On the other hand, we can point to belts that have been running day after day for some 28 or 30 years and they are still in good serviceable condition. It is evident that a larger belt investment is justified in the latter case than in the former, and such cases must be decided on their individual merits.

Perhaps a short rule for the purchaser to remember in order that he may select belts that will give him the maximum number of horsepower-hours of service per dollar of investment is to design the belts with plenty of reserve capacity.

If a belt is figured according to the ordinary rule given in a previous section of this article, there is a certain amount of reserve capacity, yet it is always safe to add to this another 10 or 15 per cent. for a long-life belt. The more reserve capacity the belt has, the longer will it last and the better will it withstand sudden and severe stresses.

However, all of this is a question of good judgment and common sense on the part of the engineer or mechanic who is putting in the drive. It should be remembered that the first cost of the belt is not the only consideration, neither can it be entirely ignored. For greatest economy, all the considerations must balance.

Leakage Past Various Types of Valve

By James Cannell

A resume of the available information upon valve leakage and deductions showing that this follows a provisional law for slide valves and piston valves.

In these days of strenuous attempts to obtain an engine of maximum efficiency, it is most unfortunate that there should be such a scarcity of reliable information regarding valve leakage. The valves in use at the present time may be classified into four groups: the slide valve, the piston valve, the Corliss valve and the drop valve. There are many varieties in each of the groups, but these variations do not affect them greatly as regards their ability to prevent steam leakage.

It appears that only the slide valve has been tested for steam leakage in a manner that can be accepted as reliable. This was done by Messrs. Callendar and Nicolson in a series of tests on a 10½ x 12-inch engine at McGill University, the report of which is to be found in the *Proceedings* of the Institution of Civil Engineers, Volume CXXXI.

Tests were first made to find the difference between the leakage with the valve as it was and the leakage after the valve had been carefully scraped and refitted. As a result of these tests it would appear that the leakage is not merely a question of such minute differences of fit as could be corrected by scraping. Trials were then made at different pressures in order to find the rate of leakage.

From tests with two other slide valves in addition to this, the investigators were able to formulate a provisional law for leakage, they having found that the leakage was independent of the speed and that the results were remarkably consistent. The formula is:

$$K = \frac{C P}{L}$$

where

K = Rate of leakage in pounds per hour per pound difference of pressure;

C = Coefficient depending upon the nature of the oil film; for slide valves, this varies from 0.20 to 0.22.

P = Perimeter of port;

L = Mean overlap.

During the tests it was seen that the rate of leakage appeared to increase slightly as the oil film was gradually dissipated. It is probably that this film of oil makes the valve steam tight when it is still, but as soon as it begins to move, the oil film becomes broken up and leakage occurs.

The only tests of leakage in a piston valve of which the writer has knowledge were made by Mr. Mitchell at the University of Pennsylvania and published in the October 11 issue of POWER. It is unfortunate, however, that these are presented in such a manner that an analysis of the tests gives only an approximately correct result, but it gives the data necessary for arriving at a formula for expressing the rate of leakage.

In these tests the leakage is shown to increase at the rate of three pounds per horsepower per hour. As the description appears to indicate that the engine was governed through varying the expansion, this leakage evidently occurred at a practically constant pressure difference. The length of the valve face was 1 ⅛ inches, the total length, therefore, being 2¼ inches, and the perimeter of the port was 17.3 inches. According to the foregoing experiments on leakage through a slide valve, the rate of leakage would be constant under the same conditions as that given for the piston valve, and it is not conceivable that it would be otherwise with a piston valve. Hence, taking the average leakage as given, 185 pounds at 100 pounds pressure, the law of slide-valve leakage can be applied to the piston valve and the value of the constant C can be found for piston valves.

$$C = \frac{L K}{100 P}$$

$$C = \frac{1\frac{15}{16} \times 185}{100 \times 17.3}$$

$$C = 0.207$$

From this it is seen that this test shows the coefficient *C* to be practically the same for piston and slide valves.

The following tests illustrate the practical use to which this knowledge of valve leakage can be applied. They were made on a 330-kilowatt high-speed engine fitted with piston valves and the experiments were carried out in order to improve the economy of the engines of this type.

They were first made at various loads with a standard engine which had valves without rings, and which had run for some days to give its bearings, piston rings, etc., time to get to a proper working fit. The engine was governed by the throttle. The curves, here shown, representing the total steam per hour, follow Willan's law.

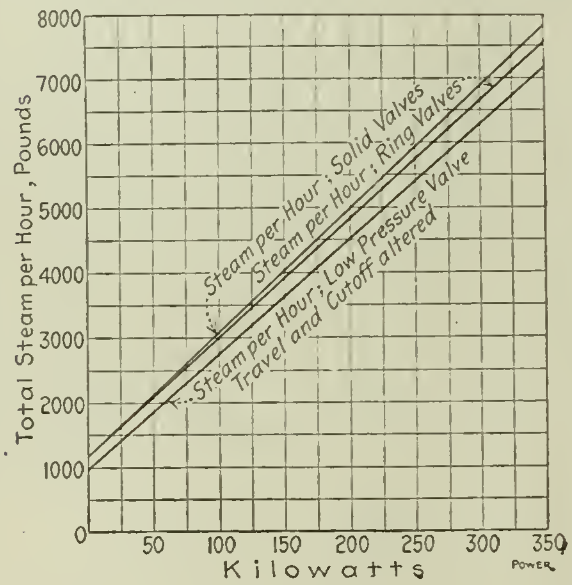
The curves show that the gain in economy with the ring valves is about 3 per cent. at full load, but at light loads there is practically no gain. This gain at full load was greater than was expected and the gain diminishing with the load is probably explained by the fact that the pressure is reduced with the load.

It was then decided to lengthen the travel of the low-pressure valve by fitting a new low-pressure eccentric; this permitted a greater length of valve face, and, as Messrs. Callendar and Nicolson found that the leakage of a slide valve was directly proportional to the length of the face, it was hoped that an appreciable saving would be effected in the economy of the engine. The travel of the valve was altered from 4½ to 6½ inches and at the same time it was arranged to cut off at 45 per cent. of the stroke instead of 60 per cent. This enabled a still greater length of valve face to be obtained. Altering the cutoff in the low-pressure cylinder does not affect the power of the engine but it slightly alters the distribution of the load between the cylinders. These alterations increased the length of the valve face from 4½ to 6 inches at the top end and from 4¼ to 5¾ inches at the bottom, giving a total difference of 34 per cent.

The results of tests at various loads with the longer travel low-pressure valve are shown by the bottom curve. Comparing these with the previous tests in which ring valves were used, it is seen that there is a gain by giving a longer travel to the low-pressure valve and having an earlier low-pressure cutoff of about 4.5 per cent. at full load and about 7 per cent. at half load. Also, the curves show that 350 pounds of steam per hour has been saved at full load but the saving gradually decreases as the load decreases.

It might be considered that altering the low-pressure cutoff improves the economy of the engine; however, it has been proved that this does not affect the economy in the slightest degree, both on piston-valve engines and on slide-valve engines.

As far as can be ascertained there are no published tests of the steam leakage of Corliss valves. It would seem probable that the leakage would follow a law somewhat similar to that of slide-valve leakage. However, it is shown by Messrs. Callendar and Nicolson that this should not be so in actual practice as with this type of valve both the live and exhaust steam do not pass through the same valve. They stated that the leakage probably occurred mainly in the form of water which was condensed on the valve faces, and then reëvaporated. As the result of their tests, they stated that this leakage might be greatly reduced by jacketing or otherwise heating the valve seat and thus minimizing the condensation; furthermore, that an engine with



LEAKAGE AT VARIOUS LOADS

separate steam and exhaust valves would possess advantages as regards steam leakage over a slide-valve engine, owing to the smaller condensation on the steam-valve face.

In the discussion on a paper read before the Institution of Mechanical Engineers in July, 1904, Mr. Longridge stated that superheating played an important part in reducing valve leakage. With fluids of small viscosity, such as steam and water at high pressure, the velocity of flow through a small orifice such as might be supposed to exist between a valve and its seat would depend almost entirely upon the difference of the pressure and would be practically equal under a given pressure whether the leaking fluid were steam or water. As the density of water is so much greater than that of steam, it is easily seen that the weight of water leakage would be very much greater than that of steam, and the effect of condensation is evident.

With drop valves the seats are either flat or conical. Experience has shown that flat seats are preferable provided the dashpot is of an efficient type; or if a positive gear is used, it might be considered that the leakage through these valves would be practically nil, for when steam is not being admitted the valves are on their seats and there is no clearance between the valve and its seat. This, however, is not true in practice, for even with the valves made to fit as perfectly as possible there is a slight leakage of steam, and if they be of large diameter this leakage becomes sufficient to run the engine if a high vacuum is maintained in the exhaust pipe and there is no load.

Tests showing the leakage of these valves have not been published, but in Volume CLXXIII of the *Proceedings* of the Institution of Civil Engineers, Mr. Preece shows that the leakage is less than with valves which have rubbing surfaces where a certain amount of clearance is necessary.

In actual practice with piston- or slide-valve engines the gain due to superheat is much greater than the gain with the same amount of superheat in drop-valve engines. This larger gain is maintained up to a certain degree of superheat, after which the gain due to increased temperature is practically the same for both types of engines, and this is correct whether the engines be expansion or throttle governed. This can be explained only by the fact that the condensation on the valve face of the slide or piston valve is decreased by the increasing temperature until the point has been reached at which the leakage of these types of valves becomes equal to that of the drop valve, the cylinder condensation and all other things affected by the superheat being the same with each type.

Warnings

The Manchester Steam Users' Association issues the following:

Don't overload the safety valves or tamper with them.

Don't let the water level sink out of sight.

Don't allow the cocks and valves to set fast.

Don't open the steam stop valves hurriedly.

Don't empty the boiler while steam is up.

Don't open manholes before easing safety valves.

Don't raise steam hurriedly.

Don't use unknown scale solvent or compositions.

Don't slake ashes against boiler fronts.

Old Hal Mossback, th' ingineer et th' ladies' rat factery, went t' sneeze tother day and his false teeth drapped out an' rolled inter th' flywheel. Hal wanted t' shet down an' get 'em out but th' boss told 'im the th' wimmin hed th' rat bizness rushed so dumd hard thet they didn't hev time t' stop. Hal sed he gessed thet et wuz up t' 'im ter live on soup th' rest uv th' week.

Cooling System for Condensing Water

By R. O. Warren

A homemade tower costing but $425 for material and labor lowers the temperature 50 degrees of all the circulating water used for 1500 horsepower of condensing engines.

A homemade cooling tower, costing but $425 for labor and material, is installed at the power plant of the Fitchburg & Leominster Street Railway Company, Fitchburg, Mass.

There is a made pond, having a natural bottom and concrete side walls, that contains the water used for condensing purposes. City water is used exclusively for boiler feed, which, when condensed, is discharged into this pond, the supply being more than sufficient to make up for the loss by evaporation. The pond is 70x70 feet, with a depth of 7 feet. Pond water is not used for boiler feeding, because it is contaminated to a considerable extent with dirt and oil.

The design of the cooling tower is shown in the accompanying illustrations. It is a structure 150 feet long and 10 feet wide, equipped with three cooling platforms, as shown in Fig. 1.

The platforms, all of which have a drop of 1 foot in 50, are made of 2-inch spruce planking and are supported by 6x6-inch timbers, each 8 feet long. The top cooling floor has baffle strips secured to the upper surface in the form of a V, which ruffles the water and causes some of it to fall over the edges of the platform, as shown in Fig. 2. There are four rows of side deflecting pieces, also shown in Fig. 2, the three top deflectors slanting toward the outside edge and downward; the lower one slants toward the bottom floor. This arrangement causes the water to drop from one deflector to the next one below, the bottom deflector catching the water and diverting it to the lower cooling platform.

The condensing water is discharged from a jet condenser through a 14-inch pipe which is capable of taking care of two of the largest engines in the plant. The second discharge pipe is 10 inches in diameter and is connected to a second jet condenser. Both of these pipes are fitted with a Y connection, so that by opening a valve in the bottom pipe, the condenser water can be discharged direct to the pond through the lower pipes, shown in Fig. 3, without passing over the platforms of the cooling tower. This is desirable when the water is at a high level in the pond due to heavy rains, for it is then cool enough for condensing purposes. The discharge from the lower platform is onto a float, as shown in Fig. 2. This causes the water to flow into the pond in a thin film from the four sides of the float.

The temperature of the circulating water, after passing over the cooling platforms is lowered 50 degrees Fahrenheit. The tower will easily handle the

Fig. 3. Arrangement of Discharge Pipes

Fig. 1. Showing Three Cooling Platforms

Fig. 2. Showing Deflecting Boards

condensing water for 1500 horsepower of engines and 2000 horsepower if necessary, although there would be less drop in temperature with the greater quantity.

The pond is connected to the suction well by a 24-inch pipe. In case it is necessary to clean the well, a gate is lowered over the end of the 24-inch pipe leading to the pond. The slides for the gates are made of railroad rails and the gate is raised by means of a handle passed through an extension rod.

Special Setting for Water Tube Boilers

By Edward J. Kunze

An outline of the fundamental principles of combustion and heat transmission, application of which is made in a special form of setting intended to eliminate smoke when using soft coal.

Viewed from the standpoint of smoke formation, one of the worst conditions where soft coal is used, is that of having the grate directly under the tubes in the first pass. In many plants, thus equipped, there is not enough space in front of the boilers to permit adding an extension furnace, and it is to meet this condition, particularly, that the setting here illustrated was designed. Before examining in detail the constructive features of this setting it might be well to consider the fundamental principles which underlie its use.

Among the agents that prevent the proper mixing of air and gas are the so called "neutrals" consisting mainly of carbon dioxide, nitrogen and water vapor. If enough neutral is added, combustion may be entirely prevented. For instance, if one part of carbon dioxide is mixed with seven parts of a combustible mixture of gas and air, ignition and combustion will not take place. Likewise, if one part of nitrogen is mixed with six parts of the combustible mixture, the power of combustion is nullified. Therefore, it is important that the neutrals be removed from the combustible matter as soon as they are formed. If the water vapor, formed by combustion, is allowed to mix with the heated gases, it may also become dissociated, taking up heat from the surrounding gases and cooling them.

The quantity of steam in a boiler produced does not depend upon the intensity of the fire, but upon the amount of heat absorbed by the water from the burnt gases which are the conveyer of the heat. According to Perry's theory, the rate of impartation to a boiler tube is for ordinary gases proportional to:

1. Temperature difference of the gases and the metallic surface.
2. Density of the gases.
3. Velocity of the gases parallel to the metallic surfaces.
4. Specific heat of the gases at constant pressure.

To these I should add:

5. Character of the metal surface.
6. Heat-conducting property of the metal.

Usually the first factor alone is considered. The second assumes that an increase in density causes the contact between the molecules of gas and the part to be heated, to be more intense. From the kinetic theory of gases the individual molecules of gas give up their heat by vibrating against the metal; the greater the number of molecular impacts per second against a unit area of the metal, the greater the amount of heat imparted to the metal. But the number of impacts is directly proportional to the density, which, in turn, at a constant pressure, is inversely proportional to the temperature. On this account there is a direct neutralization of gain when striving for high temperature; for, as the temperature is raised, the number of molecules in action against any portion of the heating surface is reduced.

Regarding the third factor, consider the molecules of the metal in a state of rapid vibration with spaces between them much larger than the molecules. Entangled among the outer molecules of the metal there would be comparatively stationary molecules of gas held close together in a dense film next to the metal. Farther out, normal gas is reached, where the molecules are widely scattered. These gaseous molecules would be in a state of rapid vibration, but those close to the metal would be more or less bound by the attraction of the metal, and serve as a poor conductor of heat. Hence, the hope of transmitting more heat lies in the dislodging of the slowly vibrating molecules and replacing them with rapidly vibrating or hot ones. The dislodging molecules fly back and forth perpendicularly to the surface, and this scrubbing effect on the layer adhering to the metal is proportional to the velocity of the gas parallel to the heating surface. This velocity, therefore, has an important influence upon the heat transmission.

The products of combustion at a high temperature take the shortest course and will not spread over the entire heating surface unless external means such as baffling are resorted to. In order to prevent the thinning out of the heat current or short-circuiting the flow, A. Bement advises increasing the number of passes. He gives, as a result of changing from the single to the double pass, an increase of 10 per cent. in efficiency and about 4 per cent. more horsepower than the regular design of boiler. The result of triple passing as compared with the single pass gave an increase in efficiency of about 20 per cent. and an increase in capacity of approximately 4 per cent. In other words, the increased capacity of this triple pass is the same as with the double pass, although the gain in efficiency is twice as great. With the double pass the draft at the fire was unaffected. With the triple pass, however, the resistance offered by the passages reduced the draft at the fire, so that less coal was burned than with the same boiler having a single pass; but this is not a serious objection, because more horsepower was produced. Since baffling of this character brings into use twice as much or more boiler surface than was formerly utilized, it justifies the realization of a much larger capacity and the use of higher draft.

In considering factor four, it is evident that since a given volume of any gas at any temperature and pressure contains the same number of molecules as the same volume of any other gas under the same conditions, and since various gases upon cooling give up various amounts of heat per degree of temperature drop, a given number of molecular impacts of different gases will give up more or less energy according as the specific heats of the gases are respectively higher or lower.

Regarding factor five, the nature of the metal surface, this affects the heat transference by its ability to more or less entangle the molecules of the gas.

The reversed setting here shown has been criticized because it requires a greater hight, of about 4½ feet, in both setting and boiler house, with a correspondingly larger investment and maintenance cost; also that the mud drum is over the ignition arch. It is claimed further that this arrangement is not as effective in producing complete combustion as one which pitches downward toward the back. The writer believes, however, that these objections are not well taken.

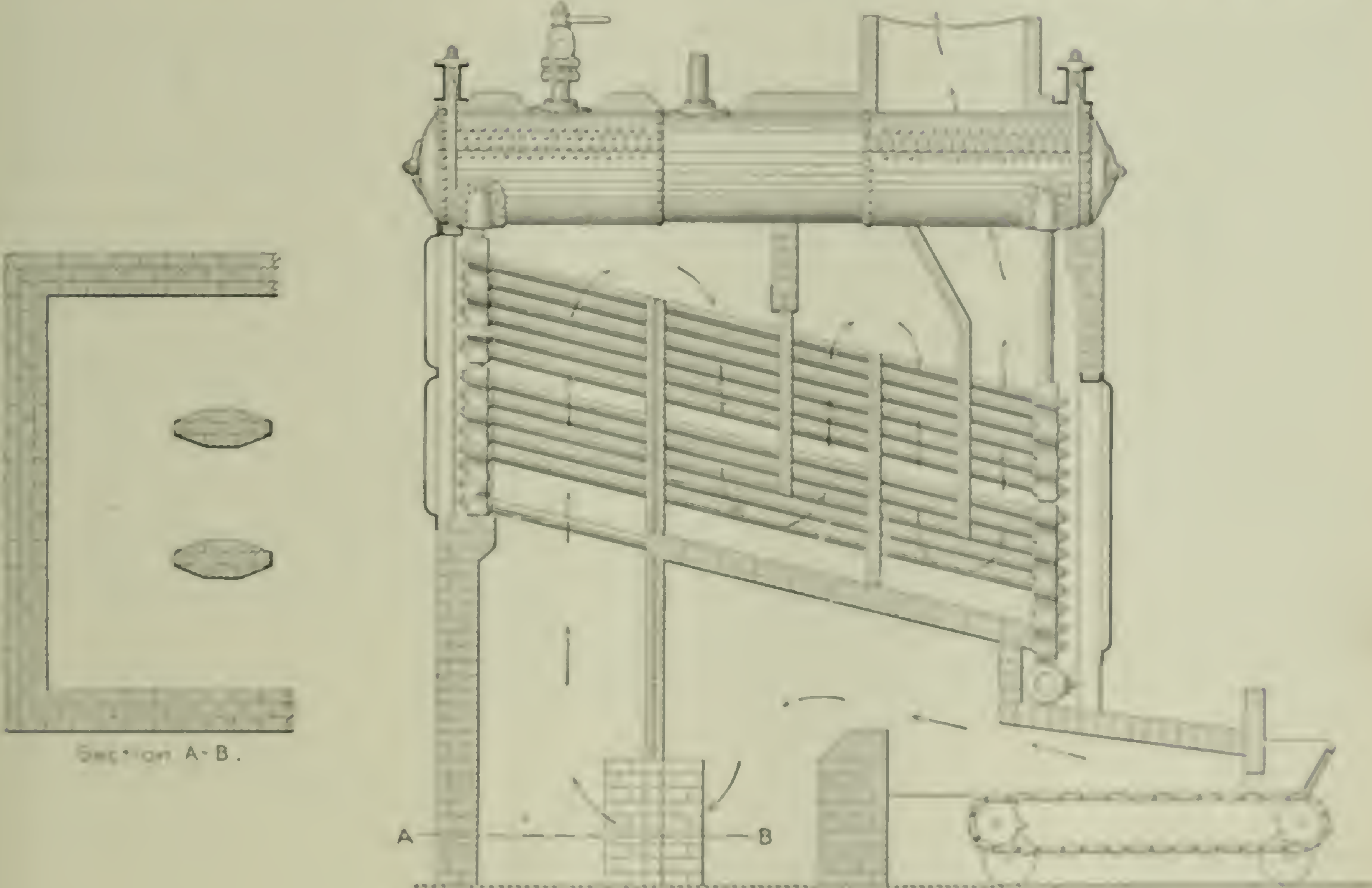
The advantages of a larger combustion chamber more than counterbalance the expense attendant upon a higher setting, and while it is admitted that the extra hight increases the cost of the building, it is more essential to decrease

*From a paper delivered at the annual meeting of the Michigan Engineering Society, January 11, 1911.

floor space which is more valuable, especially in plants already constructed. Floor space costs more than hight in large cities; also it is more necessary to keep the floor space in the boiler room reduced to a minimum than is the case with the engine room, so that corresponding units, especially in steam-turbine plants, may be as close as possible to each other. Regarding the mud drum, this is protected by hollow firebrick, and it would not be heated to as high a temperature as is the case where unprotected in the rear of the boiler, as is true of many settings now in operation.

The last objection may be answered by saying that in the design here shown the gases are diverted downward and pass through a more or less restricted area before rising to the tubes.

Another objection that has been raised to the reversed setting is that the radiation and unaccounted for losses would be increased. The fact is that in the majority of cases these losses amount to about 1 per cent. of the total heat available and most of this loss occurs through and around the doors, and is due to the necessity of opening the doors for feeding, slicing, poking, etc. In the case of well painted brickwork, it is often found necessary to heat the boiler room by some other means, not enough heat being radiated from the boilers.



Section through Boiler Setting

The advantages of the setting, as submitted here, may be summarized as follows:

1. Increased combustion-chamber volume without increased floor space.

2. Decreased velocity of the gases as they enter the combustion chamber, since there is a gradual increase in cross-sectional area. This permits better mixture between the combustible gases and the air, tending to avoid the formation of air shoots or impinging streams of cooler air with the accompanying tendency to effect an unequal heating of the tubes and cause unequal expansion of parts. The better mixture permits a reduction in the percentage of excess air required, hence there will be less cooling of the gases and better economy. Ordinarily the time required for the gases to pass from the grate to the heating surface of the boiler averages considerably less than a second, which is a very short time for the process of combustion to take place. If the passages are of large enough cross-section, a better opportunity is given for the neutral gases to separate from the burning gases; the latter, being hotter and lighter, will take the upper paths while the carbon-dioxide, water vapor and similar gases take the lower paths and avoid the detrimental action of preventing proper combustion. If the carbon dioxide generated on a thin fire is permitted to rise promptly from the fuel bed, as is the case when the space above the grate is large, there is less tendency for conversion into carbon monoxide. It is only when the carbon dioxide is passed through a thick bed of fuel or in close contact with an incandescent bed of fuel that this conversion takes place.

3. With the baffle in the rear, the gases are brought close together because of the restricted area just before rising to the tubes; therefore, there is a greater tendency toward complete combustion, and equal heating exists.

4. The large combustion chamber affords a large capacity for heat storage.

5. The larger cross-sectional area of the combustion chamber permits the introduction of firebrick baffles, without reducing the area of draft.

6. There will be a tendency for a body of air or cooler gas to collect under the roof. This body would not move as fast as that directly in the line of travel. As this line of travel is lowered by the baffle in the rear, there will be less injury to the furnace roof due to erosion than in the case of the downward sloped roof.

7. The boiler tubes can be readily removed or cleaned from the front of the boiler, thus avoiding the requirement for much room at the rear of the boiler for this purpose.

Indicator Diagrams and Calculations

By Frank S. Bunker

The steam-chest and the friction diagrams and what they show. The valve-rod diagram and how it is obtained. Method of plotting the combined diagram and the diagram of useful work. How to estimate the quality of the steam and the cylinder clearance from the diagram.

The taking of indicator diagrams from the cylinders of an engine and the subsequent examination, together with the time-worn formula,

$$HP. = P\,L\,A\ (2N) \div 33{,}000,$$

using the mean effective pressure estimated from the diagram to ascertain the indicated horsepower, form a part of every engineer's stock in trade.

The indicator diagram is, in reality, a graphic portrayal of the performance of the working medium (steam, gas, etc.), in whatever type of machine it may be necessary to inspect.

With favorable conditions and an equipment in proper shape, diagrams may be obtained which can be accepted as an infallible guide. Every precaution should be taken so that the sample of the working medium tested by the indicator will have the same physical and chemical qualities as those of the mass from which it is drawn. Care should be exercised so that the temperature, the degree of saturation or dryness fraction and the degree of superheat, if there be any, be unaltered. In other words, make the conditions in the indicator conform as closely as possible with those in the part under examination.

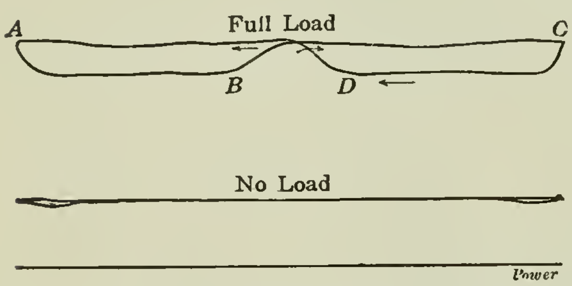


Fig. 1. Steam-chest Diagram at Full and No Load

Valve-chest Diagrams

Diagrams taken from the steam chest of an engine are always advisable as they show the fluctuation of pressure that takes place there and are thus a very good indication of the adequacy or the inadequacy of the carrying capacity of the steam-supply pipe which for many reasons may not supply the engine with the necessary number of B.t.u. An insufficient supply may be due to too small a supply pipe, a very crooked pipe offering an excess of friction or to an exceptionally long pipe improperly insulated, thereby causing excessive condensation.

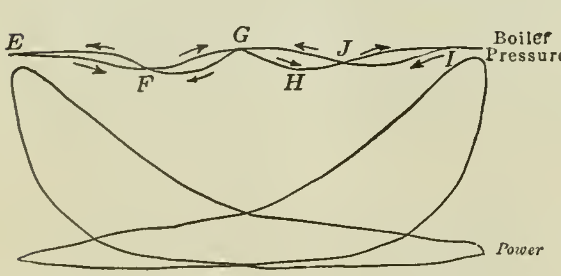


Fig. 2. Combined Steam-chest and Cylinder Diagrams

Fig. 1 shows diagrams taken from the steam chest of a high-speed engine under full load and under no load. The speed was 325 revolutions per minute and the cutoff, ⅖ of the stroke. As the valve opened at points *A* and *C*, the pressure dropped, thus showing the draining influence of the engine on the steam supply. When cutoff occurred at *B* and *D* the pressure rose to boiler pressure.

Fig. 2 shows combined steam-chest and cylinder diagrams from a twin-cylinder high-pressure launch engine with atmospheric exhaust. One steam chest supplied both cylinders with steam through two D-valves. The valve opened to steam at *E* and caused a drop in pressure until cutoff at *F*, after which the pressure rose to *G*, at which point the companion cylinder began to take steam and cause the drop in pressure to *H*. After cutoff the pressure again rose to boiler pressure until the end of stroke, when the opposite end of the first cylinder again took steam, causing a drop along the line *I J*, and thus the cycle was continued on back to the original point *E*.

Friction Diagrams

Another diagram of vast importance is the friction diagram. With its aid it is possible to estimate the amount of power necessary to overcome the friction of the engine. Such diagrams are taken in the usual manner with the engine running at full speed but with absolutely no outside load.

Fig. 3 shows a set of friction diagrams taken on a cross-compound automatic engine of 1200 horsepower capacity. The boiler pressure was only 37.5 pounds. The high-pressure diagram was taken with a 15-pound spring and the low-pressure with a 10-pound spring. The high-pressure diagram indicated 81.7 horsepower and the low-pressure indicated — 5.2 horsepower. This nets a total of,

$$81.7 - 5.2 = 76.5$$

indicated horsepower. It therefore required 76.5 horsepower to overcome the internal friction of this 1200-horsepower engine.

Friction diagrams are valuable for they give information which will oftentimes indicate trouble due to increased friction and consequently increased waste of power.

The Valve-rod Diagram

Although the valve-rod diagram is unique, very valuable information may be obtained from it. The indicator is placed on the cylinder of an engine having an inertia governor and consequently having a variable valve travel. The paper drum receives its motion from the travel of tho valve stem. The length of the diagram should be as near as possible some even fraction of the valve travel as ¾, ½ or ⅓, as this will greatly facilitate later computations. Having determined this fraction it will be necessary to open the valve chest and obtain the following data for use with the diagrams: width of steam port, steam lap and exhaust lap when the valve is in mid-position.

With these data as a guide, a valve model is constructed, as shown below the diagram in Fig. 4. The line *C L* being the mid-position, lay off from it equidistant on each side the distances *K* and *L* equal to the exhaust lap and the distance $K + M$ and $L + N$ equal to the steam lap. The distances *P* and *Q* are equal to the width of the steam ports and the total distance overall is the total valve travel. The diagram shown in Fig. 4 is a facsimile of a diagram obtained in the manner described, by giving the paper drum its motion from the valve travel.

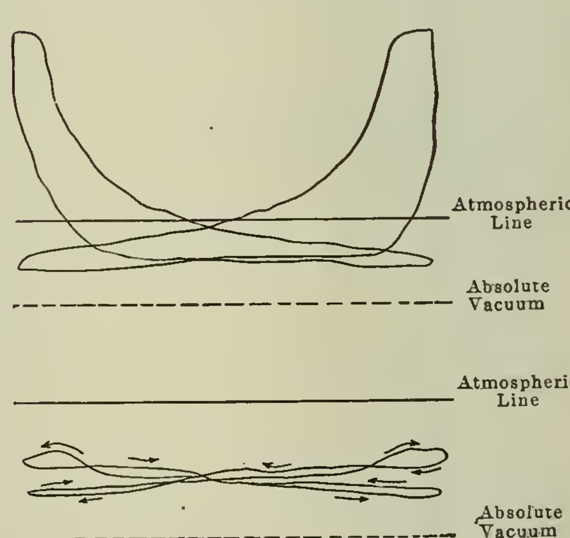


Fig. 3. Friction Diagrams from a 1200-horsepower Compound Engine

After dividing the total length of the diagram into two equal parts and marking the center as the mid-position, then by placing the valve model *mid-position* in line with this position and extending the various lines in it upward until they cut the diagram the perfect cycle of events is shown much more clearly than with diagrams of the ordinary kind. At *a*, exhaust has just closed and compression begins and when the valve has traveled the distance equivalent to *K* the valve is in mid-position. Compression continues until the distance $L + N$ has been traveled, when the valve opens to lead and the pencil rises along the steam-inlet line and continues on along the steam line to the end of the valve travel, getting slightly higher as the valve opening increases and slanting downward as the valve opening diminishes until the point *b* is reached. At this point the steam valve closes, cutoff is completed and expansion begins. During the expansion of the steam in the cylinder the valve must travel through the distance $N - L$ or the steam lap and through the distance *K* or the exhaust lap. At the point *d* the valve opens to exhaust and the pressure drops until forced to rise slightly by the forcing effect of the piston in purging the cylinder. The pressure continues thus until the exhaust closes at *a*. On no other type of diagram can the points of absolute cutoff and release be ascertained as accurately as on this type; and as the load changes and the valve travel increases or diminishes, the same events may be distinguished even though the travel becomes so short as not to allow the valve to uncover the steam ports.

A leaky piston may be indicated by this diagram as well as by any other, and in the case of leaky valves it will show the exact point in the valve travel at which the leak occurs.

The diagram may be taken from any engine having a piston or slide valve. It is exceptionally valuable with engines having inertia governors as it gives accurate information in regard to the action of the governor during operation when it is not possible to get data in any other way.

The Combined Diagram

It is often necessary to reconstruct the diagrams obtained from an engine the better to portray the performance of the machine. This is especially true of compound-, triple- and other multiple-expansion engines for which the diagrams are so reconstructed as to appear as if the steam had acted all the time upon the low-pressure piston only. In reconstructing diagrams of this type they are all plotted upon the same *volume* base, but with the respective pressures represented by ordinates whose lengths are directly proportional as the scales of springs used.

Fig. 5 shows indicator diagrams from the high- and low-pressure cylinders of a very poorly designed engine. The

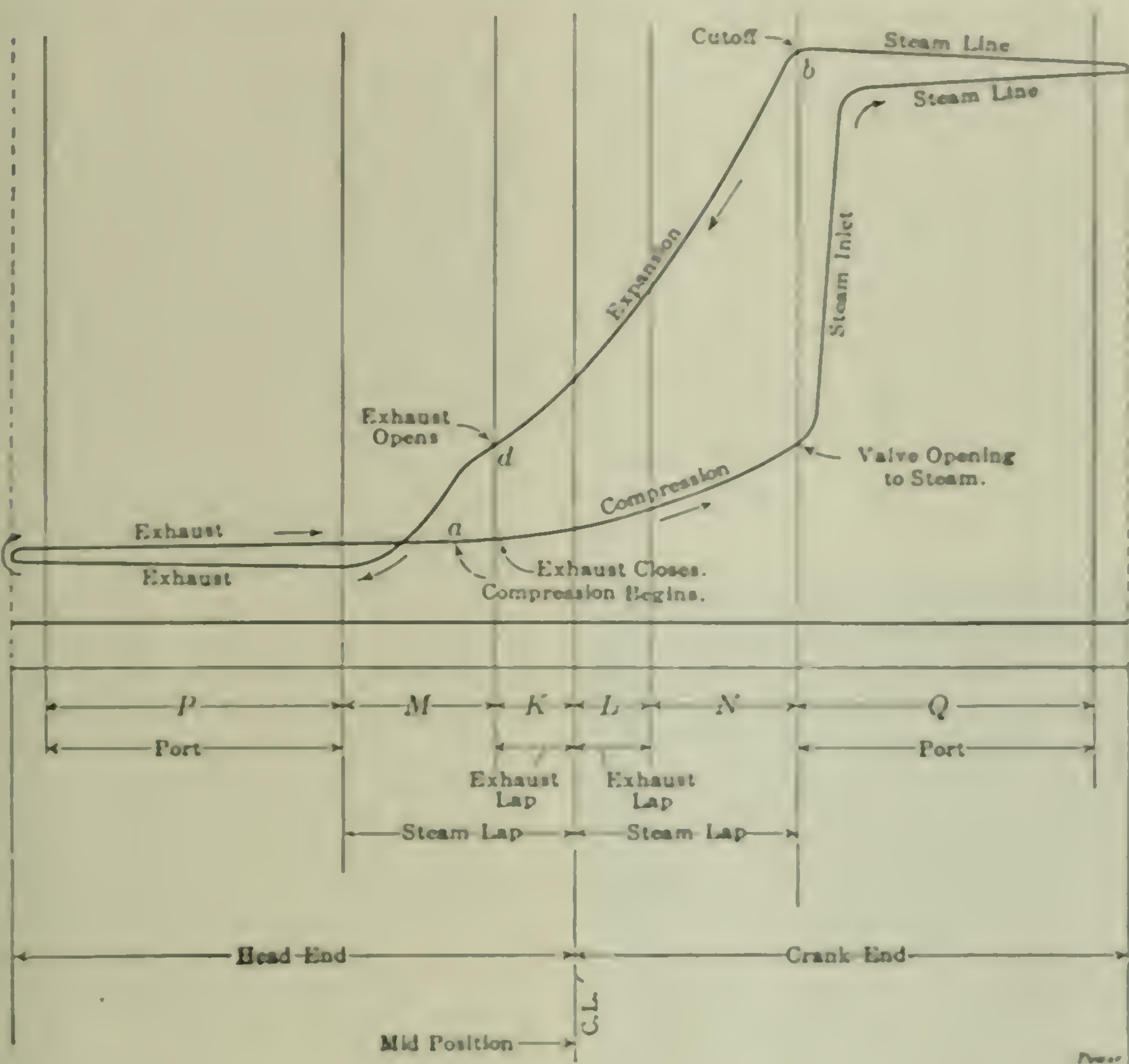


FIG. 4. VALVE-ROD DIAGRAM

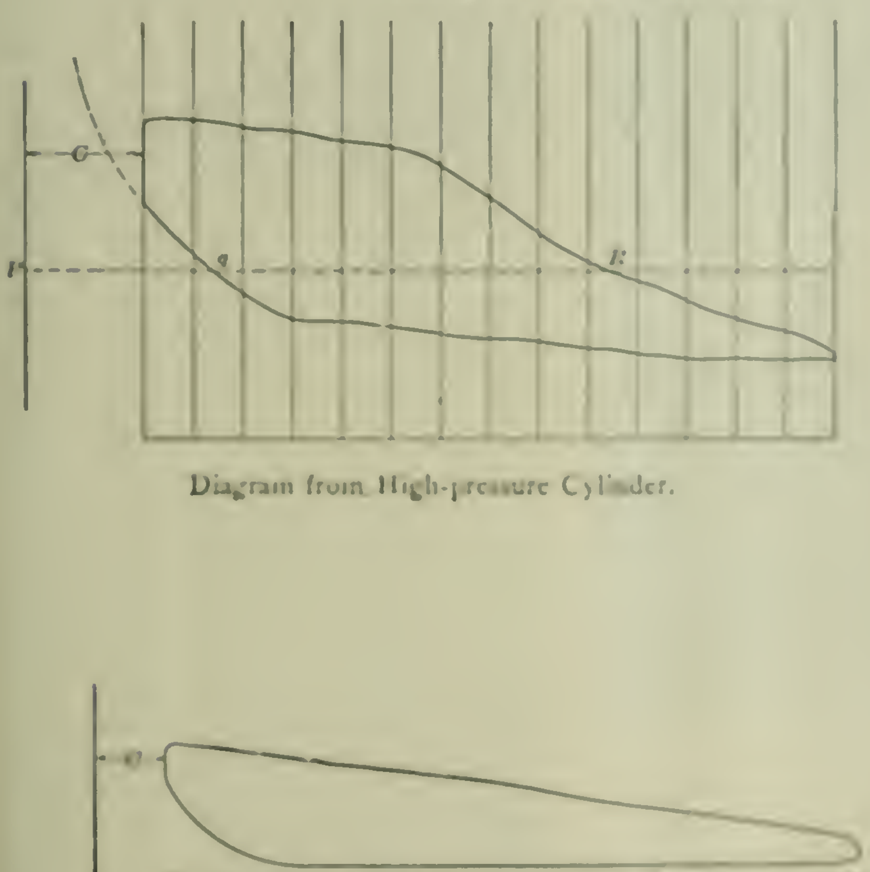


Diagram from High-pressure Cylinder.

Diagram from Low-pressure Cylinder.

FIG. 5. HIGH- AND LOW-PRESSURE CYLINDER DIAGRAMS

FIG. 6. THE COMBINED DIAGRAM

spring used for the high-pressure diagram was calibrated for 100 pounds; that for the low-pressure, 40 pounds. The cylinders were 20 and 30 inches in diameter, respectively.

In Fig. 6, *R S* is the atmospheric line and the vertical line *R T U* is the line of zero volume. The low-pressure diagram is here plotted with the clearance volume shown as *R V*. The horizontal line *W X* is the pressure line of the low-pressure diagram.

Returning now to the high-pressure diagram in Fig. 5, it is necessary to divide the diagram into a number of ordinates for future plotting. As the high-pressure spring was 100, and the low-pressure spring 40. in plotting the high-pressure diagram in the proper proportion it will be necessary to multiply each ordinate in Fig. 5 by $\frac{100}{40}$ or 2.50 before transferring to Fig. 6. Furthermore, the

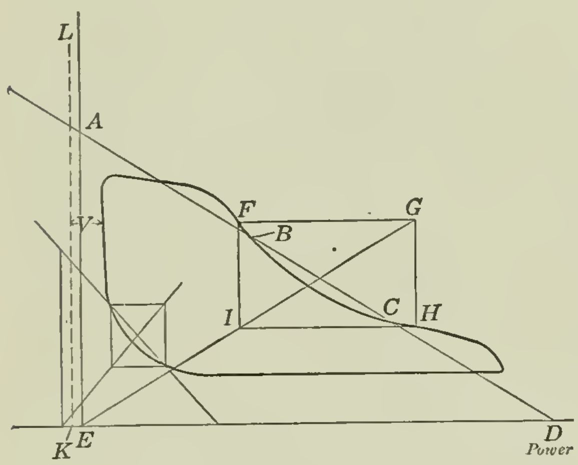


Fig. 7. Illustrating Method of Estimating Clearance

diagrams must be on the same volume base; and as the cylinders were 20 and 30 inches in diameter, the volumes swept through by the pistons vary as

$$20^2 : 30^2 \text{ or } 4 : 9 = 2.25.$$

Therefore, the horizontal length of the high-pressure diagram must be reduced by dividing its total length by 2.25. The reconstructed high-pressure cylinder appears in Fig. 6 in the upper half. In this diagram the work done in the high-pressure cylinder is represented on the same scale as is that done in the low-pressure cylinder.

The length *V S* represents the volume swept through by the piston and *R V* the clearance volume. At the pressure *R W* the actual volume of steam expanding in the cylinder is represented by *W X*. Of this total volume the amount *W Y* was trapped by the valve at the commencing of compression. Therefore, the volume represented by *Y X* is the steam which entered as new steam while the steam port was open and which will pass out during exhaust.

In the high-pressure part of the reconstructed diagram it will be seen that if the compression of the imprisoned steam had continued up to the initial pressure, the compression curve would be as *e f g* and the clearance volume would be quite full of steam at that pressure at the beginning of the stroke. All steam which then entered the cylinder would perform useful work while the compressed steam would act merely as a buffer and would exert as much work on the piston as was expended on it by the piston during compression. It therefore would neither contribute nor detract from the net useful work performed. When the cushion of steam is not compressed to boiler pressure, the incoming steam performs that function. The clearance volume represented by *U h* is filled with steam at the beginning of the stroke and the volume of the cushion steam at the same pressure is represented by *g h*. The difference or *U g* is, therefore, the volume of steam necessary to complete compression and the area *f g h* represents the amount of work lost thereby. This is replotted as *h j f* and this indicates the reduction of the area of useful work.

By referring now to a diagram of a rectangular hyperbola and placing the line of zero volume on the vertical axis *R U* and the line of zero pressure on the atmospheric line *R S*, the curve which most nearly corresponds to the expansion curve of the two diagrams may be plotted as *m n p*.

The area between the two diagrams represents the loss due to the poor construction of the engine and the faulty proportions of the design. The area between the hyperbolic curve and the diagram areas represents the losses due partially to this cause and partially to throttling, wiredrawing, radiation and condensation, and if an adiabatic curve is drawn in place of the hyperbola, the loss will show as due to condensation in the cylinders over and above what would have occurred with adiabatic expansion in cylinders which were nonconductive.

Steam Quality

The quality of the steam as it passes through an engine may be determined from the combined diagram. During the test determine the steam consumption and from this calculate the weight of steam used per stroke. Draw a horizontal line as *T e n r* so as to cut the expansion and compression curves. The line *T e* represents the cushion steam and *e n* the actual volume of steam passing through the engine per stroke. The line *t r u* is a saturation curve. Then *n r* must represent the volume of steam which has condensed and exists as moisture at that pressure.

If *n r* represents the moisture and *T n* the dry saturated steam in the cylinder and clearance space, then $\frac{T n}{T r}$ will represent the fraction of the whole which is dry saturated steam.

This is called the dryness fraction. To determine the location of the saturation curve on the diagram it is necessary to find the point *r*. The distance *e r* is laid off to represent the volume of steam used per stroke of the engine as spoken of previously.

As the same total weight of the steam and water mixture will exist throughout the stroke, it is only necessary (by reference to steam-saturation tables) to obtain the volume of that weight of dry-saturated steam at various pressures and to plot them at the right of the compression curve which, if too short, may be continued by reference to the rectangular hyperbola, as in the dotted line *f g*.

The same process is followed for the low-pressure cylinder and is necessary on account of the difference in the clearance space of each cylinder. The line *y z* is the saturation curve of the low-pressure diagram.

Estimating the Clearance

The clearance space of an engine is generally calculated from the working

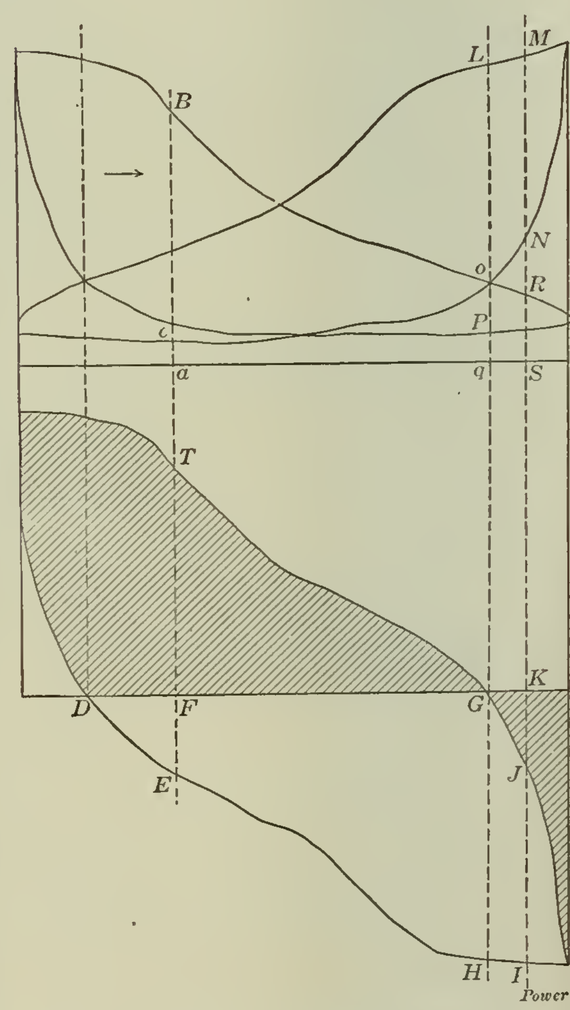


Fig. 8. Resultant-pressure Diagram

drawings of the engine. It may also be found by filling the cylinder and clearance space with water and in this way calculating the required volume. Fig. 7 serves to show the way to approximate the clearance volume from an engine diagram. Draw any line *A B C D* cutting the expansion line and lay off from *B* a distance *B A* which is equal to *C D*. Through *A* erect the perpendicular *A E* to the atmospheric line *E D*. Another method is to construct a rectangle as *F G H I F* parallel to the atmospheric line and with opposite corners on the expansion line *F H*. Then, the opposite diagonal is drawn and extended until it intersects the atmospheric line as at *E*. The same method may be followed with the compression curve and a general average taken of all the results as the dotted line KL which is then drawn. Its distance from the diagram area as V represents the approximate clearance volume of the particular cylinder under consideration.

Useful-work Diagram

It is often useful to reconstruct a set of diagrams to obtain the resultant of the positive and negative pressures acting on the piston. This is a graphic portrayal of the useful work done by the working medium. Such a diagram is shown in Fig. 8. At any point a in the stroke of an engine the pressure exerted for useful work is represented on the diagram by aB, and the pressure on the opposite side of the piston by ac.

The resultant effective pressure is therefore the differences between these two or cB. In plotting the resultant-pressure diagram, effective forward pressures are all plotted above a central line and effective pressures in the opposite direction are plotted below the line. Let $DFGK$ represent this central line. At F plot $FT = cB$. When the piston reaches q the forward pressure is qo, but the back pressure due to compression on the opposite side of the piston is also qo, so the effective forward pressure is zero and the resultant pressure line therefore crosses the base line at G.

With the piston at S and still moving in the same direction as the arrow the forward pressure is SR and the back pressure SN. The resultant is the difference or RN and is in the backward direction and therefore is plotted downward at KI. As the motion continues the same process is carried out. The cross-hatched section above the line represents the useful work done on the piston in the forward position by the steam and the shaded area below the line represents the negative work due to the purging action of the piston during exhaust and the compression. The same process may be followed for the return stroke and effective pressure plotted below the line and negative work above. The area between the two curves thus obtained would represent the net useful work performed during the two strokes or one revolution.

The resultant-pressure diagram is very necessary in the designing room and also very useful to the operative engineer.

The net area of useful work designated by the resultant pressure diagram should always equal the area of the indicated horsepower diagram.

In calculating the mechanical efficiency of an engine, it is necessary to subtract the frictional horsepower from the indicated horsepower and divide this result by the indicated horsepower, thus:

Indicated horsepower, 1200; frictional horsepower in high-pressure cylinder, 81.7; frictional horsepower in low-pressure cylinder, 5.2.

$$\frac{1200 - (81.7 + 5.2)}{1200} = \frac{1200 - 86.9}{1200} = 92\tfrac{3}{4}$$

per cent

The friction is greater at heavy loads than at light loads although not necessarily much greater. The probable mechanical efficiency of this particular engine at full economical load would be about 92 per cent., which is excellent.

Attractive Piping Job

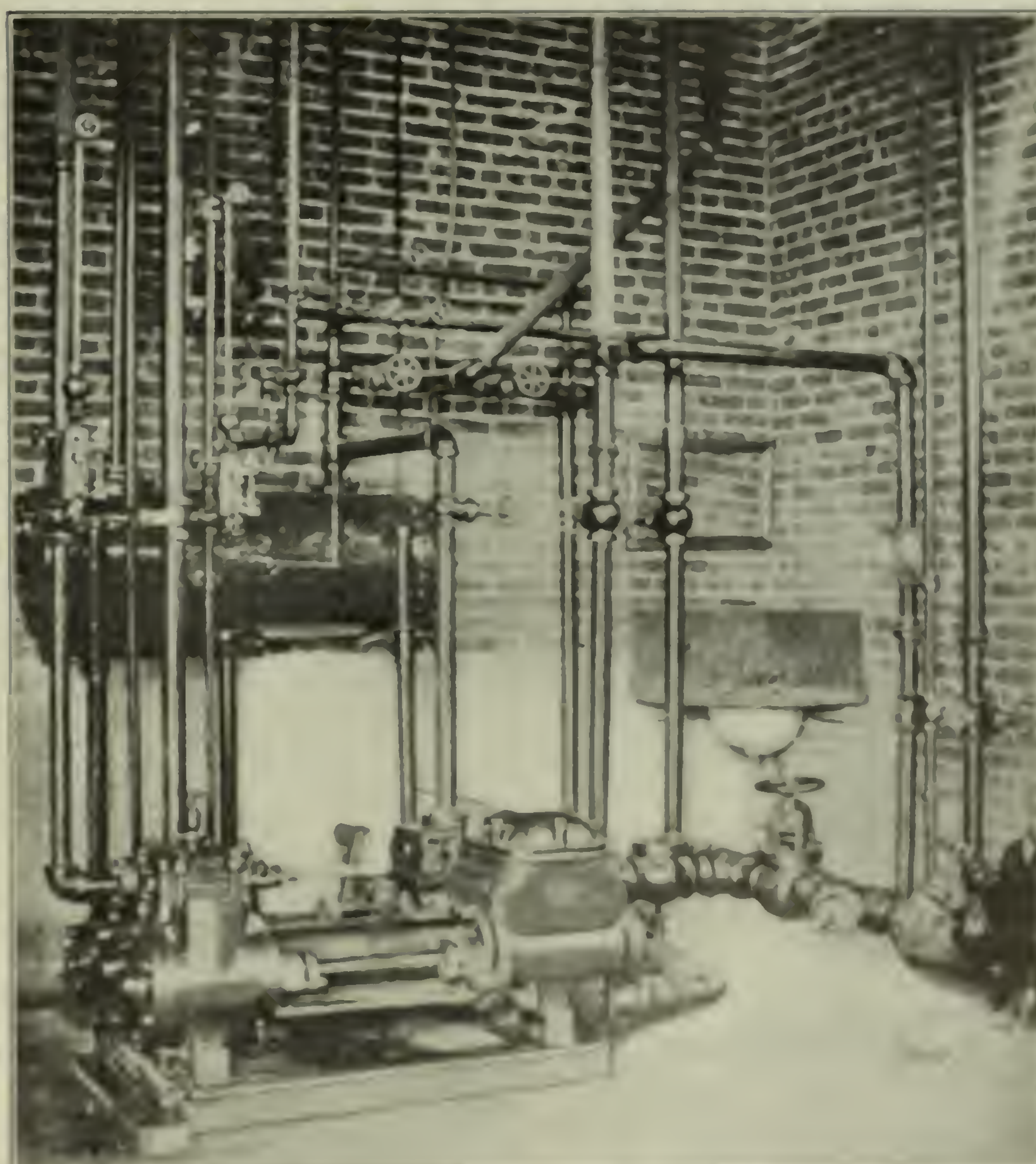
The accompanying illustration shows a neat layout of pumps, receiving tank and piping. The duplex pump is used for boiler feeding, the single pump for producing the vacuum on the heating system, and the small pump for house purposes. The receiving tank is piped to all of the returns leading from the factory. It is also connected to the city main and the make-up water is controlled by an automatic regulating float valve.

The construction of the stand supporting the tank is worthy of notice. It consists of two vertical pipes which are screwed into floor plates. A tee is screwed onto the top of each upright pipe and a horizontal pipe is screwed into the tee, the outer end fitting in a hole in the wall. The top end of each tee is fitted with an extension piece which is capped. This framework holds the tank clear of the floor and raises the float governor gear out of danger of being damaged.

The pumps are so connected that either one can draw from the receiving tank or from the city water main. An injector, not shown, can also be used as a boiler feeder.

The trap above the return tank handles all the returns from the shop in summer; the vacuum pump takes care of the heating system in winter.

The main feature is the neatness with which the piping has been put up. There is no leaning one way or the other. The upright pipes are vertical, and the horizontal pipes run true. It is an example of good pipe work.



Piping Job That Allows Freedom about the Pumps

There were imported into Russia during the first half of 1910, 1,751,000 tons of coal and 197,000 tons of coke. In the corresponding half of 1909 the imports of these fuels were 1,280,000 tons of coal and 102,000 tons of coke, which was a [illegible] over 1909 figures.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Repairing Induction Motors

By R. H. Fenkhausen

Many articles describing the winding of induction motors have appeared from time to time in various technical journals, but most of these articles have been written by men connected with the large electrical manufacturing companies, and consequently have dealt with motor repairs from the manufacturing rather than from the operating point of view.

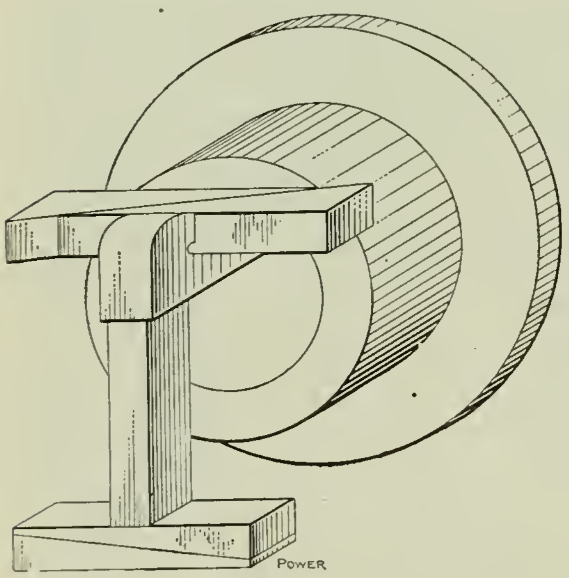


Fig. 1. Drawing a Key

It might appear at first thought that the winding of a motor at the factory and its rewinding in the field are identical operations, but besides the superior facilities available at the factory there are other advantages enjoyed by the factory winder which the field man must get along without. Take, for instance, the so called "basket" form of winding once so popular with all the motor builders, who claimed superior operating characteristics due to its use. This type of winding is largely used at the present time in partially closed slots, the coil being inserted in the slot opening one turn at a time, and the taping applied after the entire coil is in place.

No particular difficulty is encountered by the factory worker in placing these coils. He knows the exact shape required and the proper sequence of operations. The insulating materials are new and flexible and it is easy to bend the coils to make room for the operation of taping, and after the winding is complete the coils are easily shaped without danger of cracking the insulation.

The repair man in the field, on the other hand, is confronted with entirely different conditions. He handles all kinds of windings and does not become skilled in one kind like his factory brother. He must rely on his judgment as to the best way to proceed with an unfamiliar winding and, if he errs, valuable time is lost. The principal difficulty, however, is due to the brittleness of the insulation on the coils, which often defies all attempts at bending without damage. Several coats of varnish are baked on at the factory, and after being in service for a time the insulation of the coils becomes like glass and cracks as soon as any attempt to move the coil is made. The repairing of one coil damages adjacent coils, which must be also repaired, thus damaging still more. This often progresses until a large part of the winding is involved.

The foregoing remarks, though not covering all points of difference, will show that the viewpoint of the manufacturer is not that of the operator, and as evidence of this the type of winding referred to is being gradually abandoned by all motor manufacturers, except for the smallest sizes of machines, because of the difficulty experienced by operating men in making repairs.

In preparing the present article and those which are to follow, the writer has been careful to deal with his subject from the operating engineer's standpoint, and to describe only such processes as may be readily carried out with the tools and appliances available in any motor-driven plant. Many of the "kinks" described may appear simple, but it should not be forgotten that the simplest expedients are often most unfamiliar, and are only evolved from actual experience with far more intricate processes, which are gradually simplified.

Location of Trouble

The first indication of trouble with a motor is usually the appearance of a husky helper, who reports: "The motor in such a shop is burned up." This report need not cause alarm, as any motor trouble, from a blown fuse to a forgotten open switch, is usually diagnosed as a burned-out motor. Upon arriving at the scene of trouble the exact nature of the manifestation of trouble should be ascertained. If the motor was reported as smoking, it is, of course, due to overload or a short-circuit in the winding. If failure to start was the trouble, overload, blown fuses or bad contacts in the starting device should be looked for. The starter should be placed on the starting position and each phase tested for voltage by means of a test lamp.

If no trouble is found in the starter, the load should be removed from the motor by taking off the belt or pinion, and another attempt to start made. An open circuit in one phase will overload the remaining phase or phases and probably cause the motor to smoke. When the open circuit is corrected the motor should run all right. When a motor smokes from overload, it does not necessarily mean that the insulation is charred, because some insulations smoke at a comparatively low temperature and give a valuable danger signal which will save the motor from damage if heeded promptly. After the load has been removed, the motor should be allowed to run until

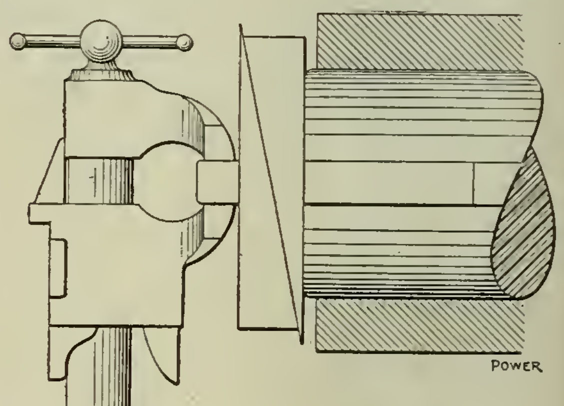


Fig. 2. Pulling a Tight Key

cooled down, as the fans on the rotor will draw cool air into the windings and cool it rapidly. As soon as it is cool the taping of one of the coils should be slit open with a sharp knife and the cotton covering of the wire inspected. If the cotton shows white or is only slightly discolored by the heat, the taping should be replaced and a patch pasted over the cut with shellac.

The earlier forms of induction motor were designed with lots of iron in the magnetic circuit and heating of the iron seldom occurred except as a result of overheated copper. An overload on one of these motors often charred the cotton covering of the wire until short-circuits resulted between turns, without any external appearance of trouble. The later forms of motors, however, use higher-grade steel and are run at high magnetic densities, so that abnormal conditions usually manifest themselves in excessive iron losses which heat the iron and char the outside insulation of the coils without even discoloring the cotton covering on the wire, so that the coils may be unharmed if the overload is of short duration.

If no overload exists, and the motor is receiving current in all phases, trouble must be sought in the windings. Test for grounds, open circuits and crossed

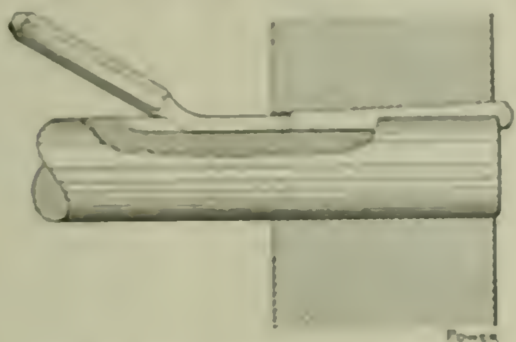


FIG. 3. "DRIFTING" A KEY OUT

phases with a magneto. In a three-phase motor the terminals of the three windings must be disconnected from each other before open or crossed phases can be detected.

WHERE TO MAKE REPAIRS

Every electrical installation should have a clean, well lighted place set aside for the electrical-repair force. A very small place will do, but it should be easily accessible so that motors can be taken there without excessive labor.

Motor winding is clean work and cannot be properly done in a dark and dirty place, so that the time spent in moving the motor to the shop will be more than saved during the winding operation. If forced to make extensive repairs to a motor in place, the repairman will usually do a poor job, and neither the appearance nor the insulation of magnet wire is improved by contact with the grease and dirt existing in some places where motors are necessarily located.

EQUIPMENT FOR HANDLING AND REPAIRING

A half-ton chain tackle hung under a convenient beam will answer most handling equipments, as motors weighing over 1000 pounds seldom give trouble, and when they do, it must usually be repaired in place.

A work bench with a couple of vises, and several pairs of horses complete the really necessary large equipment. A lamp bank, however, will prove very handy for testing, and a good type was described in POWER for May 17, 1910. Another handy piece of apparatus when rush work is to be done is an oven for drying coils. An electric oven which can be adjusted to maintain any one of three temperatures may be obtained for about $25.

The tools required are for the most part those usually owned by electrical workers, but what few special tools are needed can be easily made, and will be described in connection with the work requiring them.

The necessary supplies may be kept in the general store room and issued upon requisition signed by the proper person. The following list will cover most repair work:

Double cotton-covered magnet wire of various sizes;

Woven sleeving to fit magnet wire; two colors;

White muslin tape [illegible] and [illegible] inch wide for taping coils;

Leatheroid or fish paper 1/32 inch thick for coil cells;

Fiber 3/32 inch thick for slot wedges;

"Empire" linen 5 mils thick for cells (also called varnished cambric);

"Empire" linen tape, ¾ inch wide, cut bias;

White adhesive tape, wire solder and soldering paste;

Sheet copper about 1/64 inch thick for stub ends;

No. 22 annealed copper wire for binding joints, etc.;

Orange shellac (with denatured, not wood, alcohol);

Oil- and moisture-repelling varnish, air-drying or baking, depending on whether an oven is available or not.

These supplies represent very little investment, as only enough need be kept on hand to keep the repair force going until more can be obtained.

In case the plant is near a supply house, there is no necessity for keeping a stock on hand, except in large plants where the red tape incidental to getting an order through the purchasing department would cause delay. Even if a full stock of spare coils is carried, the foregoing list of materials is necessary for cells, connections, etc.

DISMANTLING

Upon arrival at the repair shop, the motor must be dismantled. In most cases the pulley or pinion must be removed before the heads can be taken off. If held by set screws, this is a simple matter, but if keyed it is often quite difficult, especially if no gib head is on the key. A gib-head key is usually removed easily by two wedges driven from opposite sides, as shown in Fig. 1, the end of the key being supported from beneath to prevent bending it downward. Very obstinate keys can often be removed by means of a vise from the bench, used to grip the end of the key firmly while wedges are driven between the vise and the pulley, as shown in Fig. 2.

If the key has no head it is sometimes possible to lay a short key in the keyway back of the key it is desired to remove; then, if the pulley can be driven further on the shaft, the key will be unable to follow it by reason of the short key behind it and it will remain stationary until the pulley is driven back far enough to allow the key to be gripped with the jaws of the vise.

In case there is room back of the pulley or pinion, a key drift may be inserted in the back end of the keyway and the key backed out as indicated in Fig. 3.

If none of the foregoing suggestions will start the key, it must be drilled out, but a gib-head key should always be used to replace it when the motor is reassembled.

After removing the key and pulley and taking off the journal brackets the rotor should be removed from the stator. Great care must be used in removing the rotor, because if the bolts are allowed to strike the stator coils, the insulation is liable to be damaged. The safest plan to follow with a rotor too heavy to be lifted by hand is to block up level with the bottom of the stator bore and slide the rotor out onto the blocking; very heavy rotors should be handled as shown in Fig. 4.

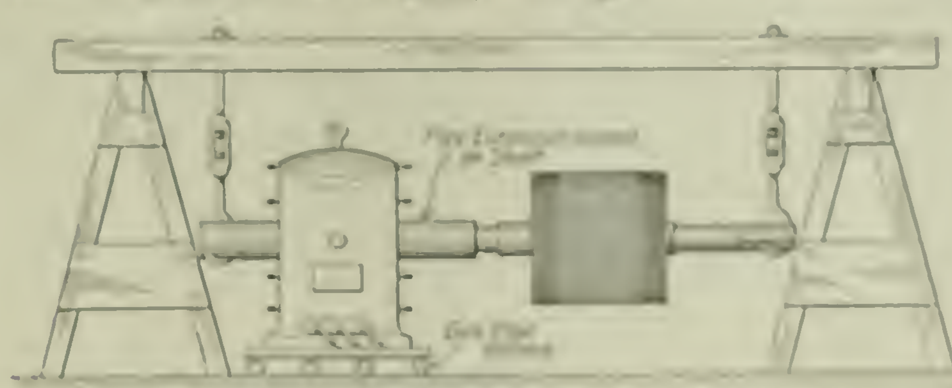


FIG. 4. REMOVING OR REPLACING AN ARMATURE

A helper should be set to work cleaning the stator and rotor thoroughly, first blowing out with an air blast and afterward washing with a rag soaked in gasolene. It is well known that gasolene attacks the varnish on the coils, but the oil and grease cannot be removed any other way, and as all coils should be given a coat of oil- and moisture-proof insulating varnish before the motor is replaced in service, the damage to the old varnish is unimportant.

SHAFT AND BEARINGS

The airgap of an induction motor is made very small as compared to that of a direct-current motor, in order to obtain satisfactory operating characteristics. Consequently, a small amount of wear will allow the rotor to come into contact with the stator, with disastrous results. It is, therefore, essential that the shaft and bearings be kept in good condition, and while the motor is in the shop advantage should be taken of the opportunity to inspect and overhaul them if necessary.

The shaft should be examined closely, and if scored or grooved it should be turned down to the next smaller thirty-second of an inch in diameter and a record kept of the size, as standard bearing sleeves can no longer be used to replace worn ones. In a large plant it often pays to renew the shaft rather than depart from the standard size. After some years it is sometimes necessary to reduce all shafts, but, of course, a new standard could then be adopted and each motor that comes in for repairs can be changed to the new standard shaft size. If the shaft appears to be all right, its truth should be verified by a test on centers if possible.

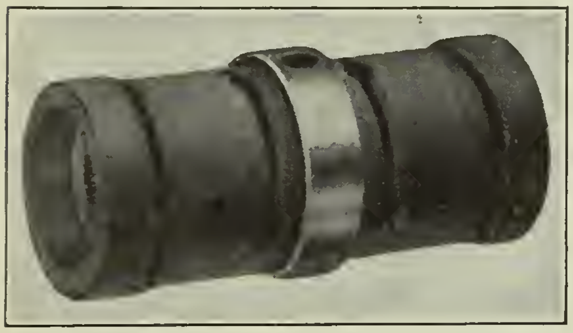


Fig. 5. Solid Journal Sleeve

The journal boxes should be removed from the heads and the sleeves tried on the shaft, all oil having previously been wiped off so that it will not form a cushion and prevent the detection of slight looseness between the shaft and the sleeve. This method is preferable to calipering, because it gives a closer indication than the average person can obtain with calipers, unless thoroughly experienced in their use. If the sleeve has more than a very slight amount of play it must be renewed, as it will grow rapidly worse because of the unbalanced magnetic pull in the airgap.

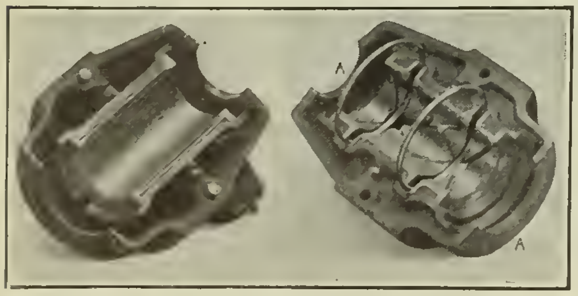


Fig. 6. Split Journal Boxes

Motors of 5 horsepower and smaller usually have solid bronze journal sleeves which must be renewed completely, although in some cases it is possible to reduce them with a bronze bushing kept from turning by a dowel pin. In motors of more than 5 horsepower, cast-iron bearing shells lined with babbitt are commonly used. These are of two types, shown in Figs. 5 and 6.

The plain sleeve type shown in Fig. 5 can be bought complete, with all oil grooves cut and ready to install, for less than the babbitt can be poured by a repairman. For example, the sleeve for a 10-horsepower motor costs but $1.65, while to babbitt the old shell, bore and cut oil grooves in the lining would cost $4 or $5 in most shops, besides the loss of time. Another advantage of buying standard bearings is the interchangeability secured. Many makers bore their bearings several thousandths small and size them by forcing a hardened-steel mandrel through them in a hydraulic press. When the journal on the shaft has been reduced, however, it is impossible to use standard bearings, and the old shells must be relined. Sleeves of the split type, as illustrated in Fig. 6, are many times as expensive as the solid sleeve type and it therefore always pays to reline old shells of this type.

Babbitting Shells

The proper grade of metal must always be used for relining bearings. The manufacturers of the motor will usually supply metal suited to its bearings, as it is to their interest to have their motors stand up well in service. The old metal must first be melted or chipped out, and remelted with a little new metal added. It is essential, however, that the two lots of metal shall be of the same composition. If any doubt exists on this point, the old metal should be discarded and all new metal used, because it frequently happens that two metals, each satisfactory for a given service, will run hot when mixed and ruin a shaft.

Fig. 7 shows how to set up for babbitting a solid sleeve of the type shown in Fig. 5. A mandrel is obtained, of a diameter from ⅛ to ¼ inch smaller than the required bore of the sleeve. This should be tapered if possible to make removal easy, but if freely coated with white lead it should give no trouble. The mandrel should be set up in a vertical position in a hole bored in a board and the sleeve slipped over it. Four wooden blocks should be spaced around the lower end of the mandrel to hold the sleeve concentric with the mandrel. Clay may be filled around blocks to keep babbitt out of the counterbore and the oil-ring grooves filled with thin wood or asbestos, cut out to fit half way around the shaft, as indicated in Fig. 7. This is not essential, but it saves cutting out the grooves in the finished lining and is well worth the trouble. The entire rig should next be heated with a gasolene torch until too hot to touch, in order to avoid chilling the metal before it reaches all parts of the shell, and also to expel any moisture. A very small amount of moisture will generate steam enough to cause a violent explosion when the hot babbitt is poured in.

While the shell is being prepared, a helper should be melting the babbitt in a ladle over a wood fire or a gasolene furnace. When the metal is hot enough to char a pine stick, a few pinches of sal ammoniac should be thrown in. This will cause all the dirt to rise to the top, where it can be skimmed off with a small ladle. Great care must be used to make sure that the metal is not overheated, as its anti-friction properties are liable to be seriously impaired.

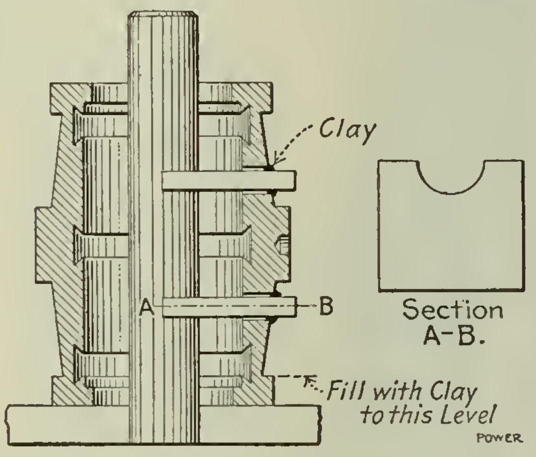


Fig. 7. Preparation for Babbitting

The metal should be slowly poured into the shell to avoid entrained air and consequent "blow holes" in the casting, and a close watch kept for leaks, which should be promptly plugged with soft fire clay. As it is obviously impossible to peen the metal in a solid sleeve, the worker must take pains in pouring to insure a tight joint with the iron. It is a good idea to tamp the metal into place with a stick while it is still in a plastic state, in order to prevent porosity and looseness of fit in the shell.

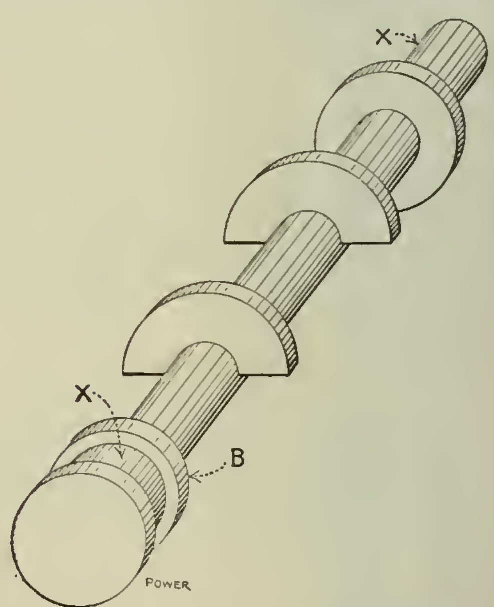


Fig. 8. Babbitting Mandrel

Split shells, such as shown in Fig. 6, are babbitted one-half at a time in the horizontal position. They are quite difficult to pour, owing to the number of grooves and shoulders that must be cast, but by means of a special mandrel like Fig. 8, which forms all grooves and shoulders without setting up, split bearings are very easy to reline. If the mandrel is made a good fit at the points *X X*, it may be used to babbitt the sleeve to exact size, because the bores *A A*, Fig. 6, are supposed to be concentric with the shaft, and to serve as guides for the accurate location of the mandrel. The shoulder *B* serves to locate the mandrel longitudinally and govern the end play of the motor shaft. The oil-groove collars embrace only one-half of the circumference of the mandrel; therefore, the lower half of the bearing is cast with the collar side of the mandrel on top. If a lathe is available, it is better to make the mandrel ¼ inch smaller than the shaft and after the metal has set, it may be peened until all pores in the metal are closed up.

The surplus babbitt must then be chipped off the seam face of the shell, care being used to chip *toward* the iron in order that the metal may not be loosened from the shell. The edges of the babbitt lining should be filed down flush with the iron; the two half shells may then be put together and bored out in a lathe.

As it is rather difficult to true up a

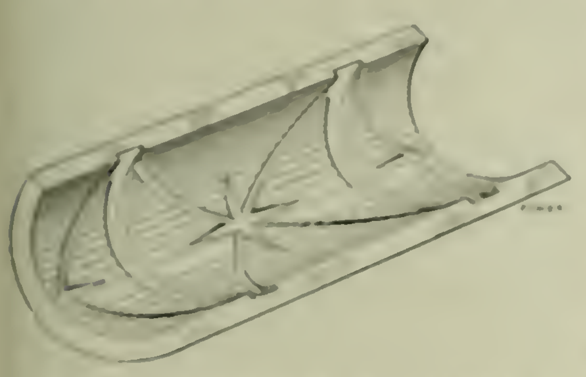


Fig. 9. Ineffective Oil Grooves

sleeve of this type, owing to the short length of turned surface exposed when the sleeve is clamped in the lathe chuck, it is better to bolt the sleeve in place in the journal bracket of the motor and chuck the bracket in the lathe. The face of the bracket may be bolted against the faceplate and trued up with the counterbore. If no lathe large enough to swing the bracket is available, it will save time and improve the accuracy of the work if a piece of cast iron from the scrap heap be bored out to fit the outside of the sleeve and the latter held in it by a set screw while being bored. Only a straight bore is required, as all grooves and both faces were formed by the mandrel.

Oil Grooves

Too much attention cannot be given to the cutting of the oil grooves, as the distribution of the oil and consequently the running temperature of the shaft and bearings are determined by the oil grooves. If the original pattern is not invisible, due to melted babbitt, it should be followed, a sketch of it being made before the old babbitt is removed.

If the old pattern has been obliterated, it should be remembered that oil, like water, does not naturally tend to flow up hill, and the grooving should be designed accordingly. Grooves cut as shown in Fig. 9 are useless; but many "mechanics" will cut grooves in this way. The grooves should start at the ring slot, on the top of the shaft, and curve down

Fig. 10. Oil-groove Chisel

toward the horizontal center line of the bearing. They should not extend to the end of the sleeve but stop about ⅛ inch from the end, to prevent the oil from flowing out at the end of the sleeve. A narrow, round-nose chisel, bent to the curvature of the bearing, as shown in Fig. 10, should be used. Oil grooves should not be cut in the lower half of a sleeve, as it reduces the bearing surface too much; the grooves in the upper half should not be cut any wider than necessary, for the same reason.

A good pattern for the oil grooves of motor bearings equipped with two oil rings each is shown in Fig. 11. It will be noticed that the grooves from opposite rings cross each other; therefore, even if one ring should fail to work, the remaining ring can supply oil to the entire bearing.

After chipping the grooves, the bearing should be carefully scraped with a half-round scraper, to remove any burs formed by the grooving chisel.

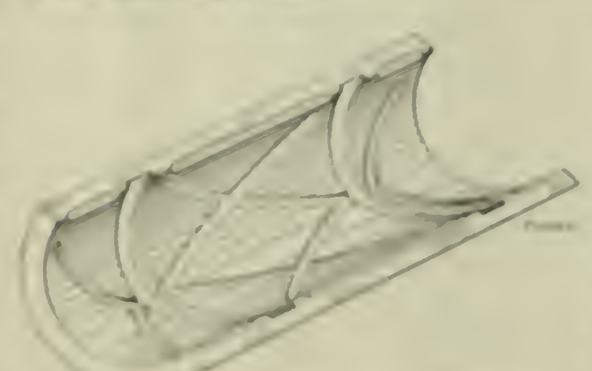


Fig. 11. Effective Oil Grooves

Before reassembling the journal brackets the oil rings should be carefully examined as they often are bent and twisted accidentally when the bearings are removed.

If the motor is a new one and the bearings have worn out without any apparent cause after a short run, it may be that the condition illustrated in Fig. 12 is responsible. At the factory a superficial examination is made to see that the rings revolve freely, but owing to slight irregularities, unavoidable in a rough casting, it occasionally happens that the rings barely clear the sharp edges *E E* by a hair's breadth. As soon as the bearing wears the least bit—as much as might occur in one day's run—the rings "hang up" on the edges *E E* and the bearing melts out from lack of oil. The remedy is to chamfer off the sharp edges at those points with a file or chisel. This will allow the rings to drop farther into the bore, as shown by the dotted lines. (The drop is exaggerated for clearness.)

When replacing the journal brackets on the motor, turn them upside down before slipping the bearings over the shaft. This will allow the rings to drop clear of the bore and avoid the necessity of lifting them with a bent wire while inserting the shaft. After the end of the shaft has passed the rings, the bracket may be turned half a revolution and shoved into position on the motor frame.

The nuts should be uniformly tightened all around the circumference of the bracket ring. If one side is tightened

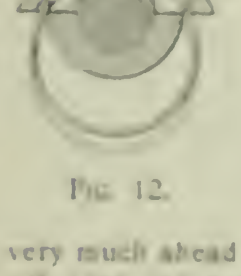


Fig. 12.

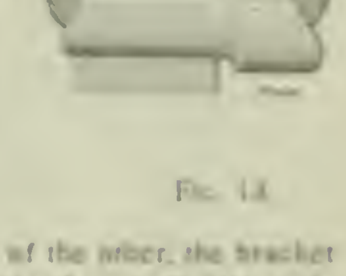


Fig. 13.

very much ahead of the other, the bracket will bind and cannot be drawn into position. The best method is to tighten all the nuts by hand until the bracket is just starting to enter the counterbore all the way around. Two opposite nuts should then be alternately tightened two flats at a time until the bracket is in place. With very large brackets and those which fit very tightly, four nuts should be worked up to avoid springing the bracket. The remaining nuts may then be run up by hand and all nuts given a final turn with the wrench.

After the brackets are in place, the rotor should be tried, and if it does not rotate freely, the brackets should be loosened and the rotor tried again. If it turns freely, the trouble is due either to poor alinement or lack of end play. Poor alinement seldom occurs, as self-alining seats are used on most bearing sleeves. Lack of end play may be corrected by moving the bearing shells outward in the housing, if means for adjustment is provided. Where no adjustment is possible, the sleeve must be faced off. End play of the motor shaft is often prevented by the entrance to the bore of the bearing sleeve not being flared enough to take the fillet on the shaft; Fig. 13 illustrates this condition.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Splash Lubrication

By James H. Beattie

A great deal of difficulty is experienced by operators of small vertical gas engines depending on splash lubrication, due to heating of the crank shafts and wrist-pin bearings. The trouble in nearly all cases is due to the lack of sufficient care in renewing the crank-case oil from time to time. It is not sufficient merely to add to the oil in the crank case as it is used up; the old oil must be removed and the crank case cleaned thoroughly and refilled with new oil. The frequency with which this should be done varies with conditions, but in no case should it be allowed to go more than a few weeks without attention. Any engine depending on splash lubrication is subject to this trouble, but the smaller sizes, ranging from about 2 to 10 or 12 horsepower, suffer particularly, as these sizes are commonly used by farmers and contractors under conditions where the amount of attention given is very small.

It has always seemed to the writer that splash lubrication is wrong in principle. The oil is used over and over again, gradually becoming mixed with particles of metal from the bearings and other forms of grit. It has been my experience that bearings lubricated in this manner wear much faster than bearings supplied by sight-feed lubricators feeding pure oil.

One of the most alluring points claimed for splash lubrication is that it is absolutely automatic and requires very little attention. On the contrary, it is rather uncertain and requires very careful and systematic attention in order to prevent serious trouble, as just pointed out. The following experience is a typical one: In cleaning the crank case of a splash-lubricated engine, a small piece of waste was accidentally left in the oil reservoir. The oil hook on the connecting rod picked it up and soon stirred up so much grit by sweeping the bottom of the reservoir at each revolution of the crank that a hot bearing resulted.

What is even worse than the excessive wear on the bearings is the excessive wear imposed on the cylinder and piston through lubrication with grit-laden oil. Another and a very serious objection to splash lubrication is the fact that it is almost impossible to keep the oil in the crank case from working out through the bearings, spreading over the frame and flywheels and making a mess of the whole engine. The writer has never yet had the pleasure of seeing an engine depending on splash lubrication which was entirely free from this fault.

It seems evident that it would be vastly better to equip the cylinder and bearings with sight-feed oilers than to depend on splash feed. The advantages are so obvious that it is not necessary to mention them all, but the chief one is that the oil after passing once through the bearings is filtered before being used in them again, or else used for other and less important purposes.

What Caused the Freak Diagrams?

By S. W. Rushmore

The three indicator diagrams reproduced here were taken a few minutes apart from my 140-horsepower single-

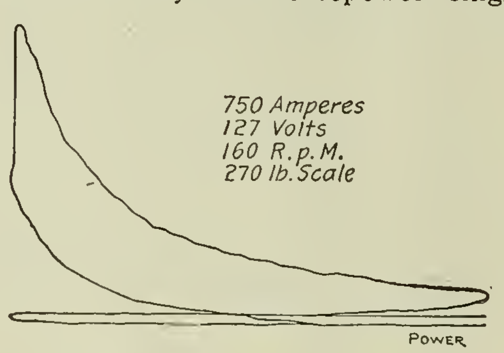


Fig. 1. Normal Diagram

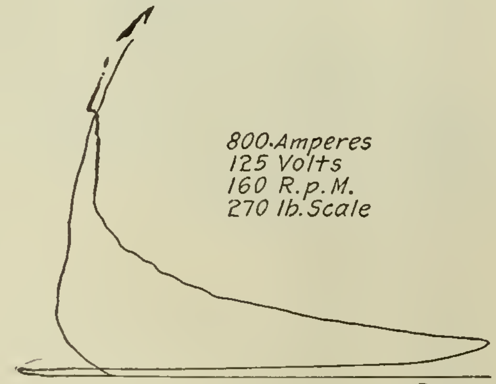


Fig. 2. First Freak

cylinder producer-gas engine. Immediately after taking the normal card, at the full rated load of the engine, the engine began to behave badly, and, while maintaining the full dynamo load of about 750 amperes, we got the two freak diagrams shown in Figs. 2 and 3.

Although the engine was carrying practically full load at the instant diagram No. 3 was taken, it is evident that the power was supplied chiefly by the flywheel. Perhaps some of the readers

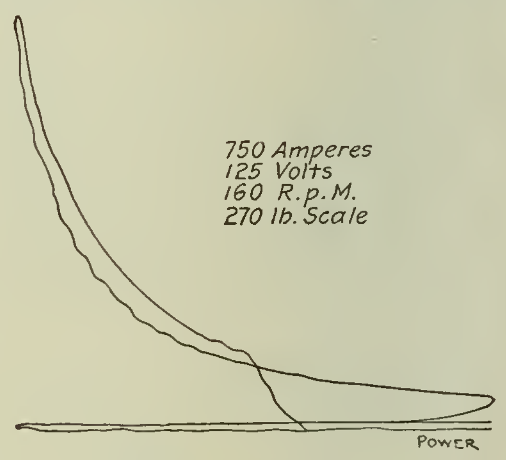


Fig. 3. Second Freak

of Power can explain the freak diagrams, in the taking of which the indicator was handled in exactly the same manner as when taking the normal diagram of Fig. 1.

Gas Poisoning

By J. O. Benefiel

In the issue of January 24 there was an interesting account of an engineer's experience with carbon-monoxide poisoning. I have had some experience along that line, being in charge of a scrubbed-gas plant of 4000 horsepower capacity.

We have had quite a number of the men overcome with the gas, but none fatally; they usually have a severe headache the rest of the day, but otherwise there do not seem to be any ill effects. Of course, the results would be fatal if the man were exposed to the gas long enough.

The gas does not seem to act gradually; apparently, one may get loaded with it before it begins to act, then the loss of consciousness seems to take place almost instantaneously. A man seldom gets a heavy charge of it the second time; in fact, we have had no one get a stronger dose the second time than he could walk away with.

The symptoms are a slightly increased rate of breathing and heart action, which will pass unnoticed by the inexperienced. Stepping into the cold air will cause it to take effect instantly.

One does not realize that one is losing consciousness, and this makes it very dangerous, especially when the workman is overhead. I had one man lose consciousness just as he was starting down a 25-foot ladder. Fortunately, two men were working together and the man on the platform dragged the poisoned man back just in time to prevent him from having a bad fall. In another case a man was working on a ladder when his senses left him, but there was a man just below him who carried him down.

The gas does not seem so effective before being cleaned. The generator men are exposed to it all day long on the charging floor and they suffer from nausea only; it is often so bad as to cause vomiting, but not dizziness or loss of the senses. It does not seem to affect the general health; some of the men have been doing this kind of work two years and are in good health.

When a workman is overcome by producer gas he should be carried to a place where the air is pure and *warm;* exposure to cold is to be avoided. There should be an oxygen outfit at hand and the oxygen should be administered at the earliest possible moment. The efforts of a physician are feeble as compared with the oxygen treatment. An oxygen outfit is not expensive; we keep two tanks on hand to avoid the liability to run short in case more than one man should be affected at the same time. A stiff drink of whisky is beneficial after the patient has regained consciousness, and he should not be allowed to go out of doors or to start home alone until he has fully recovered. We always have a doctor to attend a man who has been gas-poisoned, chiefly because the man might have a bad heart which would need the attention of a physician. Incidentally, it would clear the management of any charge of neglect in case of serious results.

Sometimes artificial respiration should be resorted to if the patient's breathing seems to be weak.

In the two years we have been using producer gas we have had only six men get knocked out, though we have had the men get a light dose often. Two pipefitters were working overhead on a plank runway one night and both of them got so weak and dizzy they could not get down; they had to lie on the runway until they recovered, there being no one else about.

LETTERS

Is This Speed Practical?

I shall appreciate expressions of opinion from POWER readers on the following question.

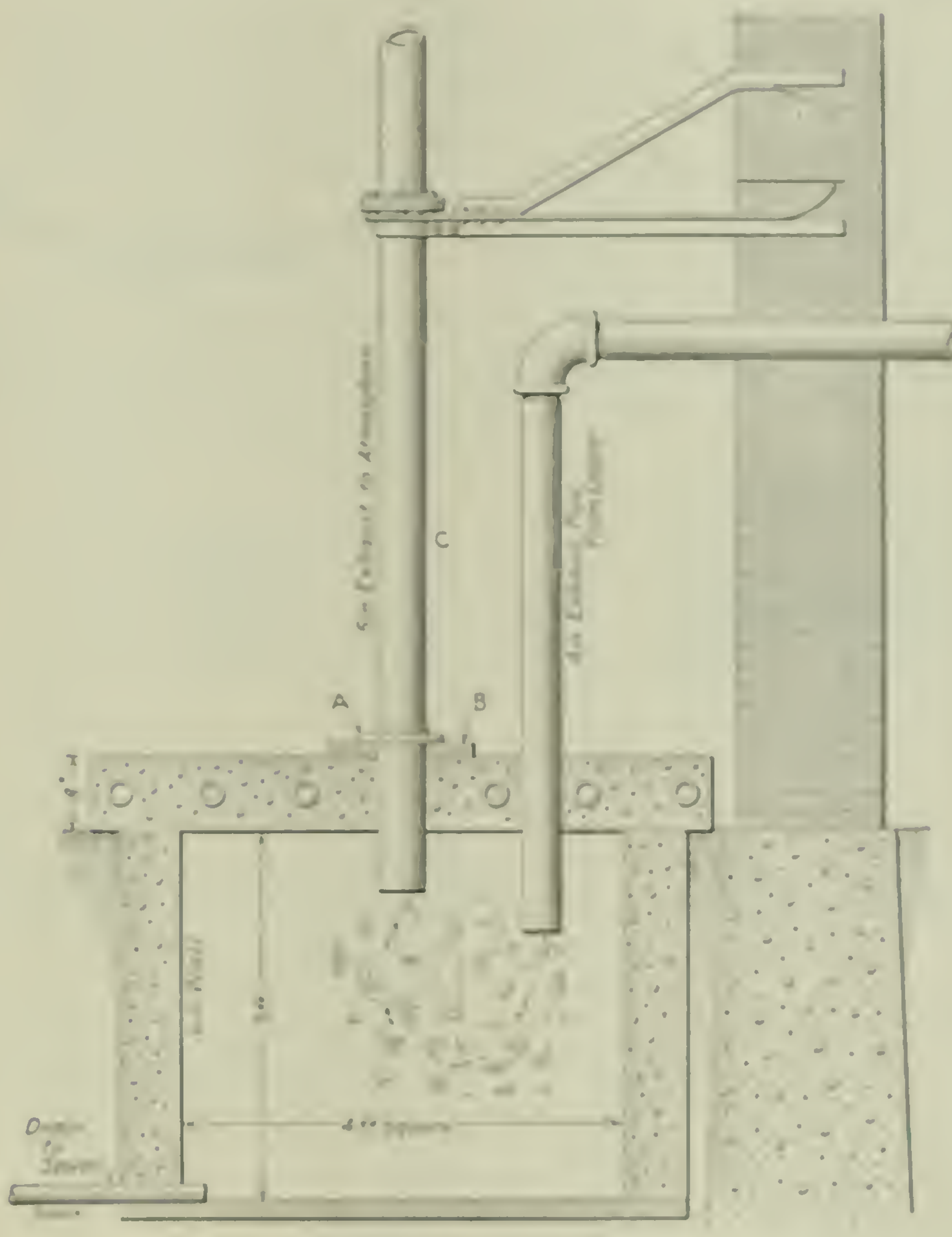
Is a rate of speed of 300 revolutions per minute too high for a vertical engine of 9½ inches bore and 12 inches stroke, with a connecting rod 30 inches long? The engine is single-acting but is built with a crosshead instead of the usual trunk piston and gudgeon pin. It is lubricated by splash from the crank case.

O. J. BARKER.

Cameron, W. Va.

A Homemade Muffling Box

The accompanying sketch shows the construction of a muffling pit which we have found very satisfactory. The pit is just outside of the engine-room wall and is 3 feet deep and 4 feet square. The walls are of concrete, 6 inches thick, and the cover is 8 inches thick and reinforced with old boiler tubes to stiffen it up. The pipe carrying the exhaust gases away from the pit is 5 inches nominal diameter; a 1-inch collar is shrunk on the pipe at *A* and this rests on a 15-inch plate *B*. The pipe *C* is braced to the building wall, as shown. When pouring the cover we put short pieces of pipe in place of the intake and outlet pipes and left them there until the cement had dried.



A CONCRETE MUFFLING BOX

This has muffled the exhaust so that the report is not as loud as that of a noncondensing steam engine exhausting to the atmosphere; in fact, it can hardly be heard when standing near the pipe.

The engine is a three-cylinder, vertical, with cylinders 12x12, rated at 100 horsepower when running at 275 revolutions per minute on natural gas of about 950 B.t.u. per cubic foot.

The first muffler was put in over a year ago and has given such thorough satisfaction that the other engines were provided with mufflers of the same construction. Of course, several engines can exhaust into the same pit if the pit be made larger; the one here illustrated is about the right size for an engine of 125 horsepower.

M. W. OTT.

Minster, O.

The briquetting industry in several European countries has made rapid advances within the past few years, the production last year in Germany alone amounting to eighteen million tons. This is due partly to the fact that the coal in these countries runs in thinner veins, limiting the supply of the larger sizes, and also that cheap labor makes it possible to use dust which would otherwise be discarded. The popularity of this form of fuel is shown by the fact that thirty per cent. of the total coal consumed in Berlin is in the form of briquets.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Repairing a Wrecked Engine

A short time ago I had a repair job on a 20 and 36 by 48-inch cross-compound engine. The low-pressure cylinder took water on the head end and forced the front of the pillow block off, as shown in Fig. 1, also breaking the cap, and before the engine could be stopped the shaft had been thrown out of alinement so that the 50-inch belt ran off the pulley so far that it got up against the foundations and ripped one edge open about 3 inches, for its entire length. The belt was taken off and repaired, and in the meantime four 1¼-inch holes were drilled and tapped in the broken pillow block, and clearance holes drilled in the broken piece, which was fastened to the main casting by means of bolts, as shown. An 8x8 timber was placed from the wall to the pillow block and in place of the cap two 2½x1-inch wrought-iron straps were used to further strengthen the block. Then the low-pressure side was disconnected and the engine ran a part of the plant until a new pillow block arrived.

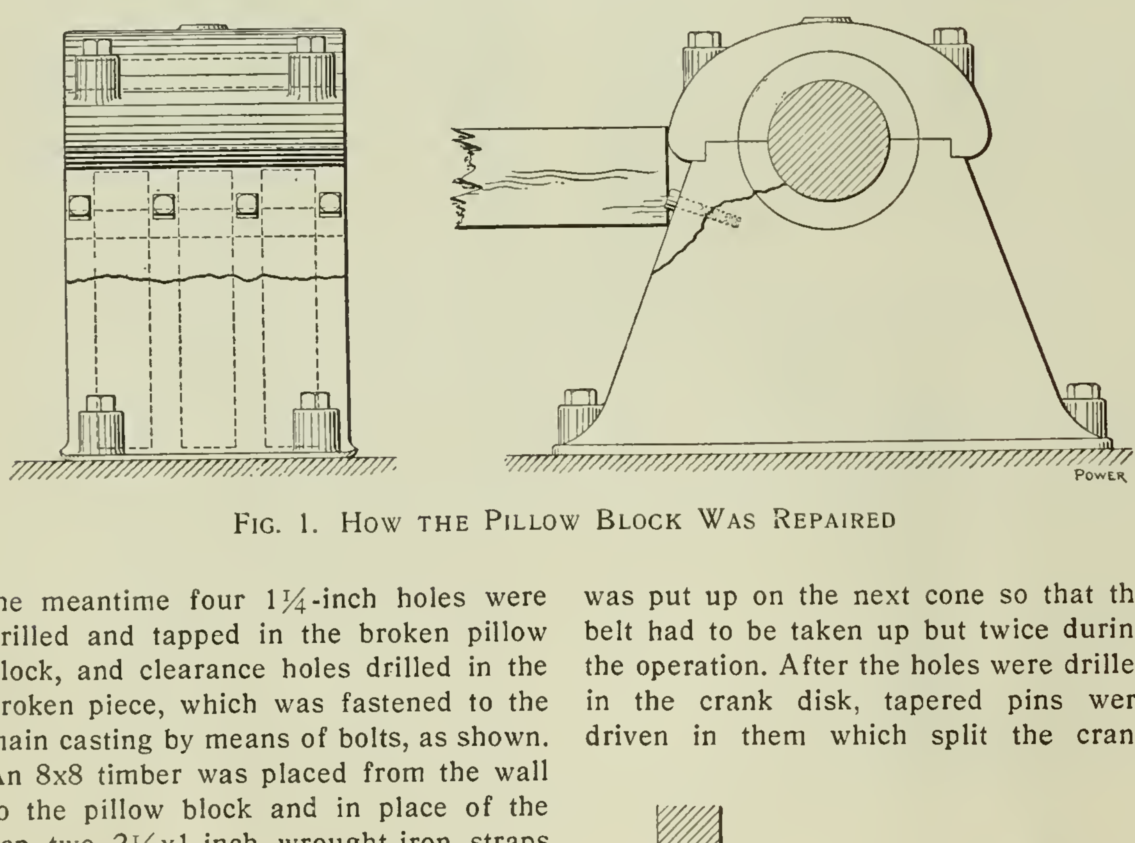


Fig. 1. How the Pillow Block Was Repaired

The shock received by the crank sheared the key about 1/16 inch on the shaft so that it had an offset, making it advisable to take off the crank and put in another. When the new crank arrived, the engine builders sent a man to assist in taking off the old crank and to put the new one on. He intended to work all night, with a ratchet, drilling holes in the crank to break it off. I suggested taking a headstock from one of the lathes in the machine shop and blocking it up level with the center of the crank shaft, and with a drill chuck in place and a jack screw between the wall and the headstock for a feed, using a small 6-horsepower engine to drive the same. It took 90 minutes to remove the crank, which was 7 inches thick. Fig. 2 shows the method of drilling the crank. A 12-inch face driving pulley was used, and as the lathe head was moved nearer the driving engine, the belt was put up on the next cone so that the belt had to be taken up but twice during the operation. After the holes were drilled in the crank disk, tapered pins were driven in them which split the crank disk along the row of holes, when the new crank was put in place. The new pillow block was then made secure, and after adjustment the job was completed.

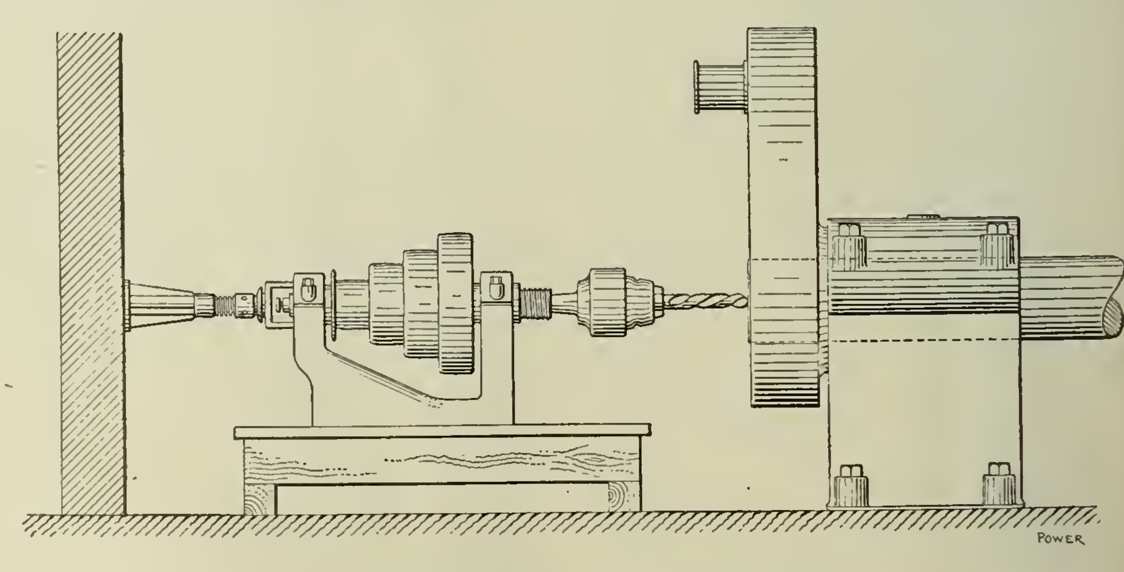


Fig. 2. Method Used in Drilling Crank

All preparations were made, such as getting the drilling apparatus, engine and lathe headstock ready during the day while the plant was running, so that no time was lost in getting to work after shutting down.

L. R. Corm.

Boston, Mass.

Slipping Latch Blocks

In a certain power station, considerable trouble and annoyance were experienced with the latch block slipping or failing to open the valve. This caused the engine to take steam on but one end, causing surges and cross currents between the alternators, which affected the most distant substation. Sometimes the slipping would be so bad that the engine would have to be cut out of service until the latch block could be changed.

As a remedy it was decided to make some latch plates of Novo steel, a very fine, hard grade of tool steel. The first effort was a failure, owing to the fact that the plates were not hardened sufficiently in tempering.

A second trial, however, produced plates that have been in continuous service for five months without being disturbed and still show no sign of wear, and have not once failed to open the valve. This steel must be annealed before working, which is done as follows: Cut it into pieces of approximately the size of the plates. The pieces should be buried in lime in a length of iron pipe, of sufficient size to hold them, and the ends capped. A hole should be drilled in one cap to let out moisture, etc. The whole is then placed in a slow fire and gradually heated until the pipe begins to take on a welding heat. The fire should then be covered with coal and left undisturbed until the steel has cooled, after which it may be worked into the desired shape for the plates. After finishing, the plates must be tempered by heating to a *bright red* and plunged into oil. This steel is expensive, costing about one dollar per pound, but considering the wear secured the cost is trifling.

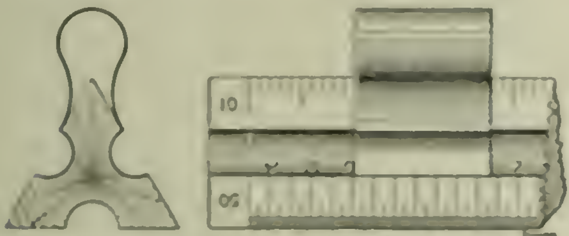
By buying the steel in bars of the proper width and thickness it is a comparatively easy matter to make any ordinary latch plate. The steel may be bought annealed but it may still be too hard to work well.

C. L. Greer.

Handley, Tex.

Boxwood Scale Holder

A device for protecting a boxwood scale is illustrated in the sketch shown herewith. It also serves as a holder for the scale, and prevents its being soiled.



Holder on Scale

The holder is made of 1/32-inch spring-sheet brass and fits snugly to the scale.

C. T. Schaefer.

St. Louis, Mo.

Gage Pipe Froze

The night breezes without registered a temperature of 20 degrees Fahrenheit and everything was lovely, so to speak. No. 3 was working connected with Nos. 1 and 2 boilers, all being 125 horsepower and of the horizontal return-tubular type. Suddenly, No. 3 gage registered a pressure of 135 pounds, but Nos. 1 and 2 gages remained normal at 90 pounds per square inch.

I began investigating, and the safety valve convinced me that the gage, and not the boiler was at fault. I soon found that the ¼-inch line to the gage had frozen, due to some person neglecting to close a window nearby, and the expansion of ice, together with the noncompressibility of water, caused an increase of 45 pounds pressure on the gage over that carried on the boiler.

This incident demonstrated three important facts; first, the incompressibility of water; second, the expansive force of ice, and third, pressure created by freezing water will release itself along the lines of least resistance.

I am none the worse for my experience, although the first discovery of the increased gage pressure gave me a "jolt" for a moment.

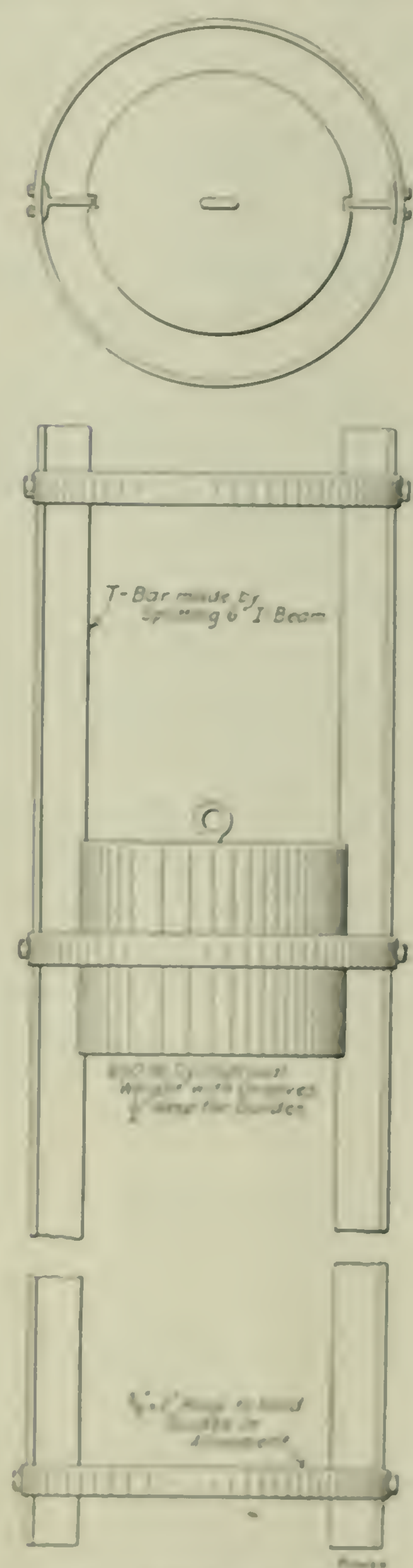
L. E. Kenney.

New York City.

Removing a Piston Rod

The accompanying illustration shows a device used to force the piston rod out of the piston of an old blowing engine.

One of the valves in the top cylinder head of the air tub broke and a piece fell into the clearance space. The result was that the piston rod was jammed



How Hammer Was Used

¼ inch through the piston. The question then was how to remove the rod. It was suggested that the piston be blocked up and a weight dropped on the protruding portion of the rod.

A pair of guides for the falling weight were made from a 6-inch I-beam, 15 feet long, which was mounted on a planer and cut into two T-bars by splitting it down the middle with a cutting-off tool. The guides were held in proper alignment by hoops made of 1½x2-inch flat bar iron, as shown in the sketch.

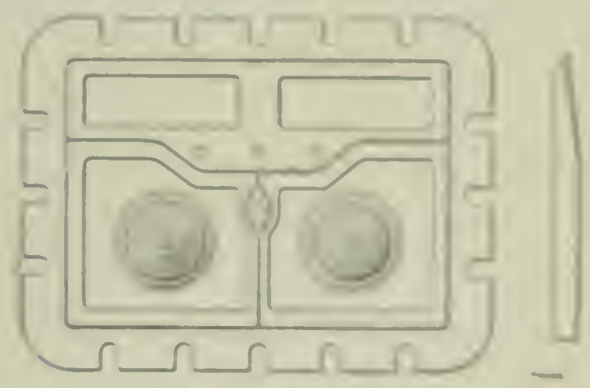
This rig was bolted into place and lashed in position. The piston was blocked up on four blocks set so as to bring the stress of the blow on the four legs of the A frames. The rod was disconnected and the crosshead moved down. The weight was hoisted 10 feet and one blow did the work.

J. J. O'Brien.

Buffalo, N. Y.

Lead Fuse Gasket

I have had a great deal of trouble keeping sheet packing between the suction valve plate and the discharge valve plate of an old tank pump. When a soft sheet packing was used it would blow out, and if it was stiff and strong enough to withstand being blown out, the water



Grooved Plate

and air would be forced between the gasket and casting.

After experimenting with several styles of sheet packing, I had a grooving chisel made as shown in the sketch, which would make a groove with about 1/32-inch radius.

The plate was grooved as shown. Then I got some electricians' lead fuse, which was the only kind available, and made an endless gasket by soldering all ends, and this lead-wire gasket was a success.

B. T. Hawley.

Starkville, Colo.

Crosshead Pound

A disagreeable knock at the crosshead of an 18x36-inch Corliss engine puzzled me for some time until I discovered that it was caused by a sidewise movement of the rod brasses on the crosshead pin. There was but little clearance between the brasses and the crosshead, yet there was enough to allow it to slap at the end of the stroke.

Efforts to remedy the trouble by means of washers, etc., were unsuccessful, but I finally gave one side of the brasses a thin coat of solder and dressed it down with a file until it made an easy fit in the crosshead. The knock then disappeared.

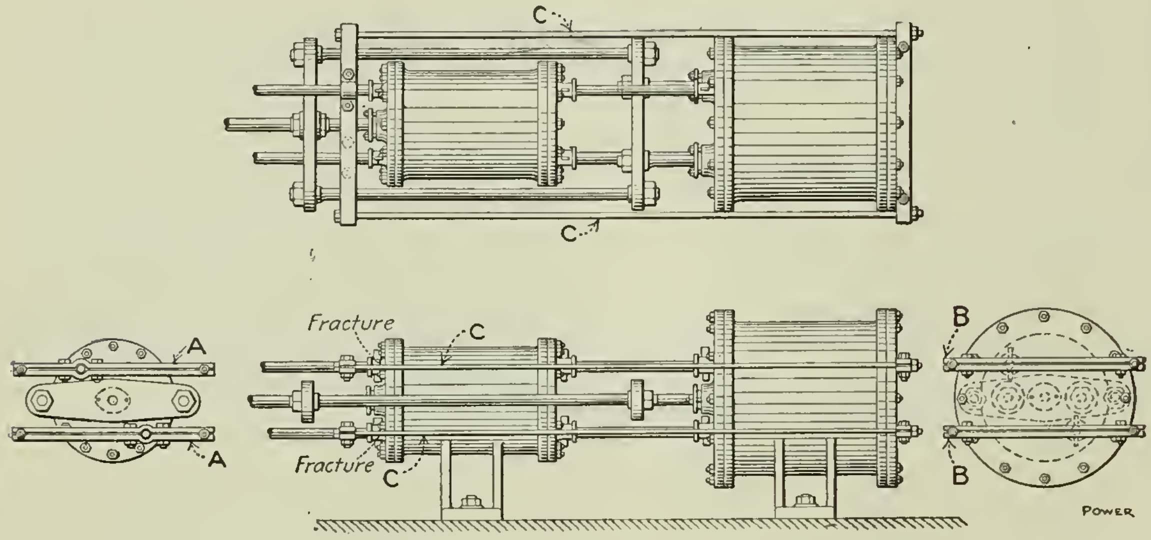
L. Mann.

Ware, Mass.

Wrecked Steam Pump

During a recent visit to the steam plant of a friend, he showed me one of the large duplex tandem-compound pumps which had clamps and rods applied to hold the steam and water ends together, as shown in the figure. The low-pressure piston had two piston rods which ran along the high-pressure cylinder, one on each side diametrically opposite, and were fastened to a crosshead on the high-pressure piston rod which was also the plunger rod for the water end, as the steam piston rod and the plunger rod were one piece, carrying on one end the steam pistons and on the other end the plunger, with a crosshead in the center of the rod between the steam and water ends. One of the piston rods in the low-pressure cylinder became disengaged on the forward stroke, but the other remained fast. This tipped the piston in such a manner that when the pump started on the back stroke the low-pressure piston moved in jerks. Several of these jerks were enough to tear the steam end from the stayrods between the water and steam ends, the fracture occurring in the sockets on the high-pressure cylinder, into which the ends of the stayrods were keyed, as shown in the upper view. The piston rods, bell crank on the vacuum pumps, and the valve rod were twisted, bent or broken when the steam end started to back off from its foundation. The water ends only are anchored to their foundations as the steam ends ride on iron plates laid on foundations to allow for a slight movement of the steam end to adjust itself to the strain on the rods between the steam and water ends.

The engineer had two clamps made as shown at *A* and two as shown at *B*. The first set were clamped to the stayrods between the steam and water ends, snug up against the parts of the sockets which remained on the rods with the keys left in place. Long bolts with a head on one end and a long thread and heavy nuts on the other end were inserted through the set of clamps on the stayrods and through another set of clamps across the low-pressure cylinder head, as shown at *C*. Nuts were then run on and all drawn up even until the fractures closed tight. The bolts on the side of the greatest strain were made of heavier rods. The strain on the bolt in the clamp on the upper left stayrod is greater than on the bolt in the other end of the same clamp. The same applies *vice versa* on the lower clamp in the same figure. The pump handles just as much water now as it did before the breakdown, but its appearance is spoiled.



Details of Pump Repair

This breakdown was caused by an engineer with a "pull" and illustrates how such an engineer can be an expensive man. There certainly must have been a warning sound before the breakdown occurred, which an engineer of real merit would have heeded and have stopped the pump in time to prevent the accident. At the time the pump was running about twenty strokes per minute.

Louis T. Watry.

Pueblo, Colo.

Dynamite in the Coal

I am in charge of a battery of seven water-tube boilers equipped with mechanical stokers. A few days ago one of the firemen brought me a piece of dynamite about 4 inches long that the coal wheeler had found in the coal. Instructions were given to be very particular and examine every shovelful of coal, and it was not long before he found two more pieces of dynamite, one about 3 inches and another about 1¼ inches long. The dynamite was frozen when found, but if it had got into the fire, there would have been an explosion, and a good many people would naturally have said the boilers were dry, or this, that and the other thing.

I have had charge of boilers for about twelve years and have always been very careful to avoid accidents, but that would not have amounted to anything if the dynamite had got into the furnace. I have wondered a good many times since if any of the boiler explosions that occur from no apparent reason have been caused by dynamite. I have found caps in the coal several times, but I have never found dynamite before.

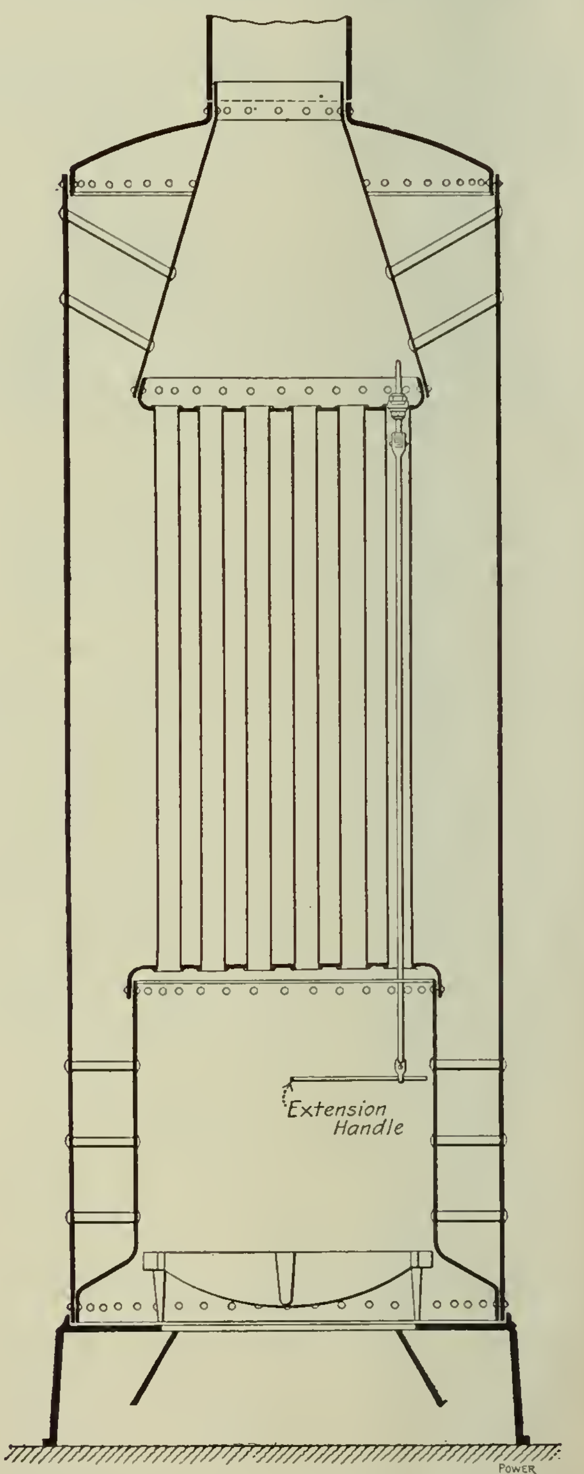
John R. Dixon.

Peace Dale, R. I.

Using a Tube Expander

Recently, while putting new tubes in an upright submerged-flue boiler, I had to devise some means of rolling the outside tubes on the top end, as the pitch of the cone was such as to make it impossible to put the roller in that end.

The accompanying illustration shows



Expander in Tube

the roller slipped in from the bottom end after that part of the roller which rests against the outside of sheet had been removed. This did the job very nicely and very little difficulty was experienced in keeping the roller in place and turning the extension rod from below.

William I. Morgan.

Augusta, Mont.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Exhaust Steam in Low Pressure Turbines

In the January 31 issue, Mr. Fenno, while attempting to prove that the statements in a certain turbine catalog are misleading, neglected to take into account an important factor in the steam-engine cycle—that of reëvaporation—and by so doing rendered his analysis more misleading than the original which he was trying to disprove.

The original statement was to the effect that a pound of dry steam expanding adiabatically from 150 pounds gage to atmospheric pressure, gives up, in work done, approximately the same number of heat units as a pound of dry steam expanding from atmospheric pressure to 28 inches of vacuum, the inference from this being that an exhaust-steam turbine working between the lower pressures would do as much work as a reciprocating engine working between the upper pressures. Mr. Fenno showed that dry steam expanding adiabatically from 150 pounds gage to atmospheric pressure would have a final quality of 85.7 per cent., which in actual practice would be further decreased by cylinder condensation and radiation; hence, the low-pressure turbine would not receive dry steam, but instead steam only 85.7 per cent. dry, at the most. If a separator were used between the engine and the turbine this would mean that the latter would use only 0.857 pound of dry steam for every pound used by the former.

Theoretically, this is true, but practically it is not. Condensation will take place in the early part of the stroke, but at some point between cutoff and release the temperature corresponding to the pressure of the steam will fall below that of the cylinder walls and reëvaporation will set in. This, although not very large at first, is greatest near the end of the stroke; but the instant the exhaust port opens there is a considerable drop in pressure (with a corresponding drop in temperature) accompanied by a rapid reëvaporation, and the exhaust steam will leave the engine very nearly dry. The application of Hirns' analysis to an engine test will show this plainly. The heat regained during the reëvaporation adds little to the work done in the cylinder but it would be available in a low-pressure turbine, and the original statements are not so misleading after all.

A. de Groot.

New York City.

Changing the Throttle

Speaking about the best position of the throttle valve, why not change it if the position in which the erecting engineer left it does not suit? Why continue from year to year to leave it in front of the cylinder, flywheel, governor or valve gear, when you know that on the other side, upstairs or below the floor would be better? Several times you have

Diagram Showing Change in Position of Throttle

ducked from the firing line, wished for better things and let it go at that.

I am reminded of a case where the engineer of a plant in a large department store reversed the throttle as a temporary expedient and became so tickled with the handiness of the new location that he made the change permanent. He also changed the throttle on the duplicate unit, for if one was good, two were better.

There came an emergency call one day for special lighting in a neighboring building where the steam plant had a breakdown. A small generator was borrowed and belted from the flywheel. The only thing that could be done was to fasten the generator to the floor near the head end of the cylinder, thus running the belt across the throttle wheel, as indicated at *A* in the accompanying diagram. This made the symptoms of trouble so acute that a decision was made to reverse the throttle instanter. The pipe flanges being symmetrical, the trick proved so easy that the engineer wondered why he had not made the change before. His memory also carried him back through the long years spent in other plants where throttles and other things made operation unhandy, not to mention occasional flashes of unsafety. The erecting fellow had happened to put things together so and so, and it had never occurred to him as operating engineer to make any changes.

F. Webster.

Scranton, Penn.

Liquid Discharging Device

Mr. Seibert's article in the January 10 issue seems to imply that I have made use of his idea in the design of my device and also that the device in itself is a dangerous one to use.

In answer I would say that the device is entirely my own idea, and while Mr. Seibert may have had the same idea, he failed to protect it with a patent.

The principle on which the device works is old and not patentable, but the combination is new and I hold the patent.

I do not recommend the use of over 20 pounds pressure, and every purchaser is cautioned against anything in excess of this in wooden barrels, unless the heads are clamped.

It is immaterial to me how this pressure is obtained, whether by maintaining a receiver or boiler pressure of only 20 pounds or by using a reducing valve to step down from a higher pressure. I can do the trick nicely with no other apparatus than a common globe valve between the high-pressure line and the device and anyone else can do the same by using a little judgment.

While an opening 1/16 of an inch in diameter, as Mr. Seibert used, might not maintain an overpressure in the barrel with 80 pounds primary pressure and a light grade of oil, it can easily be seen that it would and did give an overpressure while discharging a heavier grade of oil.

If anyone has any liquids so gummy that 20 pounds will not push out, I think that such liquids are approaching the state of solids and that it might be best to knock in the head of the barrel and use a paddle or a spade.

Mr. Seibert's experience proves that the device was not at fault, but the operator.

EARL PAGETT.

Coffeyville, Kan.

Beading Boiler Flues

In reply to L. Earle Brown's inquiry in the December 13 issue about beading flues, the following is submitted from experience gained in practical work as a boilermaker in marine, locomotive and stationary work:

The beading should be put down close to the head until the sheet is nearly nicked by the beading tool. The flues will hold better and last longer because there is less metal exposed to the hot gases and, being tight against the head, there will be less difference in temperature between the sheet and the head and in consequence less difference in expansion and contraction. It is this difference in expansion that causes the flues to leak.

I would like to add a few words here about renewing and repairing flues that are leaking, especially about the use of expanders. It would surprise anyone who had not had years of experience to learn how little expanding is needed to make a tight job and a lasting one.

The majority of engineers always instruct the repair men to expand the flues well, and if he is a boilermaker from a contract shop he will follow instructions with the result that the flues are rolled so thin that the next thing in order is a new set of flues and the contract shop has another order on hand.

When the flues leak, the beading tool only should be used, as it will do all the expanding necessary and not split the bead. If the flue is loose in the head, of course the expander will have to be used.

WILLIAM BEATON.

Gold Roads, Ariz.

Treatment of Subordinates

A great deal has been said recently in the columns of POWER concerning the manner of treating subordinates and I desire to give my views on the matter.

I can heartily indorse Mr. McGahey's letter in the January 24 issue, for I know him personally and have worked for him and his brothers for six or seven years. He practises what he preaches.

I have been a chief engineer for the last four years. I find that by giving fair treatment I can get better results from my assistants than otherwise.

Rightly educated and treated, an assistant can and will save his superior much trouble and annoyance.

I find that the man who must be continually hammered at and driven is practically worthless. The sooner such a man is weeded out, the better for all concerned.

DAVID M. GROVE.

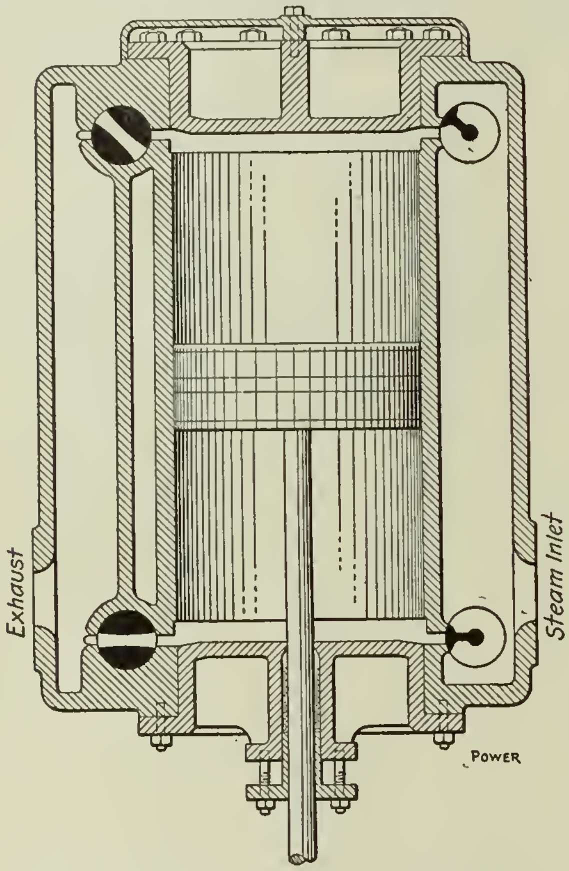
Covington, Ky.

Water Wrecked Cylinder

In the January 17 issue, Mr. Sheehan tells of the wreck of an 18 and 36 by 36-inch compound-condensing Corliss engine.

The cause given is that the valve failed to open on account of the hook blocks being worn, the valve remaining closed long enough for the steam chest to fill with water. When the valve was made to open, this water passed into the cylinder and caused the wreck.

If this statement is correct, it behooves all engineers in charge of vertical Corliss



CHANGE IN LOCATION OF STEAM AND EXHAUST OPENINGS

engines to take notice, for they all might meet with the same trouble.

Why, if there is danger of wrecking an engine in the manner stated by Mr. Sheehan, do not builders design the steam and exhaust connections as shown in the accompanying figure?

A. W. GRISWOLD.

Adams, Mass.

Federal Laws

In the issue of January 10 is an article on Federal license laws by A. A. Blanchard. I believe this article to be a good one and indorse Mr. Blanchard in trying to expand a good thing by which every engineer in the United States would be benefited. I am with him in this great movement and will do all that I can and use my influence with others to help in this great cause; the protection and conservation of life and property.

But stop—and think! Are we getting good results with the present license law in Ohio?

Do you know it to be a fact that politics plays a great part with this law and its enforcement?

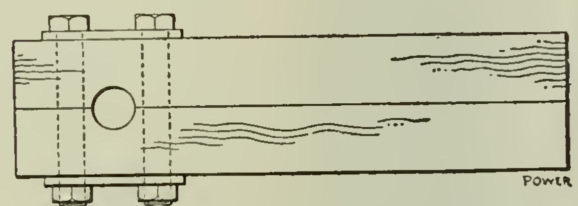
Study your law! Watch its enforcement. The robe of the license examiner is too precious a garment to hand out to any political machine or system. What we need and want is efficiency from the men who secure license. And we *must* have it or else we decay. The examiners themselves should be examined as to their ability in order that when they get a violation they may not always be outgeneraled or defeated to the carelessly concealed mirth of the violators.

ORRIN C. WERNER.

Kent, O.

Piston Rod Clamp

In the Jan. 3 issue, Alfred Woolcock described a piston-rod clamp. I have used the one shown herewith for a number of years; I think it is superior and easier to make.



HARDWOOD CLAMP FOR PISTON ROD

Take two pieces of hard wood 2 inches square by 12 to 16 inches long and bolt them together as shown, using either washers or a plate under the heads and nuts. Then drill a hole the size of the rod, or a trifle smaller, through the wood. Should the hole be too large, so as not to clamp tightly, a thickness of paper may be wrapped around rod.

I have never yet had this clamp slip or mar the rod.

G. A. RAND.

Freeport, Ill.

Arrangement of Boiler Feed Pipes

A great deal of useful information has appeared in POWER as to the proper point at which to enter the feed water to the boiler. My experience leads me to believe that the layout of the plant should be taken into consideration, also the nature of the feed water.

Water that contains sulphates of lime and magnesia will form a hard scale, and if not put through a process of purification before entering the boiler, will form scale in the boiler when the steam pressure is above 50 pounds. With this kind of water little or no trouble would be met with in circulating it through pipes in the boiler before discharging. But with water that contained carbonates of lime and magnesia considerable trouble would be experienced in keeping the feed pipes clear, as the carbonates precipitate at a temperature of from 190 to 212 degrees. With water containing carbonates, my idea is to get the water into the boiler as soon as possible after leaving the feed pump.

W. G. WALTERS.

Stratford, Ont.

Economic Engineering

I noted with interest Mr. Allison's criticism in the January 17 issue of my views in regard to the economic engineer and the superintendent or chief engineer.

I offered no criticism whatever of the economic engineer, neither did I express the opinion that he had not "come to stay." On the contrary, I think that the inefficiency of a good many superintendents and chief engineers has made the economic engineer a necessity, and I do not doubt for a minute that he has come to stay. But, this does not necessarily prove the inefficiency of everybody else.

Mr. Allison does not mention the chief engineer in his criticism, but deals entirely with the superintendent and regards him as the head of a business organization. Looking at the matter from that point of view, I agree heartily with Mr. Allison's views on the subject, but by referring to the editorial in the September 27 issue and also to my "argument" in the November 22 issue, it will be seen that both the superintendent and the chief engineer are considered. I understood the term "superintendent" to refer to the man who superintends the operation of the power plant, and not to the head of a business organization; sometimes he is called the superintendent and sometimes the chief engineer, and sometimes, in the case of a large plant, both are in evidence. If I understand rightly, the manager is considered the head of the organization.

Looking at the matter in this light, I still contend that the man who is "onto his job," I mean by this the man who knows his job as he ought to know it (I did not say "the man on the job"), should be just as efficient as the economic engineer.

Mr. Allison, because he considers the superintendent as an employer, accuses me of contradicting my statements by saying that I had found a great deal more unwillingness on the part of employers to furnish new equipment with which to improve the methods of operation, than unwillingness on the part of the operators to break away from old established customs.

To be sure, the superintendent is usually considered as an employer, so is the section boss on a railroad, but it does not necessarily follow that either has the power to purchase new equipment. This is generally up to the manager, who is also an employer.

A man's title does not necessarily make him more efficient than another man. The most efficient man is the one who does the job right, regardless of his title.

R. L. Rayburn.

Kansas City, Mo.

Introducing Solvents into Boilers

I read with interest Mr. Taylor's letter in the December 6 issue on the above subject. In the plant where I am employed there is an arrangement for feeding solvents into the boilers which is similar to that described by him, but I never use it except just before washing out. There is a ¼-inch pipe which connects the feed-pump suction line to a barrel on the roof. The solvent is ordinarily placed in this barrel and fed through the small pipe at a rate which is regulated so that three-quarters of a barrelful is fed in during the day's run.

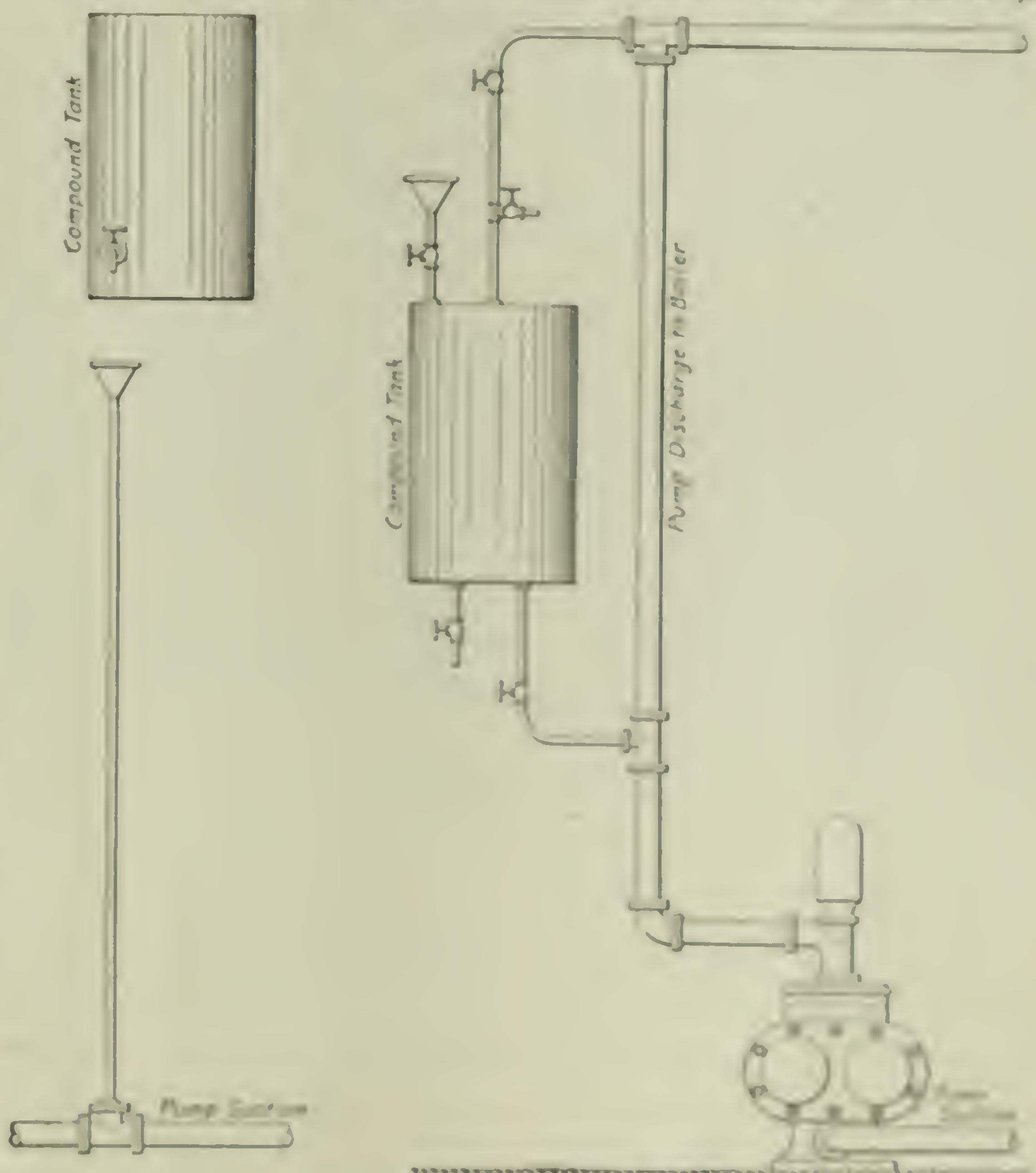


Fig. 1. Two Methods of Introducing Solvents Into Boilers Fig. 2

Just before running up the water level in the boilers at night, the balance of the solvent in the barrel is pumped into the boiler.

The object of this arrangement is to treat the water uniformly.

N. J. Keith.

Dublin, Tex.

In reply to Frank H. Williams, in the January 3 issue, in regard to introducing boiler compounds, I submit the following arrangements both of which may be rigged up from material from the scrap pile.

The device shown in Fig. 1 did not prove to be very satisfactory because the solvent passed through the pump, caused it to stick and filled up the water chambers.

The arrangement shown in Fig. 2 was substituted and gave good results. The drain valve should be a gate valve. All the piping is of ½-inch material.

William J. Martin.

Appleton, Wis.

An Engineer on Success

In the January 3 number, Mr. Eldredge writes about engine-room ethics.

No man can succeed unless he puts his whole soul into his work. With a determination to succeed he will surely rise to the top. It may take him years to do so but there is always a reward for those who keep steadfastly to their determination to win.

Many men make a mistake by not holding to one position, but moving around from one to another every few months.

The engineer who succeeds is the one who devotes his whole time and ability to the interests of his employer while on duty, and improves his spare moments by reading good engineering books or magazines.

We all have our ups and downs and the only way to come out on top is to keep up the spirit and determination to win.

George O. Griffith.

Fort Flagler, Wash.

Does the Crosshead Stop

The above title has for many a weary week adorned the pages of Power. The discussions upon the subject have been largely controversial; partaking of the nature of "Katy did" and "Katy didn't." Occasionally, there has been no reference to the subject and then I have put down my Power thinking happily, "At last that crosshead has stopped." But no! next week it crops up again as lively as ever with elaborate diagrams to show that it stops—or doesn't.

So, in self defense, I humble myself to write upon the subject. And I do hope that mine will be the last word. So here goes:

If the crosshead does not stop, it must be moving. If it moves, it has a velocity. If it has a velocity, it must have a direction. If it has a direction, please let someone who votes that the crosshead does not stop say in *just what direction the crosshead is moving at the end of the stroke.* Let him put an arrow on a diagram to show in which direction it moves. If he can prove the direction, I will yield him the palm. But, if it is impossible to find a direction, clearly there is no motion, and no further argument is needed that the crosshead does stop.

Julian C. Smallwood.

Syracuse, N. Y.

Engineer or Laborer

The advertisement copied in the editorial under the above title in Power for January 31 is enough to make every engineer in the country sit up and take notice. There are cases where a young fellow who is trying to get experience could work for such pay and be excused, but for a man who is duly qualified to take such a position is shameful. I regret that the article does not state whether or not this position was in Massachusetts; it is no more attractive than some I have seen in the daily papers in this State. Engineers in other States, who are struggling for a license law, will tell us it has a tendency to raise wages. Come and see. Here are a few specimens:

In a large office building requiring continuous service, where the engineers work seven 8-hour shifts each, the engineer does his own firing, burns screenings, operates two boilers in summer and three in winter, keeps everything in good condition and tends to the engines, generators and switchboard, all for $14 per week. This job requires a second-class license.

A first-class engineer recently made vacant a position for which he was receiving $35 per week, and another engineer with a first-class license took it for $18.

Another engineer with a first-class license took a job for $16 per week while he was looking for something bigger to turn up. Before he had been there two weeks, another engineer came along and took his position for $14.

Well, who is to blame? Why, the engineers, of course. To do each other out of a job seems to be a malady that is fast growing among engineers.

The average operating engineer is the poorest paid mechanic in the country. Other mechanics are getting good pay and they cannot do each other out of a job, because they are organized, and in organization there is strength.

There is no mistaking the fact that the engineers of this country must organize. Not only engineers but every man engaged in the generation and transmission of power should be a member of one organization. Give us a national organization of all power workers, coupled with Federal license and inspection laws, and I will venture to say that within ten years we will have the wages of the average power worker increased wonderfully, and the engineer's profession raised to such a position as to command the respect of employers.

J. A. Levy.

Greenfield, Mass.

Runaway Engines

It is surprising to note that hardly anything is being done toward reducing the number of flywheel explosions. Due to the results of such accidents not being so disastrous, perhaps, the general public and, indeed, those who are more intimately concerned with engines, are surprisingly complacent toward this type of accident. The lack of publicity as to the direct cause of flywheel explosions, due to the vigilant care of owners to baffle and prevent worthy investigation, is in a large measure responsible for fostering this indifference. A boiler explosion will occupy a very prominent space in the daily newspapers while often the reader must search minutely for mention of a flywheel explosion, and when he finds it, 99 times out of 100, the direct cause of the accident is not reported.

Why? Is it because the cause would incriminate the owner, or his servant, the engineer? That runaway engines are of frequent occurrence, though in the majority of cases stopped before damage is done, can be attested to by a large number of engineers.

When an engineer has once faced a runaway, by being obliged to stand in front of 12 tons or so of madly revolving iron, which at any moment may burst into a hundred pieces and hurl him to eternity, he generally afterward becomes most solicitous about all of the details which have to do with the safety of the flywheel. The chief cause of runaways is the governor belt, that often oil soaked, pieced, and badly spliced bit of hide to which one-half of engine builders are willing to commit the safety of valuable engines and their more or less valuable attendants.

My first experience was with a large central condenser pump with Corliss valve gear. Due to the breaking of the governor belt one afternoon it started to enliven matters by attempting to find out how fast it could go. As I descended the steps leading to the pit, I was met first by the crank-pin oil cup, and next by the oil pipe leading to it. The engine was stopped, however, without doing any further damage. My next experience was with an air pump, equipped with a throttling governor. To stop this runaway, also caused by the breaking of the governor belt, I was forced to stand on a step ladder and bend over one of the flying balance wheels to close the throttle. When stopped, the crank and wrist-pins were found to be smoking hot, and all of the foundation bolts loose. These two experiences inculcated the habit of extreme caution on my part, and taught me to seek answers to such questions as, what would I do if this, that or the other thing should happen. It is surprising how many things an engineer can do in an emergency—after full consideration under calm thought—and it will do no harm here to impress on young engineers the importance of considering the answers to these pertinent questions before an emergency arises, and not after the smoke clears.

A case to illustrate this happened some time ago. I was employed in a small textile mill erecting a line of shafting. It was my custom to spend my noon hour with the engineer, and during our conversations on engineering topics, I asked him what he would do if the engine ran away. The machine was a small slide-valve affair, equipped with a throttling governor that had no provision for stopping the engine in the event of the governor belt breaking, which, by the way, seemed to me from its condition to be imminent. His only resort at the time was to shut the stop valve on top of the boiler.

It was only a few days later that he was called upon to face the emergency. As I noticed the mill machinery speeding up, I called to the operatives to keep their looms running, and start up every loom that was idle, giving the example myself, for I had noticed that with a large percentage of the looms in operation, the speed often slackened, proving that the engine was hardly big enough to handle the mill load. But, much sooner than I expected, the racing looms slowed down. As I proceeded to the boiler room to congratulate the engineer on the remarkable agility he had shown in finding a ladder, climbing to the top of the boiler and closing the stop valve, I peeked into the engine room and beheld a most melodramatic tableau. Clinging to the lever of the 2-inch back-pressure valve that stood 10 feet above the floor and with one foot slowly but surely shutting the throttle was the engineer, while steam from several leaky gaskets was filling the place.

On being asked what had made him think of the back-pressure valve, he said that my inquiry as to what he would do when called upon to face this emergency had set him to thinking and had prompted him to try the expediency which had proved so efficacious.

Not long ago I had to deal with a very mysterious case of overspeeding on the part of a cross-compound Corliss engine, direct connected to a 1500-kilowatt alternator. I was about to stop this engine and, with a precaution that many would deem unnecessary, I had the oiler shut the throttle valve before pulling out the main switch. When this was done, we waited for the speed to slacken before releasing the steam and exhaust clutch on the high side. These clutches had been done away with on the low side as being unnecessary. To my astonishment and alarm, instead of slowing down, the engine began gradually but surely to increase its speed. Hastily I released the two clutches and, anticipating something wrong with the throttle, I picked up the starting bar and with it tightened the valve. Noting that the dashpot rods on the low side kept moving, I looked at the governor, but found it had assumed its highest plane, the spindle sleeve being tightly pressed against the top collar. Convinced that in some manner steam was being furnished to the low-pressure cylinder, I tried the low-pressure throttle, and while standing there I distinctly heard the hissing of steam, though the valve was closed tightly. Jumping over to the governor reach rod, I tapped it with the starting bar, bending it and thus shortening it, which brought the knock-off cams into action and prevented the valves from hooking. Then, as quickly as possible, the injection valve of the condenser was closed and the pump stopped. Upon investigating, I found that the low-pressure bypass valve was wide open. In order to pack the valve stem, the oiler had opened it to take advantage of the packing seat, and had forgotten to close it. It had no extension handle passing through the floor as the other valves had.

William Powell.

Ashland, Mass.

Pressure in Condensing Engine

The answer to a question in the January 17 issue under the caption, "Pressure in Condensing Engine," contains a statement that running an engine condensing is equivalent to increasing the pressure on the steam side of the piston to the extent of 10 or 12 pounds in average practice.

I think that the statement is misleading, as some would take it, that 10 or 12 pounds increase in initial pressure would give the same result, whereas it requires 10 or 12 pounds increase in the mean effective pressure.

F. M. Bennett.

Chicago, Ill.

A Practical Compression Test

"Compression or no compression" is a subject that has frequently been discussed in and out of the technical journals for the past twenty years, to my knowledge. The matter is not yet settled, although I see by some of the articles and letters in Power during the past year that some of the higher authorities in engineering are coming around to the side of no compression or, at least, very much reduced compression.

In the editorial "Two Diagrams" in the January 31 issue, the question is asked, "What is the real answer, and why does not some college laboratory find and announce it?" Must the answer come from "some college laboratory"? Can it not be found in steam plants where there is an opportunity to experiment and note results? It seems to me that it can, and to my knowledge it has been in one instance at least.

The plant, a street-railway power station, contained thirteen compound, condensing, Corliss engines of sizes varying from 500 to 1500 horsepower. The total horsepower was in the neighborhood of 8000 and for a few hours every day all of the units ran under full load. All of the engines had considerable compression in both high- and low-pressure cylinders, and were operated under a boiler pressure of 150 pounds and a receiver pressure of 15 pounds per square inch. During peak load both in the morning and the evening it was most difficult to keep up steam for even a half hour, and frequently the pressure would drop to 125 pounds, and sometimes even to 100 pounds.

After careful consideration it was decided to try reducing the compression in one of the engines, and at the same time increasing the receiver pressure. A few trials showed that the receiver pressure could be raised to 25 pounds gage. The engine was run for a day under the changed conditions and seemed to do as well, if not better, than before, as far as ordinary observation was concerned. As, apparently, the engine suffered no unfavorable effect, it was thought that a similar change could be made in the operation of all of the other ones and it could then be very soon discovered whether gain or loss resulted.

One by one, the engines were gone over, until all were changed. As the work progressed it was noticed that it was less difficult to maintain the standard 150 pounds boiler pressure. When all of the engines were finished, the peak loads were carried day after day without any trouble in the boiler rooms at all. Now, as the load conditions had not changed, as no other changes were in progress at the time and as not only one day was taken, but a number of days, it certainly seems fair to assume that the improvement was due to the reduction in compression, the increase in receiver pressure, or to both. I think that each contributed its share of the decided improvement.

I am not going to attempt any theoretical explanation, nor do I care particularly about such, just at present, but I do know, positively, that after the changes less steam was consumed to do the same amount of work in the same period of time, and every one of the engines behaved splendidly while carrying its share of the load. There was no more dropping of steam pressure with the consequent long cutoffs and the disagreeable possibility of having to shift some of the load onto some of the other stations.

From a purely practical and commercial standpoint, what difference does it make as to just exactly what caused the improvement, as long as it was effected by the expenditure of a few hours' time on the part of the station men who were on duty anyway. There is hardly any doubt that had a mistake been made in reducing the compression and in increasing the receiver pressure in so many engines, it would have manifested itself immediately.

Set some of the boys to trying the thing out for themselves, and report the results in Power. Report the exact conditions attending such tests, so that the whole truth may be known.

Charles J. Mason.

Scranton, Penn.

Belt Lacing

I was much interested in Mr. Kell's article on lacing belts in the January 10 issue. The illustrations were good, also the methods.

I wish more others would contribute articles on the same subject.

Thomas Clark.

Boston, Mass.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

One or Two Cylinders

We are now running an 18x36-inch engine which is supposed to develop 249 horsepower at one-third cutoff. The load has increased to 328 horsepower, and the engine takes steam seven-eighths of the stroke. If another side is put in the same as this, setting the crank pins on the quarter, would it take more steam to develop the same amount of power with the two engines than it does with this single one with the overload?

E. W. O.

A fair load for an 18-inch engine under average conditions of steam pressure is 175 horsepower. Two 18-inch cylinders will develop 328 horsepower on much less steam than one. The displacement up to cutoff will be about in the ratio of 8 for one cylinder and 5 for two.

Color of Ashes

What gives the fine ashes in the combustion chamber of an ordinary return-tubular boiler their reddish color?

C. O. A.

The color is due to the presence of sesquioxide of iron.

Peak Load

What is meant by "peak load"?

E. E. P.

The term refers to the heaviest load of the run. Where the load curve is plotted on a chart, the highest point reached is called the peak.

Brake Horsepower

What is the brake horsepower of an engine?

E. P. E.

Brake horsepower is the term applied to the power delivered from the flywheel or engine shaft. It is that determined by brake measurement, hence the term. It is the net horsepower as distinguished from the indicated horsepower, which is the power developed in the cylinder.

Effect of Safety Valve Opening

If the quick opening of a valve or the breaking of a pipe or fitting reduces the pressure in a boiler and causes a water hammer, why is there not a water hammer every time the safety valve blows?

E. S. O.

When a safety valve blows there is no sudden reduction of the pressure in the boiler. The opening of the valve prevents any further rise and if there is any appreciable reduction due to excessive "blow back," this reduction is accomplished slowly instead of rapidly as is the case with a broken pipe.

Compound Engine Cranks

In a cross-compound engine which will give the better results, to have the crank pins 90 or 180 degrees apart?

C. E. C.

It will make no difference in steam economy. But there will be a more uniform turning effect on the shaft with the cranks at 90 degrees.

Granulated Babbitt Metal

How can I make a granulated babbitt metal?

G. B. M.

Melt the metal in a ladle, remove the ladle from the fire and allow the metal to cool. When it begins to "set," stir briskly with a stick until it has all cooled into a granular mass. If any particular size of grain is desired, the metal may be sifted, using two screens, one of the desired size mesh to remove the large grains and one slightly smaller to allow the escape of the fine or too small grains.

Disabled Valve Gear

If the connection on one of the exhaust valves of the high-pressure cylinder of a triple-expansion Corliss engine should get broken, what should be done in order to keep on running?

O. W. L.

Block the exhaust valve open, then shorten the dashpot rod of the corresponding steam valve until the hook will not engage. This will leave the steam port closed and the high-pressure cylinder will run single acting.

Cutting Boiler in with Others

How should a boiler, in which steam has been raised, be cut in with others?

C. B. O.

As the steam pressure approaches that in the others, the draft should be checked and the pressure allowed to increase slowly until it is within a pound or two of the other pressure, when the connecting valve should be slowly opened.

Area of Steam Port

How is the size of the steam ports of an engine cylinder found?

A. S. P.

The velocity of the steam entering the cylinder should not exceed 100 feet per second. To find the area of a steam port for this velocity, multiply the piston area in square inches by its travel in feet per second. This product divided by 100 will give the required area of the port in square inches. Dividing the area of the port by its length will give the width.

Tubes, Flues and Pipes

What is the difference between tubes, flues and pipes?

T. F. P.

It is in the terms of the diameter. Tubes and flues are measured by the external diameter. Boiler-tube sizes run to 4½ inches. Above this they are called flues. Iron and steel pipe is measured by the internal diameter up to 12 inches and by the outside above this. Cast-iron pipe of all diameters is measured on the inside.

Corrosion and Remedy

What is corrosion in a boiler and how can it be prevented?

C. A. R.

It is the gradual rusting or dissolving of the metal by the water or oxygen or acid present in it. It may be prevented by analyzing the water and introducing such elements as will neutralize the corroding agents.

Total Pressure in Boiler

What is the aggregate pressure tending to burst a boiler 6x18 feet, carrying 120 pounds pressure per square inch?

T. P. B.

The total pressure on the shell is

$$3 \times 3.14 \times 18 \times 144 \times 120 = 2{,}879{,}996.8 \textit{ pounds}.$$

The pressure on the heads if supported by the tubes and stays has no bursting tendency.

Comparative Value of Wood and Coal

How does wood compare with coal in fuel value?

C. V. C.

Dry wood has a heat value per pound of about 0.4 that of carbon. There is little difference in the fuel value of the different kinds of wood, pound for pound.

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POWER

The Coal Mine Operator's Profit

In the January 17 issue of Power an editorial entitled "The Consumer Pays the Bill" was published. Our contemporary, *The Black Diamond*, took exception to some of the statements made, and tried to tell the coal operators that they are not receiving enough money for the smaller sizes of anthracite coal.

According to *The Black Diamond's* own statement, sixty-two per cent. of the anthracite coal now mined is sold for domestic use, and the remaining thirty-eight per cent., which is broken up into the small sizes, is sold for steaming purposes, so that there is practically no waste of actual combustible. Not long ago these smaller sizes were thrown away and therefore represented no income. During the year 1909 there were 855,933 tons of No. 1 buckwheat, 1,330,468 tons of No. 2 buckwheat and rice and 1,172,831 tons of No. 3 buckwheat coal taken from the washeries as against 8,287,401 tons of No. 1 buckwheat, 4,283,417 tons of No. 2 and rice and 2,145,938 of No. 3 buckwheat coal taken from the mines.

Coal is being mined almost as cheaply today as it was ten or fifteen years ago, but the selling price to the consumer is higher than it has ever been, under ordinary conditions; yet *The Black Diamond* contends that the money received from the sale of the smallest sizes is not "velvet" and asserts that inasmuch as it costs just as much to mine the fine coal as it does to mine the larger sizes, the anthracite companies should charge more for the small sizes instead of less. This argument might have some merit if the prices of larger sizes had been reduced when the operators began selling the fine sizes.

If the income from sixty-two per cent. of the coal mined formerly paid a good profit over the cost of mining all of it, how much profit must there be now that all of it is sold without any reduction in the price of the larger sizes? The average price of the larger sizes at the mine last year was about two dollars and ninety-two cents per ton, and how that this formerly paid a profit on the cost of mining a little over one and one-half tons of combined large and small sizes. The average price of small sizes is one dollar and twenty-five cents per ton, or fifty cents on each ton of available fuel mined. Result: instead of receiving one dollar and seventy-five cents per ton of available fuel mined, the operators receive two dollars and twenty-five cents per ton, although the cost of mining has not increased as much as the selling price of coal since the small sizes were "dumped." If that is not fifty cents of "velvet" per ton of fuel, what is it? And who pays it, if not the consumer?

Boiler Inspection and Engineers' License Legislation

It is interesting to note that the persistent agitation on the part of the more intelligent engineers for the enactment of boiler-inspection and engineers' license laws is beginning to be felt where no laws of this nature exist. There are before the legislatures of the States of New York and Kansas concise and comprehensive propositions for the examination of engineers. And there has just passed both houses of Congress a bill providing for the annual inspection of locomotive boilers.

These are steps in the right direction and when all of the States have enacted suitable inspection and license laws a part of the coroner's occupation will have disappeared. Uniform license laws throughout the country, honestly administered, will eliminate the incompetent employee and one form of menace to life and property will disappear.

Consistent boiler-inspection requirements forbidding the installation and use of boilers of defective construction and compelling the rigid examination of all already installed will add to the length of the undertaker's vacation. The most rigid laws and the utmost vigilance in their execution will probably not entirely prevent boiler accidents, but such action will reduce them to the lowest possible number. Periodic inspections have prevented almost numberless explosions, and hundreds of others would have been prevented by the enforcing of common-sense laws. There are no boiler laws in New Hampshire. In 1908 on a boiler belonging to the town of Dartmouth, Mass., the pressure allowance was reduced by a State inspector to a point which rendered it useless to the municipality as a source of steam supply and it was sold for junk for fifty dollars to an alleged engineer who represented to the New Bedford Ice Company that the boiler was safe for a much higher pressure than that allowed by the State inspector. The boiler was taken to New Hampshire and installed for use during the ice harvest. It exploded on the first day of its use, killing the man who said it was safe.

Last summer at Laconia, a boiler in the Lakeport steam laundry exploded with fatal results. Had laws similar to those of Massachusetts been in force in New Hampshire, neither of these boilers would have failed, and the State would not be characterized as the dumping ground for worn-out Massachusetts boilers.

Sign Your Full Name

From Detroit, Mich., there comes a question about the method used to determine the efficiency of riveted seams. The question is a reasonable one and is intelligently stated. But after the question comes this plea: "Now, do not turn this down and say that you have shown this more than a hundred times during the last twenty years, but kindly and considerately remember that there are many young men just beginning to read POWER while the older readers are passing away. Editors sometimes forget that new men are coming up as the old ones go, by the thousand, and refuse to reply to a question a second time. Please do not treat this one that way."

Four times within two years this question has been answered in the columns of the paper and more than fifty times by personal letter, just as it would have been in the present instance if the writer had signed his name to the letter he so painstakingly wrote.

Sometimes a correspondent will sign a letter with his initials only and hundreds of letters have been answered where the only clues to the addresses were the post mark on the envelop and the initials which fitted a name on the subscription list.

Hundreds of letters are received, read, answered and filed at this office every working day of the year and it is not strange that a few mistakes occur. But it is strange that the most, in fact nearly all, of the unsigned letters received at this office are written by engineers. Anonymous letters are annoying, whether the omission of the signature is intentional or otherwise; but are doubly so when concealment makes it impossible to perform a service so manifestly expected, as in the instance mentioned.

Engineers are not as a rule careless; their work and training, and the responsibilities of the positions they occupy preclude this. But some do slip, and when they do, how often will they accept the suggestion that possibly or very probably the miscarriage of a project was due to negligence on their part?

This was not written wholly for the subscriber in Detroit, whose question will, in the near future, be answered in the reading columns, but for all who feel that they have not been given courteous attention. This journal is for its readers, and the whole office force from the office boy to the president is at their service and they have only to ask to receive and that quickly, if they ask aright by plainly signed letters.

Stress in Boiler Sheets

It is a well understood fact that in a cylinder under pressure the stress upon the metal per unit of section is twice as much when the section is taken parallel with the axis as when it is taken at right angles thereto; that in a cylindrical boiler, for example, this stress is twice as great upon the longitudinal as upon the roundabout joint.

This stress upon the longitudinal section has been considered by designers as the maximum stress per unit of section to which the sheet is subjected by reason of the pressure; but on page 1935 of POWER for November 1, 1910, Mr. Adler advances the idea that these two stresses acting at right angles have a component acting diagonally through the sheet greater than either of them.

This proposition seems open to argument, and we should like to have expressions of the ideas of our readers concerning it.

Suppose a sheet of boiler steel to be stressed lengthwise, as in a testing machine, up to its breaking point. Would it break under any less stress and would the direction of the line of fracture be any different if at the same time it were subjected to a crosswise stress one-half of that which was being applied lengthwise?

If a square piece of perfectly homogeneous boiler steel were submitted to tensile stresses, uniformly applied to all four sides and normal to those sides, would it break into four squares or four triangles, that is, would it break on the diameters or on the diagonals?

High Boiler Efficiency

Some time ago we published the report of a test upon the boilers of the Government plant at Panama, showing an efficieny of over eighty-two per cent. Under the terms of the contract a bonus of over seventeen thousand dollars was earned by the builders upon the strength of this test. The report was furnished us by the makers of the boilers and was signed by the testing engineer for the Government.

Since publishing the report, we have received several communications questioning the correctness of the figures, and upon taking the matter up with the makers, they admit that they are at a loss to account for some of the figures. Computed rationally, the efficiency should have been about seventy-five per cent.

Hanging On to Water Power

Another instance of the keeping of the hands of the people upon their power supply is the refusal of the House of Representatives to cede perpetual control of the water power of the St. Lawrence river to the Aluminum Company of America. The Government should either itself develop or encourage the development of water powers as fast as there is a demand for them, but under such circumstances that the people can retain their rights therein and be guarded against excessive charges.

Louisville, Ky., is also out for an international exposition in 1915. The excuse is that that year marks the fiftieth anniversary of the end of the Civil war. It is to be known as the Lincoln-Davis exposition and held at Louisville as both Abraham Lincoln and Jefferson Davis were natives of Kentucky. The real 1915 exposition will be held in San Francisco and will commemorate the completion of the Panama canal. We are big enough, however, to run two international expositions at once, if it has to be done.

Have you had or do you know of any trouble with boiler tubes recently? If so, what kind of a tube was it; iron or steel, lap or butt welded or seamless, standard thickness or under or over gage? How did it fail; in the seam or elsewhere, by thinning down or breaking a piece squarely out? What were the conditions of the tube as to cleanliness, and how much water was it evaporating per square foot of heating surface?

Camille Flammarion, who in a recent issue of the *New York American* takes a Look One Thousand Years Ahead, says that "Electricity will, of course, have taken the place of steam." Where are they going to get the electricity? At present, "juice" is not a substitute for but a product of steam power.

Pittsburg will entertain the Mechanical Engineers in May. This will be the second time in the history of the society that it has met at Pittsburg, the first being in 1884.

When are they going to try John Carroll? They are waiting for him in Philadelphia after the Boston authorities get through with him.

It is rumored that the committee on power tests of the American Society of Mechanical Engineers has turned over in its sleep.

The crosshead does stop at the end of the stroke.—*Punktum.*

Prevention of Industrial Accidents

An analysis of the principal causes of injury in industrial establishments and recommendations as to the preventative measures to be adopted.

At a recent meeting of the American Society of Mechanical Engineers, John Calder presented a paper upon "The Mechanical Engineer and the Prevention of Accidents," which was, in part, as follows:

Accident clauses have been included in the labor laws of the various States for some years, but the provision for administering these laws effectively has always been inadequate.

In study and legislation upon the subject, this country is far behind Great Britain, Germany and France, which countries more than thirty years ago began to enforce the existing laws with strictness and excellent technical judgment. The reports of the Bureau of Labor show that the yearly mortality from industrial accidents, among adult wage earners alone, in the United States is between 30,000 and 35,000. It is estimated that the nonfatal injuries reach nearly 2,000,000 annually.

Scientific study and a solution by the mechanical engineer of individual problems of safeguarding, supervision and instruction of employees, as they arise in daily routine work, will do more than all other existing agencies to bring about satisfactory results. In such matters the attitude and action of the executive are all important. However, all industrial accidents are not to be considered preventable, either by employer or employee. Furthermore, of those that may be avoided, some do not fall strictly within the province of the engineer, but are directly within the control of the injured themselves.

An analysis of many thousand industrial accidents shows them to have been due principally to the following causes: ignorance, carelessness, unsuitable clothing, insufficient light, dirty and obstructed work places, defects in machinery and absence of safeguards. Accidents due to the culpable, as well as excusable, ignorance of supervisors, engineers, millwrights, elevatormen, etc., may be reduced only by administrative vigilance in selecting and instructing these employees. As for carelessness, the average American workman is very apt to take foolish and unnecessary chances with life and limb and the only way to guard against this is by the maintenance of strict discipline in the shops, the adoption of salutary punitive measures and the elimination of the dangerous employee, in addition to an educational campaign throughout the plant.

Much eloquence has been expended from time to time on assumed inherent and deadly defects in machinery and structures used in the arts. These, while contributing to some serious and a number of minor casualties, do not approach the extent commonly alleged. It certainly does not pay any employer to keep a defective machine in operation; nor is it in the interest of the employee to use imperfect apparatus which reduces the possible earnings. On the other hand, it is by no means infrequent to find workmen who have their choice of the best material and apparatus and who possess the intelligence to apply these correctly, showing a striking disregard for their own safety; this is especially true in temporary structures, such as scaffolds, frayed ropes, etc.

The absence of safeguards, although not the most prolific cause of accidents in plants, as is commonly supposed, nevertheless closely concerns the mechanical engineer who holds the possibilities largely in his own hands. However, in many cases of injuries caused by the absence of safeguards, it has been found that these were removed or rendered ineffective by the operatives themselves. All safeguards should be so designed as not to interfere with the speed and ease of operating the machine.

Mr. Calder illustrated a number of safeguarding devices, applicable for the most part to industrial machines. Regarding power-house appliances he recommended that the edges of all stairs, platforms and gratings should have toe fenders on both sides to prevent nuts, bolts, tools and other small parts rolling off onto the machinery or striking employees. Also, a double metal railing not less than three feet high and not nearer to any moving part than twelve inches should be provided at all dangerous places, such as crank and flywheel pits and the edges of all stairways. Metal tubing and disk guards should be used for all shafting, bearings and pulleys requiring to be approached closely while in motion. Seven feet clear of every moving part is considered the least height from the floor level without guarding and, even then, where a horizontal belt drives across a frequented passage it is well to have the lower side screened to avoid injuries caused by "whipping" if the belt should break.

Discussion

The discussion of the paper was opened by Professor Hutton, president of the American Museum of Safety Devices, who showed lantern slides of numerous devices and commented upon their effectiveness. A number of the devices shown were of German design and, although practically a sure preventative against accidents, many of these were of such design as to impede the speed of the operator or make their cost prohibitive. Professor Hutton laid particular stress upon the subject of signs, pointing out that the majority of signs were ineffective for two reasons: First, owing to the number of foreigners employed in this country, it is essential that the signs be printed in several languages; second, they are usually of a cautionary nature and are not expressed forcibly enough. In this connection he called attention to the practice of the United States Steel Corporation which uses the symbol of a skull and crossbones to denote a death danger.

The next speaker, Mr. Cummings, dwelt to some extent upon the economic side of the question, showing that outside of humanitarian considerations it actually paid the manufacturer to install safety appliances. It was shown that nearly all the courts hold that if an accident occurs from any device or machine, it is not valid evidence that it is not customary to guard that machine, but it is accepted as *prima facie* evidence that the machine being dangerous, the accident should not have happened and the machine could have been guarded. Thirty-one cases were cited, happening within thirty days in the State of Minnesota, in which judgments of over $140,000 were awarded by the courts; of this only $6000 was deducted by reversed decisions.

Mr. Cummings also referred to the preventative methods adopted by the United States Steel Corporation which have reduced the number of accidents 50 per cent. Here, besides the mechanical appliances employed, much of the credit is due to the system of inspection, which makes every foreman and workman an inspector. A set of inspectors is appointed in each department for a certain period, at the end of which these men go back to their work and others take their place, and so on. However, the fact of their going back to work does not relieve them of responsibility of inspection, as they are supposed to keep continually upon the alert for defects. In this way all the men are trained.

J. W. Alexander, while conceding that machines should be made safe, believed that it was not necessary to make them foolproof. He thought that more attention should be given to working conditions, the cooperation of the workmen, clothing, etc., and suggested that a committee of engineers be appointed to collect the available data on safety appliances and standardize their use.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Diamond Tube Blower

A new soot blower, known as the Diamond, has been designed for use with water-tube boilers, and is illustrated herewith. By its use soot can be cleaned from the tubes without waiting for the boiler to cool down, and as often as the operator may desire.

Fig. 1 gives a good idea of the construction and mechanical parts of the device. Fig. 2 shows three blowers installed on one boiler having two vertical baffles, and under such circumstances

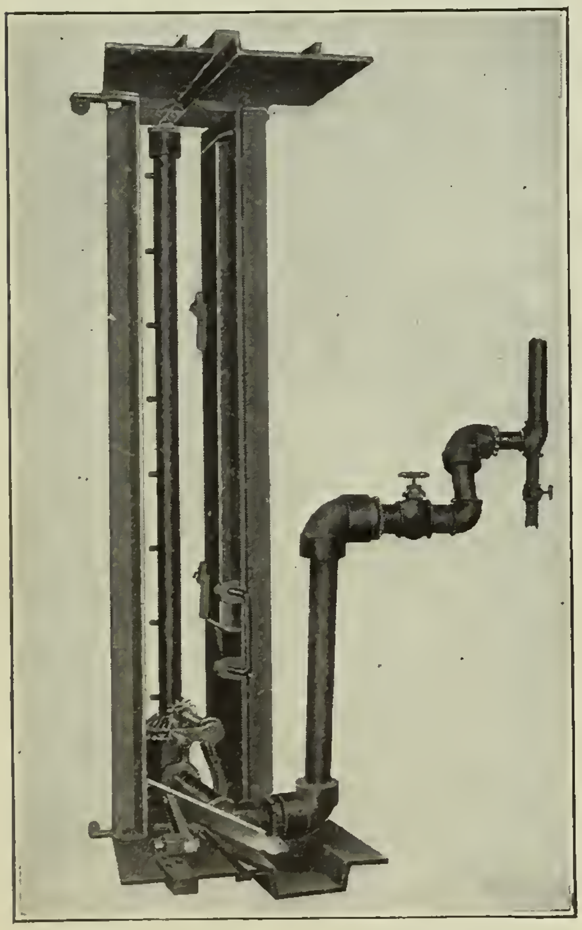


FIG. 1. DETAILS OF BLOWER

three blowers are required, one each side of the baffles. If the boiler had only one baffle, but two blowers would be necessary.

This blower is also applicable to boilers having horizontal baffles, in which case the number of blowers required is regulated by the length of the boiler, but any ordinary length can usually be covered by two blowers.

The blower is intended for use on boilers in which tubes are laid in even horizontal or nearly horizontal rows, when there is a clear passage between each row of tubes from one side of the boiler to the other, so that a jet of steam may pass through this space unobstructed for the full width of the boiler.

This blower is very simple in design, having no complicated parts to be destroyed by the effect of heat, soot or dirt.

There are three main parts to the blower: the door frame, the door and the standpipe resting on its slide. The slide operates in a groove in the top and bottom plates of the frame, and is moved in and out of the operating position by means of a vertical hand lever, as shown in Fig. 1, this lever being in a vertical position when the device is out of use, and in a horizontal position when the blower is thrown into the operating position.

When the blower is not in use it is protected by the door which closes behind the standpipe. This protects the working parts of the blower from the heat of the boiler, no parts being exposed when the blower is not in use. The door itself is protected by a filling of asbestos and cement about ½ inch thick.

When the blower is thrown into an operating position, by pressing down the lever, the standpipe is moved toward the inner side of the boiler wall so that it projects slightly beyond the inner face of the boiler setting.

In cleaning the tubes the standpipe is rotated through an arc of 180 degrees, or 90 degrees to the right and 90 degrees to the left, by the geared handle on the pinion shaft, as shown in Fig. 1.

The standpipe is provided with small jets so placed that one will come between each row of boiler tubes, and as the operator turns the handle, a jet of steam is thrown between each row of tubes from one side of the boiler to the other, and within the limits intended to be covered by one machine.

This blower is manufactured by the "Diamond" Power Specialty Company, 80-82 First street, Detroit, Mich.

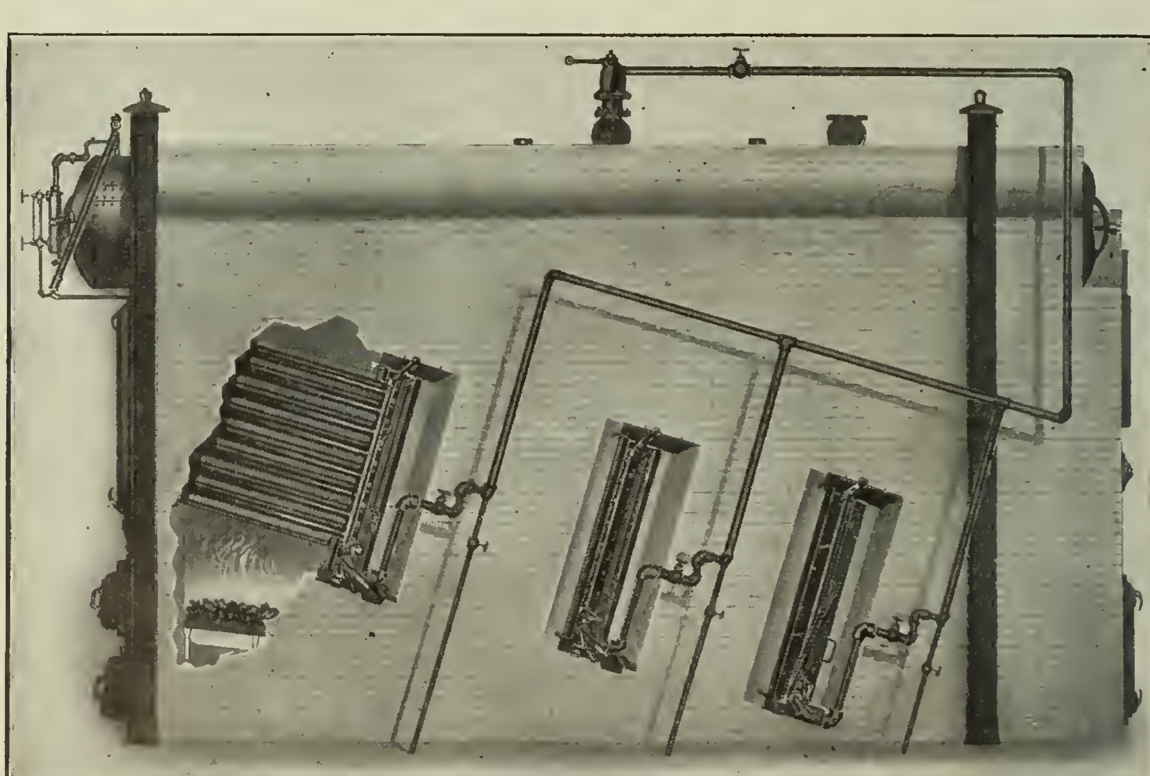


FIG. 2. APPLICATION OF BLOWER TO A BOILER

Mound No. 4 Packing Irons

These tools are for the purpose of replacing packing in the stuffing box of an engine, pump, etc.

They are forged from tool steel, and,

NO. 4 PACKING IRONS

having no sharp edges, are not liable to cut the piston rod during the process of packing.

There are four tools in each set, each 7, 9, 11 and 14 inches long, and they are nickel plated. The set is known as No. 4, and is made by the Mound Tool and Scraper Company, 7 Hickory street, St. Louis, Mo.

Court Rulings on Pittsfield Explosion

By John L. Robbins

In filing the report of the inquest on the recent boiler explosion at Pittsfield, by which seventeen lives were lost, the court found that there was violation of law in substituting a new safety valve of larger size and increased pressure for the one allowed by the State inspector, and in afterward tampering with the safety valve and thereby greatly increasing the pressure at which it was set. But it was held that no one living was responsible for it.

With a view to preventing further accidents from a like cause, it was recommended that the law be so amended as to require that all connections between the steam gage and the boiler shall be of brass or other metal that does not rust, and that all safety valves on boilers which require a licensed engineer to run them, shall be locked and a key kept in possession only of the State inspector of that district in which the boiler is located.

Long Beach Plant of the Southern California Edison Company

To insure continuity of service, the Southern California Edison Company has already invested about $2,000,000 in steam auxiliary generating plants to supplement in case of necessity their hydroelectric developments on the Kern river, the Santa Ana cañon and other water courses that derive their flow from the Sierras.

At Long Beach a steam plant is now under construction which will have a total ultimate capacity of 125,000 horsepower when entirely completed. This amount of energy will be necessary for carrying the peak loads of Los Angeles and the towns of southern California. The final cost of this plant will be about $6,000,000.

The new station, which will be located on a site adjacent to the inner harbor, will comprise two buildings having a combined floor space of nearly an acre. The generator and boiler house will have a floor area of 30,000 square feet and will be 60 feet high, while the transformer building will cover 7800 square feet and will be four stories in hight. Both structures are to be of reinforced concrete with artificial-stone base, ornamental cornice and mission-tile roof. The generator room will have a floor of imported Welsh quarry tile, with a glazed-tile wainscot. Everything considered, this will be the most handsome and best equipped steam plant west of Chicago.

The main unit will consist of a steam turbine of 12,000 kilowatts capacity.

For supplying steam to this turbine, there will be eight 750-horsepower Stirling boilers. Crude oil will be used for fuel, large concrete supply tanks being located on the west end of the property. This oil will be shipped in tank cars or may be pumped through a main which now runs by the company's property. Salt water will be used for condensing purposes.

Although only one unit will be installed at the present time, the buildings are being built of ample size for two large machines with their boilers and auxiliaries. The property on which the plant is located will allow for future growth. Frederick Sargent, of Chicago, has been retained as consulting mechanical engineer. The Edison company's engineering department is supervising the construction work and has made all of the designs and plans, except the purely architectural details which were designed by Parkinson & Bergstrom who have been retained as consulting architects.

Cost of Industrial Power

On Friday evening, March 10, the American Society of Mechanical Engineers, coöperating with the American Institute of Electrical Engineers, will hold a meeting on the cost of industrial power in the Engineering Societies building, 29 West Thirty-ninth street, New York. Papers will be presented on power costs by members of both societies. All members having intimate knowledge of cost of producing power in either central or isolated and industrial plants are invited to take part in the discussion. That there may be a proper standard for comparison it is necessary that the cost figures be itemized and the method of analysis by which each is determined, together with primary data from which determined, be given in detail. It is hoped that reliable information as to practical year in and year out operating costs will be presented so that it will be possible to differentiate between test conditions and actual operating costs. Those intending to discuss the question are requested to notify the New York meetings committee at an early date.

The Naval Dinner

On February 11, the American Society of Naval Engineers held its third annual banquet at Rauscher's, Washington, D. C. The banquet was a brilliant one and well attended by representative men of the naval, executive and army departments. Walter M. McFarland was toastmaster. Ernest W. Roberts, L. P. Padgett, Rear Admiral R. Wainwright and Col. Robert M. Thompson were on the program for toasts to the navy and Rear Admiral Melville concluded the speaking with a few brief remarks on the navy of the past and the present.

Newport Cannot Use Rhode Island Coal

Rhode Island coal may burn satisfactorily in some cases, but reports from Newport indicate that it cannot favorably compete with other coals for boiler use. Bids for supplying the city hall and overseers of the poor with fuel for the present year were requested by the board of aldermen. Rhode Island coal was offered at the lowest price and the company's agent in Newport was given a chance to take charge of the city-hall furnaces for a few days. The engineer of the plant reported that while the coal seemed to burn well enough, its heat value was apparently low and with the equipment in the plant did not raise steam as readily as other coals. An unsatisfactory report was also received from the overseers of the poor.

Oil Burning Engines for New Haven Road

It is reported in the daily press that the New Haven road is planning to try oil-burning locomotives on a more extensive scale than has been attempted by any other railroad in the East.

One locomotive has been transformed and the directors of the road will consider at their next meeting the project of converting twenty-two more locomotives.

The road has been quietly running an oil-burning locomotive daily from Boston to Provincetown, Cape Cod. The experiments show a saving of $12 a day and a speed fully as great as that of coal-burning engines.

Boiler Explosion in Philadelphia

On February 15 a boiler exploded in the basement of the candy factory of H. Nuss & Co., Philadelphia. The engineer of the plant was killed and considerable damage to the boiler room is reported.

Locomotive Explodes

A locomotive-boiler explosion is reported in the daily press to have occurred in Smithville, Tex., on February 9. Two were killed and nine injured and a property damage of $20,000 was effected. Details of the explosion will be given in an early issue.

PERSONAL

Frank Koester, previously with the Interborough Rapid Transit Construction Company, J. G. White & Co., the Guggenheim Exploration Company and the American Smelting and Refining Company, all of New York, recently opened an office at 115 Broadway, New York City, as consulting engineer. Mr. Koester is author of "Steam Electric Power Plants" and "Hydroelectric Developments and Engineering."

Arthur Ritter has succeeded Clayton W. Old as manager in charge of the New York sales office of the American Blower Company. Mr. Ritter has been connected with this company for a number of years and is well and favorably known among its clientele in the New York section.

SOCIETY NOTES

The next meeting of the Engineering Society of Wisconsin will be held in Madison on March 8, 9 and 10.

The spring meeting of the American Society of Mechanical Engineers will be held in Pittsburg, Penn., May 30 to June 2.

The national convention of the Building Owners and Managers Association will be held at Cleveland, O., on July 10, 11 and 12.

The Southern Supply and Machinery Dealers' Association, the National Supply and Machinery Dealers' Association and the American Supply and Machinery Manufacturers' Association will hold a triple joint convention in Louisville, Ky., on April 3, 4 and 5, 1911.

On the evening of March 9, 1911, the Institute of Operating Engineers will hold its second monthly meeting in its rooms in the Engineering Societies building, 29 West Thirty-ninth street, New York. William D. Ennis, professor of mechanical engineering in the Polytechnic Institute of Brooklyn, will deliver a paper on "Commercial Aspects of the Work of the Operating Engineer." Two other prominent engineers will be called upon to enter into the discussion of the paper. As this subject is one of great importance to the operating engineer, a large attendance is expected.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

INTERNAL COMBUSTION ENGINE. William J. Perkins, Grand Rapids, Mich. 983,307.

COMBUSTION ENGINE. Jakob Sulzer, Winterthur, Switzerland. 983,322.

INTERNAL COMBUSTION ENGINE. Leonard Archibald Vallillee, Buckingham, Quebec, Canada. 983,328.

TWO-CYCLE GASOLENE ENGINE. Fred Howes, Burlington, Vt. 983,369.

INTERNAL COMBUSTION ENGINE. Thos. Turnbull, Jr., Pittsburg, Penn. 983,583.

TURBINE. Byron Stevens, Oakland, Cal. 983,653.

ROTARY ENGINE. Franklin Priestley Nichols, Houston, Tex. 983,754.

BOILERS, FURNACES AND GAS PRODUCERS

STEAM GENERATOR. John N. Leach, Melrose, Mass., assignor, by mesne assignments, to Judson L. Thomson Manufacturing Company, Waltham, Mass., a Corporation of Maine. 983,296.

MECHANICAL STOKER. Edgar D. Newkirk, Canastota, N. Y., assignor to the Westinghouse Machine Company, a Corporation of Pennsylvania. 983,305.

WATER-TUBE BOILER. Amasa Worthington, New York, N. Y. 983,339.

OIL BURNER. William S. Dowell, El Reno, Okla. 983,484.

SMOKE CONSUMER. Charles D. Leonard, Rochester, N. Y. 983,503.

SMOKE-CONSUMING FURNACE. John W. McNeal, Chicago, Ill. 983,510.

GRATE. Robert Hilprecht, Lansing, Mich. 983,716.

POWER PLANT AUXILIARIES AND APPLIANCES

FEED-WATER HEATER. Francis Hodgkinson, Edgewood Park, Penn., assignor to the Westinghouse Machine Company, a Corporation of Pennsylvania. 983,282.

STARTING DEVICE FOR EXPLOSIVE ENGINES. Frederic N. Howard, Harris, R. I. 983,282.

OIL SAVER. Clark F. Rigby, Butler, Penn. 983,314.

FEED-WATER CONTROLLER. George Fleming, Chicago, Ill. 983,356.

PUMP. Byron W. Haskell, Oakland, Cal. 963,365.

STEAM TRAP. Jarad W. Lytton, Franklin, Va., assignor to Lytton Manufacturing Corporation, Franklin, Va., a Corporation of Virginia. 983,384.

LINING FOR ENGINE CYLINDERS. Einar N. Sorensen, Athens, Penn. 983,409.

CARBURETER. William T. Dawson, Helena, Ark. 983,541.

ROTARY GAS-ENGINE VALVE. William E. Ewart, Seattle, Wash. 983,546.

VALVE GEAR FOR ENGINES. Charles D. Parker, Worcester, Mass. 983,564.

COMPRESSOR. Henry W. N. Cole, Brooklyn, N. Y. 983,605.

COAL-HANDLING APPARATUS. George E. Titcomb, Philadelphia, Penn., assignor to the J. M. Dodge Company, Naugatuck, Conn., a Corporation of Pennsylvania. 983,659.

HOSE COUPLING. John E. W. Boesch, Columbia, Nev. 983,671.

LOCK COCK. Joseph Schneible, Weehawken, N. J., assignor to Schneible Company, Buffalo, N. Y., a Corporation of New Jersey. 983,842.

ELECTRICAL INVENTIONS AND APPLICATIONS

ELECTRIC HEATER. Milton M. Kohn, New York, N. Y. 983,291.

ELECTRIC FURNACE. Hans Nathusius, Friedenshütte, near Morgenroth, Germany. 983,303.

ELECTRICAL SIGNALING DEVICE. Joy Glenn Schafer, Brighton, Iowa. 983,403.

MOTOR-CONTROL SYSTEM. Emmett W. Stull, Milwaukee, Wis., assignor to Allis-Chalmers Company, Milwaukee, Wis., a Corporation of New Jersey. 983,519.

ELECTRIC SWITCH. Charles S. Van Nuis, Philadelphia, Penn. 983,680.

ALTERNATING-CURRENT SYSTEM OF DISTRIBUTION, REGULATION AND CONTROL. Joseph Bijur, New York, N. Y., assignor, by mesne assignments, to the Electric Storage Battery Company, Philadelphia, Penn., a Corporation of New Jersey. 983,670.

ELECTRICAL WRITING APPARATUS. Dinshah Pestanji Framji Ghadiali, Surat, India. 983,703.

INSULATOR FOR ELECTRIC INSTALLATION CANOPIES. George W. Gardiner, Chicago, Ill. 983,701.

POWER PLANT TOOLS

PIPE WRENCH. Frank F. Corbin, Easthampton, Mass. 983,267.

PIPE WRENCH. Ernst Enderes, Littleport, Iowa. 983,271.

WRENCH. William N. Jay, Moscow, Idaho. 983,447.

WRENCH. Andrew J. Curtis, East Williamson, N. Y., assignor of one-half to Daniel Wagemaker, East Williamson, N. Y. 983,483.

PIPE-FLANGE WRENCH. Michael Murray, Chicago, Ill. 983,562.

WRENCH. Robert D. Lindsay, Monaca, Penn. 983,628.

WRENCH. Edward Kukuruda, Saginaw, Mich. 983,728.

WRENCH. Ellnathan Allen, Chicago, Ill. 983,796.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City. Spring meeting in Pittsburg, May 30 to June 2.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York. Next meeting in New York City, May 29 to June 3.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Commander U. T. Holmes, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., O. P. Chamberlain; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., Walter Riddle; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Pres., R. P. Bolton; sec., W. W. Macon, 29 West Thirty-ninth street, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting at Detroit, Mich., January, 1912.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

POWER

NEW YORK, MARCH 7, 1911

When the hotel owner with one glass eye returned to his establishment after his first trip through the land in ten years, he remarked to the steward that anyone with even half an eye should be able to see that many things in the said establishment were "all to the bad," or words to that effect.

Things were not by far as uptodate as they should be. The steward had evidently been "asleep at the switch."

For one thing, why had not the steward looked up the suitability of a set of those new Marks-Davis steam tables for use in the restaurant kitchens? He of the one eye had discovered that they gave more heat per pound of steam than the old Peabody type.

Most emphatically, things would have to be watched more carefully in the future, else there would be a new steward on the job.

Now, the steward had no excuse to offer. His trouble was that he stuck too close to actual business to be an all-round big success. He bothered personally with too many details, most of which should have been entrusted to suitably selected subordinates. The result was that while he was always busy "stewarding" he wasn't getting the results that he should. He never had time in which to look around and see what progress others were making.

Engineers are troubled with this same complaint. Partly the engineers themselves are to blame, and partly the employers.

When an engineer's horizon extends only as far as the walls of his plant it is a fairly safe wager that he is not and never will be of very great caliber.

Unquestionably, many an employer could make a profitable investment by sending his engineer out on a trip of discovery to plants similar to his own, say, once a year. Such a trip would be a mental tonic for the engineer, giving him a different point of view of his plant and imbuing him with new ideas to be used to advantage in the future.

The engineer, himself, should get outside of his plant as much as possible on his own "hook." By that we mean that he should do some outside reading and studying bearing on his line of work, should take advantage of every legitimate opportunity to see neighboring plants and should talk with other engineers and with salesmen that happen to call on him.

Try to see your plant as others see it—see its defects and its weak points as well as its strong ones.

A Modern Blast Furnace Equipment

By A. R. Maujer

The most interesting features are a constant-volume turbine-driven centrifugal air compressor, a barometric injector condenser which produces a vacuum of over 28 inches and a single-wall radial-brick chimney which is withstanding temperatures up to 1400 degrees. The suction line for the condensing water is made with welded and Van Stone joints.

The Empire Steel and Iron Company has recently made some extensive changes in the equipment of its blast furnace at Oxford Furnace, N. J. Chief among the several interesting pieces of new apparatus is the steam turbine-driven centrifugal air compressor, built by the General Electric Company, which is used to furnish the air blast for the furnace. Next, is the highly efficient barometric condenser. And third, is the radial-brick chimney which is successfully withstanding continuous high temperature.

A general view of the plant is offered in Fig. 1. The large, square brick building in the foreground is the old blowing-engine house. The brick extension upon the left contains the new compressor. The boilers which furnish steam for the compressor and auxiliary apparatus are just back of this building. The boiler equipment consists of three 300-horsepower Babcock & Wilcox boilers and two 200-horsepower Wheeler vertical boilers. The former are served by the big brick chimney and the latter by the two short steel stacks, shown in Fig. 1, extending a little above the roof line. Steam is generated at 140 pounds gage pressure. Blast-furnace gas is the fuel used under the boilers.

The brick chimney also serves the four 20x80-foot two-pass stoves, which stand back of it. Beyond the stoves is the blast furnace itself, 80 feet high, 17 feet 6 inches in diameter at the bosh and 11 feet at the hearth. Its average production is 200 tons of pig iron in 24 hours.

Centrifugal Compressor

Until the centrifugal air compressor, shown in Fig. 2, was installed and put into service at Oxford Furnace, the air blast for all of the blast furnaces in this country was furnished by reciprocating compressors, or blowing engines, either steam or gas driven.

The two engines at Oxford Furnace which formerly furnished the air blast are typical of the majority of the steam-driven blowing engines at present in use. They are of the single-cylinder long-crosshead steeple type. The steam cylinder, which is below the air cylinder, is 54 inches in diameter; the air cylinder is 72 inches in diameter with a stroke of 72 inches. There are two large flywheels, one on either side of the engine. The connecting rod for each wheel is on the outside; hence, the crosshead extends from one side of the frame clear to the other. Normally the engines ran at 26 revolutions and each furnished 8000 cubic feet of air per minute. The maximum combined capacity of the two engines is 20,000 cubic feet.

The centrifugal compressor has a rated

Fig. 1. General View of Oxford Furnace Plant of Empire Steel and Iron Company

capacity of 22,500 cubic feet of air per minute, but at present it is handling only about 17,000 cubic feet. The normal speed of the machine is 1650 revolutions per minute and the normal discharge pressure is 15 pounds per square inch. The pressure varies, however, with the operation of the furnace, the compressor being regulated to deliver a fixed quantity of air at a variable pressure. The compressor has six stages, each of which contains a disk on which are mounted steel blades or vanes. The disks are separated by water-cooled diaphragms. diaphragms between stages, is water cooled; the cooling-water jets and intake pipes are above the casing, as shown in Fig. 2, where they are in plain sight of the operator.

The driving end of the unit consists of a Curtis horizontal four-stage steam turbine. The impeller disks of the compressor are so designed that there is no unbalanced end thrust; hence, the ordinary means used in the Curtis turbine for locating the rotating elements and preserving the proper clearances are sufficient for the entire apparatus.

from the bearings and cylinder to a tank where it is settled and strained before reuse. As a precaution against any stoppage of circulation, an alarm is provided which causes a steam whistle to blow when the oil pressure falls to 5 pounds per square inch. The oil is cooled in the bearings at the point where the heat is generated by means of water-cooled coils, embedded in the bearing linings.

When delivering 22,500 cubic feet of air per minute against a pressure of 15 pounds per square inch, the turbine runs at a speed of 1650 revolutions per min-

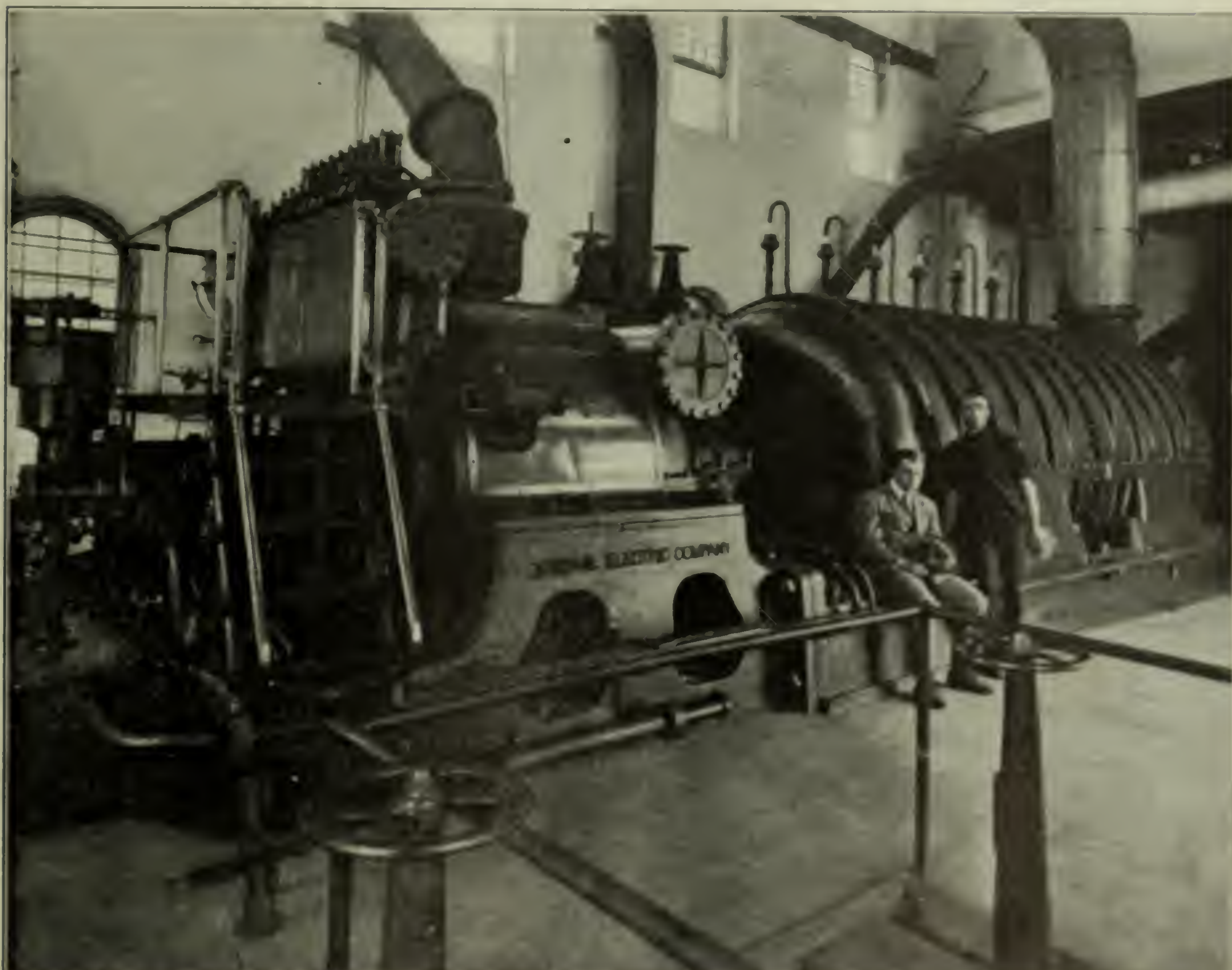


FIG. 2 THE TURBINE-DRIVEN CENTRIFUGAL AIR COMPRESSOR

Air is drawn in at the turbine end of the compressor and passes through each stage successively, the pressure being gradually increased to that which the conditions in the furnace may require. The discharge pipe is at the far end of the compressor, as is shown in Fig. 2; it is insulated with wood-covered lagging. The pipe passes across the old blowing-engine house and out through the wall just above the lower windows, as shown in Fig. 1. It then drops down and connects into the header which in turn connects with the stoves. The compressor shell, as well as the

There are three bearings, one at the head end of the turbine, one between the turbine and the compressor and one at the discharge end of the compressor.

As in all high-speed apparatus the continuity of the oil supply is important. The oil is circulated automatically by a valveless gear pump driven through a worm gear by the main shaft. The oil is pumped through the bearings at a pressure of from 15 to 25 pounds. The same pump supplies oil to the hydraulic cylinder, which operates the automatic steam-valve gear. The oil is returned

ute and develops 1790 brake horsepower with a guaranteed steam consumption of 19.1 pounds per horsepower-hour. When delivering the same quantity of air against 25 pounds pressure, the speed of the compressor is 1875 revolutions per minute; the horsepower developed is 2600 and the guaranteed steam consumption is 14.6 pounds.

Method of Regulation

The manner in which the steam is regulated to deliver constantly a predetermined volume of air against any ressure within the limits of the capacity f the machine is illustrated in Fig. 3. A unterweighted-steel disk is sustained by e current of inflowing air in the conical nlargement of the intake pipe. The rod which the disk is attached passes

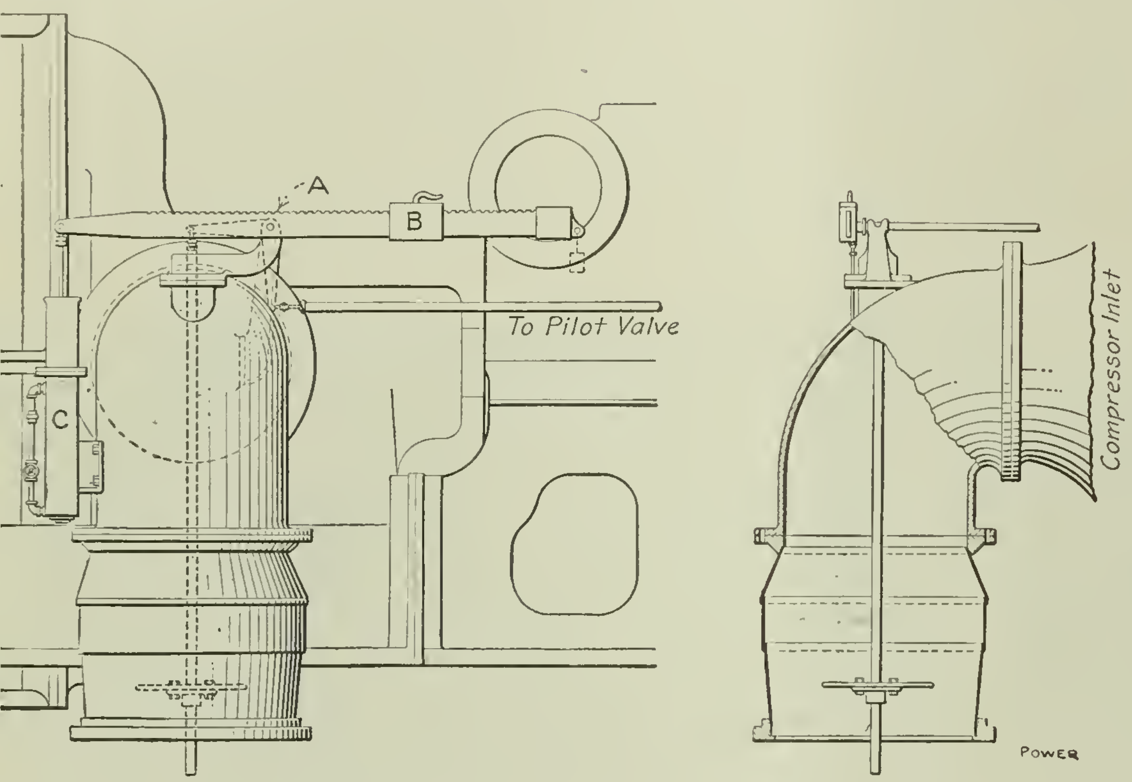


Fig. 3. Showing Method of Regulating Compressor

rough a stuffing box in the elbow of e intake and is connected to the weight eam *A* and to a system of levers which perates the pilot valve of the hydraulic alve gear, mounted over the head end f the turbine.

The notches on the beam are marked correspond with various quantities of ir delivered per minute. When the eight *B* is set at a given notch to deer a certain quantity of air, the disk ands normally at a certain level in the take cone. When the pressure against hich the compressor is working ineases for any reason the amount of r delivered begins to fall off. This reuces the velocity of the air being drawn rough the intake cone and unbalances e disk, which consequently sinks to a wer level. The movement of the disk, cting through the system of levers, the lot valve and the hydraulic valve gear, auses more steam to be admitted to the rbine. The turbine then speeds up and eëstablishes the proper rate of flow gainst the increased pressure.

This may be continued until the speed mit, 1975 revolutions per minute, is eached when a centrifugal governor omes into action and prevents any inease in the rate of steam admission. he dashpot *C*, Fig. 3, coupled to the eight beam, prevents undue fluctuation speed and any tendency to race.

The turbine is fitted with an emergency overnor which shuts down the machine hen the speed for any reason exceeds 10 per cent. the limit for which the peed governor is set.

The advantages of this type of comressor over the reciprocating types, either gas- or steam-driven, are, briefly: better over-all economy, economy in space occupied and more uniform operation. A rough idea of the saving in space occupied and the consequent saving in the cost of building effected by the use of a centrifugal compressor may be gained by observing the difference between the size of the old and that of the new engine house as shown in Fig. 1. The more uniform operation of the compressor results in an increase in the capacity of the furnace and an improvement in the quality of the product.

Condenser

The condenser is of the twin-barometric injector type and was designed by F. E. Johnson, of the M. W. Kellogg Company, New York. The location of the condenser is shown in Fig. 1 and its general arrangement in Fig. 4. The details of the heads are shown in Fig. 5.

The exhaust from the turbine passes out of the building below the turbine floor and enters the 36-inch cast-iron riser, Fig. 4. At the top of the riser the exhaust divides, one-half going to each condensing unit. The water belts of these units are connected by a 4-inch equalizing pipe, which eliminates all possibility of the units bucking each other on account of an unequal distribution of the exhaust steam or of the injection water.

The cast-iron elbow which connects

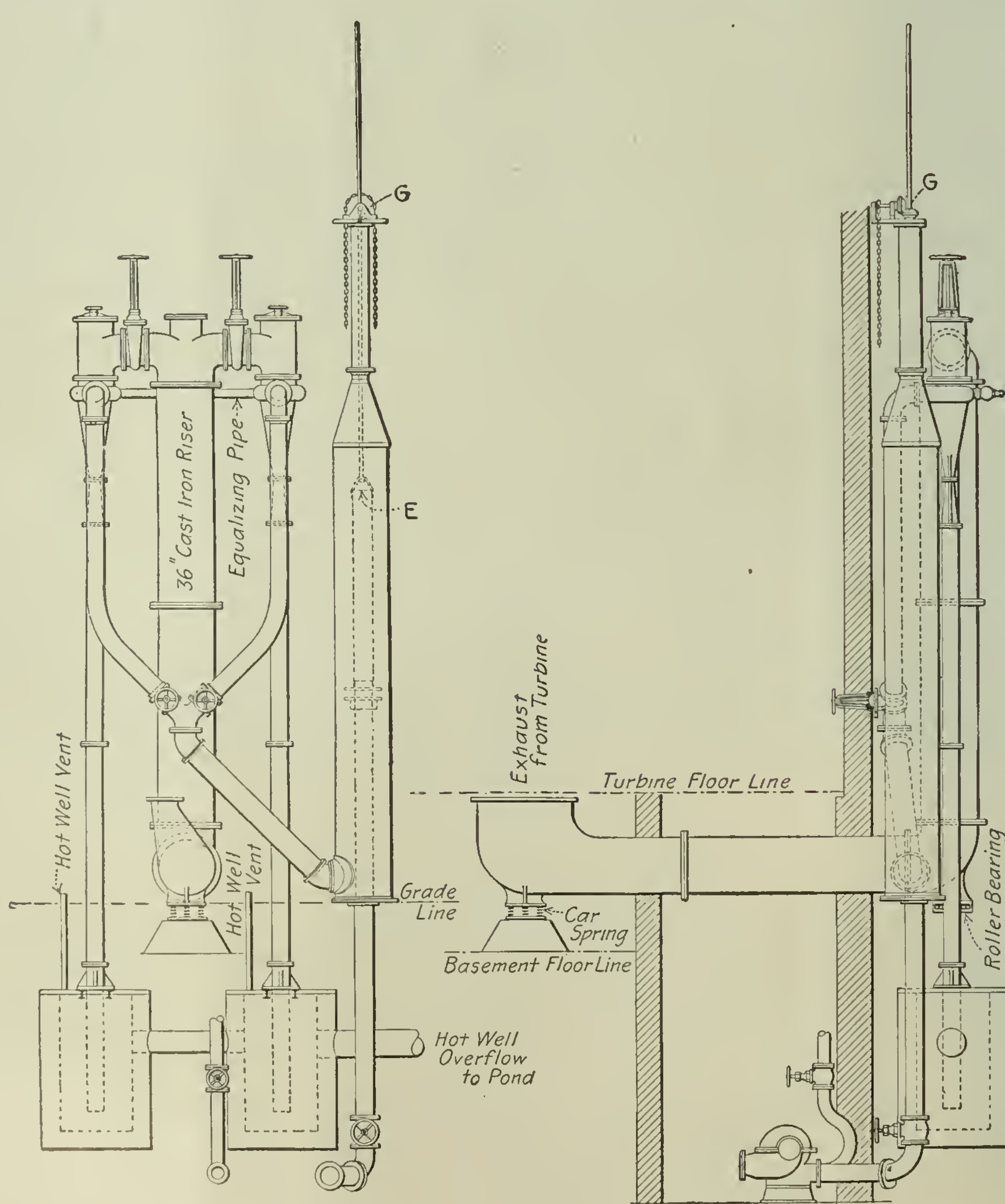


Fig. 4. General Arrangement of Condenser

with the exhaust outlet of the turbine is supported on heavy car springs. By this simple arrangement the use of an expansion joint between the elbow and the exhaust outlet was avoided, and expansion joints are not the most satisfactory of things that have been devised. The base of the riser rests on a roller bearing so that provision is made for lateral as well as vertical expansion.

The condenser was sold under a guarantee that it would maintain a vacuum of 28 inches of mercury, referred to a 30-inch barometer, when condensing 30,000 pounds of steam per hour with injection water at 70 degrees and produce a hotwell temperature within 10 per cent. of that theoretically obtainable.

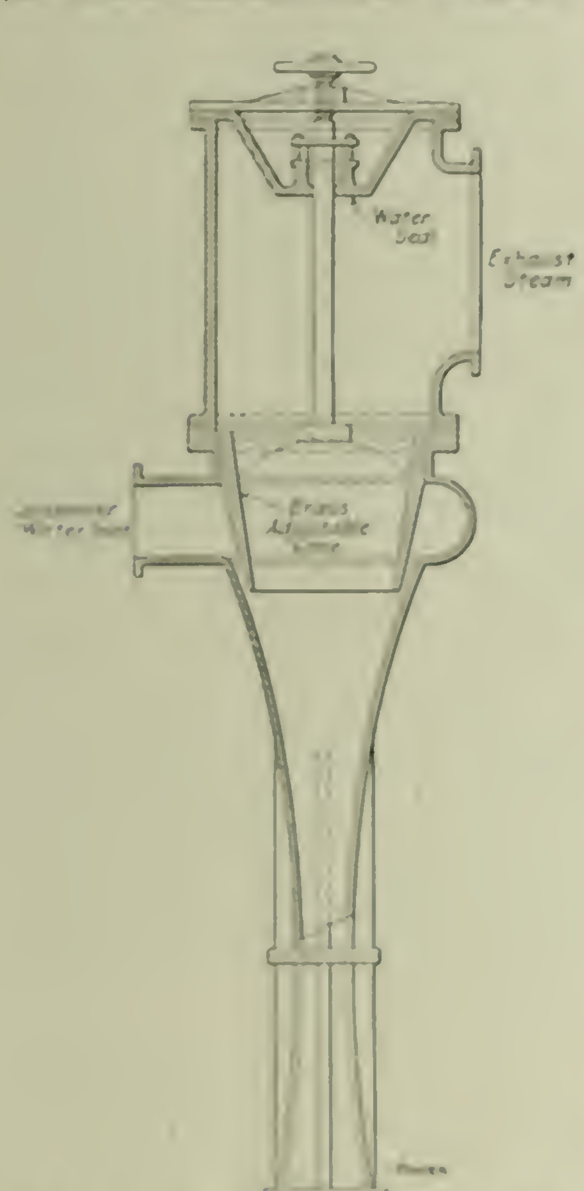


FIG. 5. DETAILS OF CONDENSER HEAD

The injection water leaves the pump through the 12-inch vertical pipe shown in Fig. 4 and spills over the edge of the open end *E* into the 30-inch steel-riveted standpipe from the base of which it is drawn to the condenser belt. In spilling out of the 21-inch pipe in a comparatively thin stream the water liberates a large proportion of the entrained air which escapes through the vent at *G*. Thus, the injection water goes through the condenser in an almost air-free condition and such air as is mingled with the exhaust steam is practically all that must be handled by the condenser.

PIPING AND PUMPS

The injection water is drawn from a pond 450 feet from the pump and 8 feet below the pump suction inlet. The suction line is 16 inches in diameter and made up of standard 20-foot lengths of pipe welded into 40-foot sections by the Kellogg system of electric welding, 40 feet being the limit of length convenient for transportation. Standard Van Stone joints are used between the sections. Due to this construction, which is unique in suction-pipe work, the line is absolutely air tight.

The injection water is handled by a 12-inch Morris Machine Works centrifugal pump, located as shown in Fig. 4, direct driven by a 100-horsepower noncondensing Terry turbine running at 1650 revolutions per minute. The pump has a capacity of 3300 gallons per minute against a normal static discharge head of 37 feet or a total normal static head of 45 feet.

The condenser-discharge water is received by the two hotwells shown in Fig. 4, from which it flows back to the pond by gravity. The hotwells are at a net hight of 15 feet above the pond. A natural-draft wooden cooling tower has been erected and will be put into service for the summer months. It stands at a level between that of the hotwells and that of the pond; hence, no pump will be required for the return of the discharge water even when the tower is in use.

In addition to the condenser pump, an 8-inch Morris Machine Works centrifugal pump is connected to the Terry turbine on the same shaft. This pump supplies 1200 gallons of water per minute to an elevated reservoir from which cooling water for the blast furnace and the air compressor is supplied by gravity. The total static head against which this pump works is 68 feet.

The amount of water which passes through the compressor jackets is just sufficient for the boiler feed. This water leaves the jackets at a temperature of about 100 degrees and enters a Cochrane open heater in which it is mingled with the exhaust steam from the Terry turbine. The temperature of the water as it enters the boilers is 180 to 200 degrees. The boiler feed pumps, two in number, are 12 and 8 by 12 inches in size and of the outside-packed duplex type. They were furnished by the Scranton Pump Company, Scranton, Penn.

Steam from the boilers enters a 12-inch header, 100 feet long, through welded nozzles carrying welded flanges. This construction eliminates about 70 per cent. of the joints ordinarily necessary.

CHIMNEY

The brick chimney which serves the blast-furnace stoves and the three Babcock & Wilcox boilers represents the latest chimney practice and is remarkable inasmuch as it is successfully withstanding, although only partially lined, temperatures which never fall below 800 degrees and sometimes run as high as 1100.

The hight of the chimney above its foundations is 175 feet, and the internal

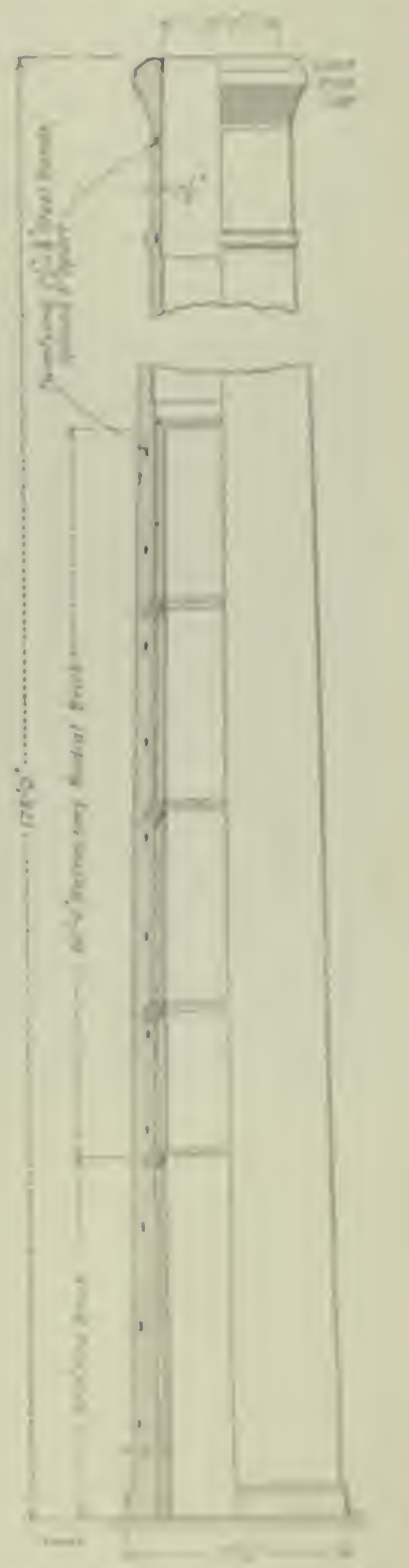


FIG. 6. DETAILS OF RADIAL BRICK CHIMNEY

top diameter is 10 feet. The underground flue which connects the chimney with the stoves and boilers is built of concrete and lined with firebrick. The chimney wall is built in eleven sections. The bottom section is 15 feet high and is inches thick; the ten sections above are each 16 feet 6 inches high, but vary in thickness from 24 inches, the thickness of the lowest one, to 7½ inches for the top one. The head of the chimney is finished with a sectional cast-iron cap which locks the top course of brick solidly in place and protects it from the action of the elements.

The chimney proper is built of perforated, corrugated radial brick laid in cement mortar. The lining is 90 feet high. The lower 30 feet is built of 4-inch firebrick laid in fire-clay mortar. The upper 60 feet is built in 15-foot sections of 4¼-inch hard-burned refractory radial brick. Each section is carried on a firebrick corbel and separated from the chimney wall by a 2-inch air space. The chimney wall is reinforced at 8-foot intervals by 2½x¼-inch steel bands. The M. W. Kellogg Company, New York, which erected the chimney, guarantees it to withstand a temperature of 1500 degrees Fahrenheit.

We acknowledge with appreciation the courtesy of R. H. Rice, of the General Electric Company, in supplying information concerning the centrifugal-air compressor and H. B. Cox, of the Empire Steel and Iron Company, in supplying the other information contained in this article.

The Confessions of an Engineer

By R. O. Warren

In this story the CO_2 recorder is up for discussion, and once more the manager finds that the engineer has failed to apply his knowledge and has missed an opportunity of making good by neglecting to suggest the purchase of a CO_2 recorder.

Manager Wood was about as progressive a man as one would meet in a long time. If I could have absorbed some of his push and hustle I might have occupied a pretty "hefty position" today, and incidentally been better off in dollars and cents.

One day Wood strolled into the boiler room where I was at the time, and, after his usual greeting, said. "What do you know in favor of CO_2 recorders?"

"They are a mighty good thing," said I. "Every boiler plant of any size should have one. A CO_2 recorder shows just what is going on in the boiler furnace, and tells just what percentage of CO_2 gas passes up the stack. Are you thinking of getting a recorder?"

"Not just yet. I never go into a thing before I have a pretty good idea of its value, what it does, how it works and of what use it can be to me. I'll confess I'm a little lame on the finer points of furnace combustion.

"I do know," went on Wood, "that the heat produced in a furnace depends on the completeness of combustion and on nothing else, and that the quantity of heat transferred to a boiler is determined by the state of the escaping gas."

"Yes, that's right," I replied, "and the escaping gas can be burned either to CO or to CO_2, according to the amount of air admitted to the furnace. The difference between the heat values of these two gases would surprise most engineers."

"What is the difference?" asked Wood.

"Well, burn a pound of carbon to CO_2, or carbon-dioxide, and it will yield 14,540 British thermal units. If the same carbon were burned to CO, or carbon-monoxide, it would yield but 4350 British thermal units—a difference of 10,190 heat units."

"Well, what makes the difference? A good deal must be in the method of firing, don't you think?"

"Sure, that has a whole lot to do with it," I replied, answering the last question first. "The reason that CO is formed is because not enough air has been admitted to the furnace. Of course, a furnace has got to be in decent shape, or the best firemen that ever lived can't fire and get good results."

"Most engineers don't really understand what burning flue gases to CO_2 means, but good combustion is simply burning coal to get the best results with the least possible air supply."

You see I was right at home on the CO_2 question, because I had read a good deal on the subject, knew all about the various apparatus on the market; and had a pretty good idea as to just the advantage of a CO_2 recorder. I knew that in the complete combustion of pure carbon there would be 20.7 per cent. by volume of CO_2, which fact I told the manager.

"But," said he, "you don't mean that you can get that amount of CO_2 from the fuel burned in a furnace, do you?"

"I should say not," I answered. "The best that can be got with the regular furnace is about 15 per cent. of CO_2 and that only for short periods. An average of 12 per cent. would be considered good for most plants."

"What saving would that make over, say 3 per cent. of CO_2?" was the next question.

"Well," I replied, feeling considerably gratified that we were considering a matter with which I was tolerably well familiar. "With 3 per cent. CO_2 the loss in coal is about 60 per cent., while with 12 per cent. CO_2 obtained, the loss in fuel is but 15 per cent."

"Whew—quite a difference. That's worth looking into."

"You bet," said I. "Every engineer should know about such things, for he don't know when he will have a chance to use the information."

Wood looked at me in rather an amused-surprised manner, and I, not knowing what was passing in his mind, went on with my explanation.

"The only way that a high percentage of CO_2 can be obtained is by firing at frequent intervals, by maintaining the proper thickness of fuel bed, and by supplying the correct amount of air for the fuel used. This can't be done if a furnace setting is full of cracks through which air can leak. If air leaks into the furnace it simply means that the furnace gases have to heat the excess air before it escapes to the stack, and much of the heat absorbed by the useless excess air is lost."

"There is usually excess air entering into a furnace, I take it."

"Yes, probably about 40 per cent. above the amount theoretically required," I replied. "This excess air dilutes the gases and reduces the percentage of CO_2 in the total volume of gases going up the stack. Under such a condition about 14 per cent. of CO_2 will be shown upon analysis, and the more air admitted to the furnace the lower the percentage of CO_2 and the greater the loss of fuel."

"And you say that this excess air is generally due to imperfect firing, and leaky settings?"

"Sure," I replied. "About nine out of every ten cases are due to these two causes, and it will be found that the flue gases contain only about 5 to 7 per cent. of CO_2, when they should contain at least 10 or 12 per cent.; and this means a loss of about 25 per cent. in coal."

"Then this 25 per cent. loss is a preventable loss. isn't it?" asked Wood.

"That's about the size of it," I replied. "The fact of the whole matter is that the furnace don't want too much or too little air, but just the right amount, for the varying condition of the fire."

"The idea," said I, "is that if the furnace conditions are so bad that the gases and air don't thoroughly mix, or if the temperature of the furnace is so low that the gases won't ignite, or if the boiler plates are cold enough to cool the gases and flame before complete combustion takes place, then CO is present in large quantities and the CO_2 percentage is low.

"About the air," I went on. "If there is too much, then the fire is obliged to heat it before it goes up the stack, and no engineer tries to see how high he can get his chimney gases, or how low he can keep the temperature of a boiler furnace. The whole proposition hinges on the way a fireman handles his fires, providing, of course, that the furnace and grate, etc., are in good condition."

"I suppose then, so long as air plays such an important part, that the draft in the stack must be reckoned with?" said Wood, in a thoughtful tone.

"It certainly must," I replied. "A strong draft eats up coal, and no more draft should be allowed drawing on a boiler furnace than is absolutely necessary to produce a fire of such intensity as to supply the necessary steam to carry the load on the boiler. But the only way to know when the proper draft has been obtained is by knowing what percentage of CO_2 is being obtained."

"And that is by means of a CO_2 recorder of some make," said Wood, in a very positive tone. "Why don't more engineers have these recorders?" According to what you have told me, more steam can be raised with the same amount of coal if a CO_2 recorder is used than without the recorder. Or, in other words, the same amount of steam we are now using can be made with a less amount of coal if a recorder were used. If that is the case, it would not take very long for a recording instrument to pay for itself."

"I guess that is about right," I replied, dimly gathering an idea as to the point Wood was leading up to.

"A good CO_2 recorder would act in three capacities at once," went on Wood. "It would be a simple guide for the fireman and an effective check for the engineer."

"Yes, there's no doubt about that," I answered.

Wood mused for a moment and then said, "It seems strange that so many companies will spend thousands of dollars in building a modern steam plant, pay particular attention to pipe-line design, protect the steam pipes from atmospheric influences, install the best types of boiler and engine, and, in fact, take practically every known precaution against steam losses, and then pay no attention to the loss due to escaping combustible gases."

"It is a little strange," said I, while a slight shiver ran up and down my spine, for I began to see that in not getting after this matter of flue gases I had allowed a good opportunity to slip by unnoticed until the new manager had taken it up.

"The personal element in the boiler room is, in most cases, overlooked as either unimportant or not existing. I think that is what is done here, isn't it?" asked Wood.

"We have a good set of firemen," I answered. "They are careful and ———." Then I came to a halt, for it flashed through my mind that but a few days before the manager had seen a fireman standing lighting his pipe while the furnace doors were open.

Wood evidently recalled the same conversation for he smiled a little and said, "You are not quite sure as to their merits now, are you?"

"Of course, they are men, but when compared with other firemen they are above the average," I protested.

"Yes, they are men, and for that reason they need some means of guidance and control if proper combustion is to be obtained. And that guidance is the CO_2 recorder, because if they are to get the proper CO_2 percentage the proper draft must be maintained and the firing properly performed. A fireman will do his work better if he knows it is being checked. Isn't that so?"

I had to admit that it was.

Then Wood got right down to business and said, "You are a strange proposition, Warren. You know about things, but don't make good."

"How so," I asked, although I well knew what was coming.

"How so! Why you have known all about the losses due to imperfect combustion ever since you have been here, but the only thing I can discover you have done to prevent them is that you have stopped up the cracks in the boiler settings."

"Well, that made quite a difference," I protested.

"Some, but not enough," retorted Wood. "You have told me enough about CO_2 recorders to satisfy me that you knew the full value of such apparatus, but you have never intimated that it would be advisable to have one in our steam plant."

"I know I never have, because they cost so much. I would have been wasting my breath, if I had proposed such a thing," I answered.

"How do you know you would?" demanded Wood. "While most business men don't care to spend money foolishly, there are but few who will not spend three or four hundred dollars if they are reasonably sure of getting the amount back in a reasonable time, because of the saving the expenditure will make.

"And another thing worth remembering. No business man will refuse to at least listen to any sane proposition. From what you have told me, together with the argument of the salesman, I think a CO_2 recorder will be a money saver in this plant."

I HAD ANOTHER INTERESTING SESSION WITH THE MANAGER

Here was another chance gone for making good. Although I knew all along of the advantage of a CO_2 recorder and about what saving one would make in a plant the size of mine, I had made no use of my knowledge, but had waited for the new manager to introduce a recording instrument, and, of course, the saving made would be to his credit.

Although I profited by this experience in after years, the occurrence made but little impression then, for in a few days after the new CO_2 recorder had got to be an old story, I forgot that I had missed one of the greatest opportunities of my life for making good by not applying what I knew in my everyday work.

Aid to Plotting Compression Curves

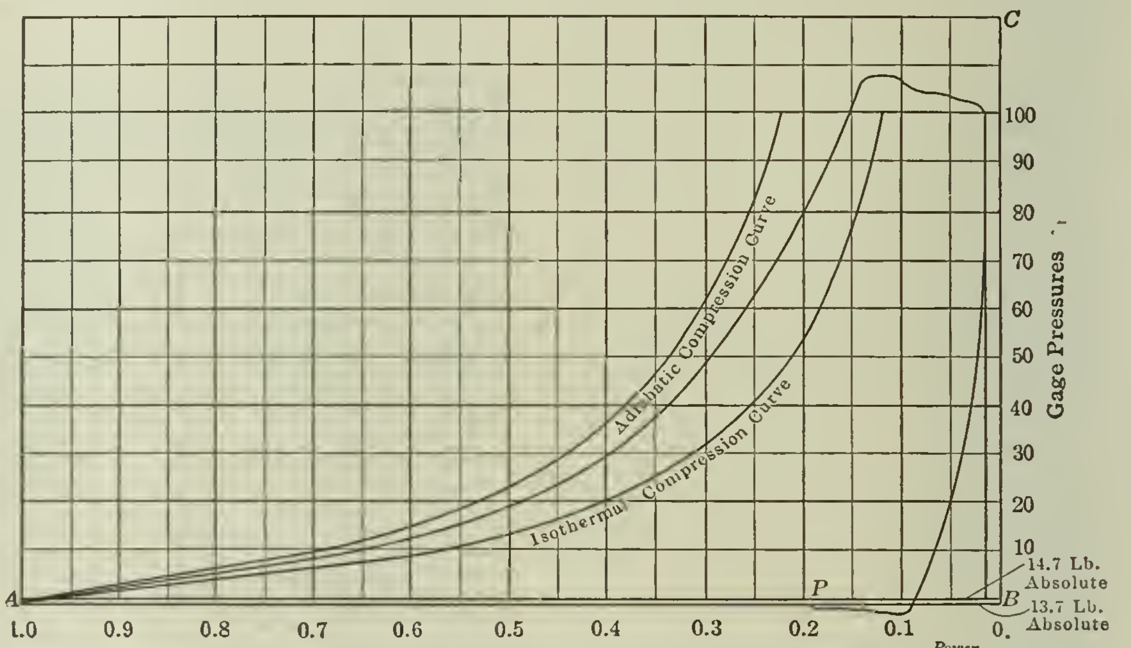
By H. V. Conrad

Tables providing data for conveniently laying out the theoretical isothermal and adiabatic curves on an indicator diagram taken from an air-compressor cylinder.

Indicator diagrams taken from air cylinders always show the compression curve as starting below the atmospheric line, when the compressor is drawing free air. This starting point of compression may range from ¼ pound, in the high-class machine, to 1½ pounds or more, below the atmospheric pressure, in machines having more or less restricted inlet passages.

Tables 1 and 2, provide data for quickly laying out in tenths of a pound the theoretical isothermal and adiabatic curves on indicator diagrams which start their compression anywhere between 14.7 and 10 pounds absolute. To prepare the indicator diagram for applying the tables, (see sketch) draw horizontal pressure lines at 10-pound intervals, to the scale of the indicator spring, using the portion *A P* of the diagram as a base line. Next, increase the length of the diagram by an amount equivalent to the percentage of the volumetric clearance in the cylinder at the end of the stroke, and erect the perpendicular line *B C*. Consider the length *A B* as one and divide it into 10 equal divisions. The tables give the horizontal measurements in percentages of one measured from the line *B C*; these locating the points of the compression curves on the various pressure lines.

As an example, the sketch shows a normal indicator diagram from an air cylinder compressing to 100 pounds, the volumetric end clearance being 1½ per cent., with compression starting at 1 pound below atmosphere at sea level; that is, at 13.7 pounds absolute. The diagram having been ruled with pressure lines and the subdivisions in length marked off, refer to isothermal values in Table 1 for 13.7 pounds absolute initial pressure. In the pressure columns will be found the horizontal measurements to be made on *A B*,



Isothermal and Adiabatic Curves Plotted on Indicator Diagram

TABLE 1. ISOTHERMAL COMPRESSION LINE TABLE.

Absolute Initial Pressure, Pounds.	Gage Pressures in Pounds.													
	2.5	5	10	20	30	40	50	60	70	80	90	100	110	130	150
14.7	0.855	0.746	0.595	0.424	0.329	0.269	0.227	0.197	0.174	0.155	0.140	0.128	0.118	0.1016	0.0894
14.6	0.854	0.745	0.593 +	0.422	0.327	0.2675	0.226	0.196	0.1728	0.1542	0.1393	0.1273	0.1172	0.101	0.0888
14.5	0.852 +	0.743 +	0.592 +	0.420	0.326	0.266	0.225	0.195	0.1716	0.1535	0.1386	0.1265	0.1165	0.1002	0.0882
14.4	0.852	0.743	0.591	0.418	0.3245	0.2648	0.224	0.1937	0.1706	0.1525	0.1380	0.1258	0.1157	0.0996	0.0876
14.3	0.852 —	0.742	0.589	0.417	0.323	0.2635	0.2225	0.1925	0.1696	0.1516	0.1372	0.1250	0.1150	0.0991	0.0870
14.2	0.851	0.741	0.587	0.416	0.3215	0.2622	0.221	0.1915	0.1686	0.1508	0.1364	0.1242	0.1143	0.0986	0.0864
14.1	0.850	0.740	0.585	0.414	0.320	0.261	0.220	0.1905	0.1676	0.1500	0.1356	0.1235	0.1137	0.0979	0.0859
14.0	0.849	0.738	0.583	0.412	0.3185	0.2595	0.219	0.1895	0.1666	0.1491	0.1347	0.1228	0.1130	0.0972	0.0853
13.9	0.848	0.736	0.582	0.411	0.3165	0.2578	0.2175	0.1884	0.1657	0.1482	0.1338	0.1220	0.1123	0.0966	0.0848
13.8	0.847	0.734	0.580	0.409	0.3150	0.2563	0.2165	0.1873	0.1648	0.1472	0.1330	0.1212	0.1116	0.0960	0.0842
13.7	0.846	0.733	0.578	0.407	0.3135	0.2550	0.2152	0.1862	0.1638	0.1462	0.1322	0.1205	0.1109	0.0953	0.0837
13.6	0.845	0.732	0.577	0.405	0.3120	0.2537	0.2140	0.1850	0.1627	0.1453	0.1313	0.1197	0.1101	0.0947	0.0831
13.5	0.844	0.730	0.575	0.403	0.3105	0.2522	0.2125	0.1838	0.1616	0.1444	0.1305	0.1189	0.1093	0.0940	0.0825
13.4	0.843	0.728	0.573	0.402	0.309	0.2510	0.2112	0.1826	0.1606	0.1435	0.1296	0.1181	0.1085	0.0934	0.0820
13.3	0.842	0.726	0.571	0.400	0.307	0.2495	0.2100	0.1814	0.1596	0.1426	0.1286	0.1173	0.1078	0.0928	0.0814
13.2	0.841	0.725	0.569	0.398	0.305	0.248	0.2090	0.1803	0.1586	0.1418	0.1278	0.1166	0.1071	0.0922	0.0809
13.1	0.840	0.724	0.568	0.396	0.304	0.2465	0.2076	0.1792	0.1575	0.1408	0.1270	0.1158	0.1063	0.0916	0.0804
13.0	0.839	0.723	0.566	0.394	0.302	0.2452	0.2062	0.1780	0.1565	0.1398	0.1263	0.1151	0.1057	0.0910	0.0798
12.9	0.838	0.721	0.564	0.3923	0.301	0.2437	0.205	0.1770	0.1556	0.1389	0.1254	0.1142	0.1050	0.0903	0.0792
12.8	0.837	0.719	0.562	0.3908	0.2992	0.2424	0.2035	0.1758	0.1546	0.1379	0.1245	0.1136	0.1043	0.0896	0.0786
12.7	0.836	0.7175	0.560	0.3892	0.2975	0.2410	0.2023	0.1747	0.1536	0.1370	0.1238	0.1128	0.1036	0.0890	0.0781
12.6	0.835	0.716	0.558	0.3875	0.2960	0.2395	0.2012	0.1735	0.1526	0.1361	0.1229	0.1119	0.1028	0.0884	0.0775
12.5	0.834	0.714	0.556	0.3850	0.2942	0.2380	0.2000	0.1725	0.1516	0.1352	0.1220	0.1111	0.1021	0.0877	0.0769
12.4	0.832	0.713	0.554	0.3827	0.2925	0.2368	0.1987	0.1712	0.1505	0.1341	0.121	0.1102	0.1012	0.0871	0.0764
12.3	0.831	0.712	0.552	0.381	0.291	0.2355	0.1974	0.1701	0.1495	0.1331	0.120	0.1094	0.1005	0.0865	0.0758
12.2	0.830	0.71 —	0.550	0.379	0.289	0.2338	0.1961	0.169	0.1485	0.1322	0.1192	0.1086	0.0998	0.0858	0.0752
12.1	0.829	0.709	0.548	0.377	0.2872	0.2321	0.1948	0.1679	0.1474	0.1314	0.1185	0.1078	0.0992	0.0852	0.0747
12.0	0.828	0.707	0.546	0.3755	0.2857	0.2306	0.1936	0.1667	0.1463	0.1306	0.1177	0.1070	0.0985	0.0847	0.0741
11.9	0.827	0.705	0.544	0.3735	0.2842	0.2292	0.1925	0.1656	0.1452	0.1295	0.1168	0.1063	0.0977	0.0840	0.0736
11.8	0.826	0.703	0.542	0.3715	0.2821	0.2278	0.1910	0.1644	0.1441	0.1285	0.1159	0.1055	0.0970	0.0833	0.0730
11.7	0.8245	0.701	0.540	0.3692	0.2805	0.2262	0.1895	0.1632	0.1431	0.1276	0.115	0.0048	0.0963	0.0826	0.0725
11.6	0.823	0.699	0.538	0.367	0.279	0.225	0.1884	0.162	0.142	0.1266	0.1142	0.104	0.0956	0.082	0.0719
11.5	0.8215	0.697	0.536	0.365	0.277	0.2235	0.1872	0.1609	0.141	0.1258	0.1133	0.1032	0.0947	0.0813	0.0713
11.4	0.820	0.695	0.532	0.363	0.2755	0.222	0.186	0.1598	0.140	0.1249	0.1124	0.1024	0.0939	0.0807	0.0707
11.3	0.8185	0.693	0.530 +	0.361	0.2738	0.2205	0.1845	0.1585	0.139	0.1239	0.1116	0.1015	0.0932	0.080	0.0701
11.2	0.817	0.6915	0.529 —	0.359	0.272	0.219	0.183	0.1574	0.138	0.1229	0.1108	0.1007	0.0925	0.0794	0.0695
11.1	0.8157	0.690	0.527	0.357	0.2704	0.2175	0.1818	0.1564	0.137	0.1219	0.1099	0.0999	0.0917	0.0787	0.0689
11.0	0.8143	0.688	0.5245	0.355	0.2685	0.216	0.1805	0.155	0.136	0.121	0.1090	0.0992	0.091	0.0781	0.0684
10.9	0.8136	0.686	0.522	0.353	0.2665	0.2142	0.179	0.1539	0.1348	0.120	0.1080	0.0984	0.0902	0.0774	0.0678
10.8	0.813	0.684	0 520	0.351	0.2645	0.213	0.1775	0.1525	0.1335	0.119	0.107	0.0976	0.0895	0.0768	0.0672
10.7	0.812	0.682	0.518	0.349	0.263	0.211	0.176	0.1513	0.1325	0.118	0.1061	0.0968	0.0887	0.0761	0.0666
10.6	0.810 +	0.680	0.515	0.346 +	0.261	0.209	0.175 —	0.150	0.1315	0.117	0.1053	0.096	0.088	0.0755	0.0661
10.5	0.808 +	0.678	0.512	0.344	0.259	0.208	0.1735	0.149	0.1305	0.116	0.1044	0.0951	0.0872	0.0748	0.0655
10.4	0.807	0.676	0.510	0.342	0.257 +	0.2065	0 172	0.148	0.1295	0.115	0.1035	0.0943	0.0864	0.0741	0.0649
10.3	0.805	0.674	0.508	0.340	0.256 —	0.205	0.1705	0.1465	0.1283	0.114	0.1026	0.0935	0.0857	0.0735	0.0643
10.2	0.804	0.672	0.506	0.338 —	0.254	0.203	0.1695	0.145 +	0.1272	0.113	0.1017	0.0926	0.0849	0.0728	0.0638
10.1	0.802	0.669	0.503	0.335	0.252	0.202	0.168 +	0.144	0.1261	0.112	0.1008	0.0918	0.0841	0.0721	0.0632
10.0	0.80	0.666	0.50	0.333	0 25	0.20	0.1666	0.143	0.125	0.111	0.10	0.091	0.0834	0.0715	0.0625

TABLE 2. ADIABATIC COMPRESSION LINE TABLE

Absolute Initial Pressure, Pounds	Gage Pressures in Pounds														
	2.5	5	10	20	30	40	50	60	70	80	90	100	110	120	130
14.7	0.895	0.812	0.692	0.544	0.454	0.393	0.349	0.315	0.288	0.266	0.248	[illegible]	[illegible]	[illegible]	[illegible]
14.6	0.895−	0.811+	0.691	0.542	0.453	0.392	0.348	0.314	0.287+	0.265	0.247	[illegible]	[illegible]	[illegible]	[illegible]
14.5	0.894+	0.811	0.690	0.541	0.452	0.391	0.347	0.313	0.286	0.264	0.246+	[illegible]	[illegible]	[illegible]	[illegible]
14.4	0.894	0.810	0.688	0.539	0.450	0.389+	0.345+	0.312−	0.285	0.263+	0.245	[illegible]	[illegible]	[illegible]	[illegible]
14.3	0.893	0.809	0.686	0.538	0.448	0.388	0.344	0.310+	0.284	0.262	0.244	[illegible]	[illegible]	[illegible]	[illegible]
14.2	0.892	0.808	0.685	0.537	0.447	0.387−	0.342+	0.309	0.282−	0.261−	0.243	[illegible]	[illegible]	[illegible]	[illegible]
14.1	0.891	0.807	0.683+	0.535	0.445	0.385+	0.341+	0.308	0.281+	0.260	0.242	[illegible]	[illegible]	[illegible]	[illegible]
14.0	0.890	0.806	0.682	0.533	0.444−	0.384−	0.340	0.307	0.280+	0.259	0.242	[illegible]	[illegible]	[illegible]	[illegible]
13.9	0.889	0.805−	0.681	0.532	0.442	0.382+	0.338	0.305	0.279+	0.258−	0.241	[illegible]	[illegible]	[illegible]	[illegible]
13.8	0.889−	0.803	0.680−	0.530	0.441	0.381−	0.337	0.304	0.278	0.257−	0.240	[illegible]	[illegible]	[illegible]	[illegible]
13.7	0.888	0.802+	0.678	0.528	0.439+	0.379+	0.336	0.303+	0.276+	0.256+	0.239	[illegible]	[illegible]	[illegible]	[illegible]
13.6	0.888−	0.801	0.677	0.527	0.437+	0.378−	0.334+	0.302−	0.275+	0.254	0.238	[illegible]	[illegible]	[illegible]	[illegible]
13.5	0.887	0.800−	0.676−	0.525	0.436	0.376−	0.332+	0.300+	0.274	0.253−	0.237−	[illegible]	[illegible]	[illegible]	[illegible]
13.4	0.887−	0.779	0.674	0.524+	0.434	0.374	0.332−	0.299	0.273+	0.251+	0.236+	[illegible]	[illegible]	[illegible]	[illegible]
13.3	0.885+	0.798−	0.672	0.522	0.433	0.373+	0.330	0.298−	0.272	0.250+	0.234+	[illegible]	[illegible]	[illegible]	[illegible]
13.2	0.884	0.796+	0.671	0.520+	0.431+	0.371+	0.329	0.296+	0.270+	0.249+	0.233	[illegible]	[illegible]	[illegible]	[illegible]
13.1	0.884−	0.795	0.670−	0.518	0.429	0.369	0.328	0.295	0.269	0.248+	0.232	[illegible]	[illegible]	[illegible]	[illegible]
13.0	0.883−	0.794	0.667+	0.516	0.428−	0.368	0.327	0.293+	0.268	0.248−	0.231	[illegible]	[illegible]	[illegible]	[illegible]
12.9	0.882	0.793	0.665+	0.515−	0.426+	0.367+	0.325	0.292	0.267	0.246+	0.230	[illegible]	[illegible]	[illegible]	[illegible]
12.8	0.881+	0.792	0.664	0.513	0.425−	0.366	0.323	0.291	0.266−	0.245	0.228+	[illegible]	[illegible]	[illegible]	[illegible]
12.7	0.880+	0.791	0.662+	0.512−	0.423	0.364	0.322−	0.290−	0.264	0.244	0.227+	[illegible]	[illegible]	[illegible]	[illegible]
12.6	0.880	0.790−	0.661	0.510	0.421	0.362+	0.320+	0.288+	0.263	0.243−	0.226+	[illegible]	[illegible]	[illegible]	[illegible]
12.5	0.880−	0.788	0.660−	0.508	0.420	0.361	0.319	0.287	0.262	0.241+	0.225+	[illegible]	[illegible]	[illegible]	[illegible]
12.4	0.878+	0.787−	0.658	0.506	0.418	0.360−	0.318	0.286	0.260	0.240	0.224+	[illegible]	[illegible]	[illegible]	[illegible]
12.3	0.877	0.785+	0.656	0.504	0.416	0.358	0.317	0.2848	0.259	0.239	0.223	[illegible]	[illegible]	[illegible]	[illegible]
12.2	0.876	0.784	0.654	0.502	0.414−	0.3556	0.315	0.283	0.258−	0.238	0.222	[illegible]	[illegible]	[illegible]	[illegible]
12.1	0.8755	0.783	0.652+	0.500	0.413−	0.354	0.314+	0.281+	0.2565	0.237	0.221	[illegible]	[illegible]	[illegible]	[illegible]
12.0	0.875	0.782	0.651	0.498	0.411	0.352	0.312−	0.280	0.255−	0.236	0.220	[illegible]	[illegible]	[illegible]	[illegible]
11.9	0.874	0.780+	0.649	0.496	0.409	0.351+	0.310	0.279	0.254	0.235+	0.219	[illegible]	[illegible]	[illegible]	[illegible]
11.8	0.873	0.779−	0.647	0.4945	0.407	0.350	0.309−	0.278−	0.2527	0.233	0.218	[illegible]	[illegible]	[illegible]	[illegible]
11.7	0.872	0.777	0.646−	0.493	0.405	0.348+	0.307	0.2765	0.2515	0.232−	0.2167	[illegible]	[illegible]	[illegible]	[illegible]
11.6	0.871	0.776−	0.644	0.491	0.4035	0.346+	0.3055	0.275	0.250	0.2307	0.2153	[illegible]	[illegible]	[illegible]	[illegible]
11.5	0.870−	0.774	0.642	0.489	0.402	0.345	0.3041	0.2738	0.2486	0.2294	0.2144	[illegible]	[illegible]	[illegible]	[illegible]
11.4	0.869−	0.772+	0.640	0.487+	0.400	0.344−	0.3028	0.2721	0.2473	0.228	0.2132	[illegible]	[illegible]	[illegible]	[illegible]
11.3	0.867+	0.771	0.638	0.486−	0.398+	0.342	0.3014	0.2707	0.2462	0.2268	0.2119	[illegible]	[illegible]	[illegible]	[illegible]
11.2	0.866	0.770−	0.636	0.484	0.397−	0.340+	0.3001	0.2692	0.2450	0.2256	0.2107	[illegible]	[illegible]	[illegible]	[illegible]
11.1	0.865	0.768	0.634	0.482	0.395	0.339−	0.2992	0.2678	0.2439	0.2245	0.2095	[illegible]	[illegible]	[illegible]	[illegible]
11.0	0.864	0.767	0.632	0.480	0.393	0.337	0.2986	0.2663	0.2428	0.2232	0.2084	[illegible]	[illegible]	[illegible]	[illegible]
10.9	0.863	0.766	0.630	0.478	0.391	0.335	0.295	0.265	0.2412	0.2218	0.2072	[illegible]	[illegible]	[illegible]	[illegible]
10.8	0.862+	0.7645	0.628	0.476	0.389	0.333	0.2935	0.2634	0.2399	0.221	0.2061	[illegible]	[illegible]	[illegible]	[illegible]
10.7	0.862−	0.763	0.626	0.474−	0.387	0.3315	0.292−	0.262	0.238	0.219+	0.205	[illegible]	[illegible]	[illegible]	[illegible]
10.6	0.861	0.761	0.624	0.471	0.385	0.330−	0.290	0.2606	0.237−	0.218−	0.204−	[illegible]	[illegible]	[illegible]	[illegible]
10.5	0.860	0.759	0.622	0.469	0.384	0.328	0.288+	0.259	0.2355	0.217−	0.2026	[illegible]	[illegible]	[illegible]	[illegible]
10.4	0.858+	0.757+	0.620	0.467	0.382	0.326	0.287	0.258−	0.234−	0.2155	0.2015	[illegible]	[illegible]	[illegible]	[illegible]
10.3	0.857	0.756−	0.618	0.465	0.380	0.324+	0.286	0.2561	0.232−	0.214	0.200	[illegible]	[illegible]	[illegible]	[illegible]
10.2	0.856	0.754	0.616	0.463	0.378	0.323	0.2835	0.254	0.2317	0.213	0.199−	[illegible]	[illegible]	[illegible]	[illegible]
10.1	0.855	0.752	0.614	0.461	0.376	0.321	0.282	0.253+	0.230	0.2116	0.1977	[illegible]	[illegible]	[illegible]	[illegible]
10.0	0.854+	0.750	0.612	0.459	0.374	0.319	0.280+	0.251+	0.2285	0.210+	0.196	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 3. NUMBER OF ATMOSPHERES OR COMPRESSIONS

Absolute Initial Pressure, Pounds	Gage Pressures in Pounds														
	2.5	5	10	20	30	40	50	60	70	80	90	100	110	120	130
14.7	1.170	1.340	1.680	2.360	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.6	1.171	1.342	1.685	2.370	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.5	1.173	1.344	1.690	2.380	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.4	1.174	1.347	1.695	2.390	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.3	1.175	1.350	1.700	2.400	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.2	1.176	[illegible]	1.705	2.408	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.1	1.177	[illegible]	1.709	2.418	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.0	1.178	[illegible]	1.714	2.428	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.9	1.180	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.8	1.181	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.7	1.182	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.6	1.183	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.5	1.185	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.4	1.186	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.3	1.188	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.2	1.190	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.1	1.191	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.0	1.192	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.9	1.194	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.8	1.196	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.7	1.197	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.6	1.198	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.5	1.200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.4	1.202	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.3	1.203	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.2	1.205	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.1	1.208	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.0	1.209	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.9	1.210	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.8	1.212	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.7	1.214	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.6	1.216	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.5	1.218	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.4	1.220	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.3	1.222	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.2	1.224	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.1	1.226	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.0	1.228	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.9	1.230	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.8	1.232	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.7	1.233	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.6	1.235	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.5	1.238	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.4	1.240	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.3	1.243	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.2	1.245	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.1	1.248	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.0	1.250	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

for the points in the compression curve—on the 20-pound line this is 0.407, on the 40-pound line 0.255, etc. The adiabatic values in Table 2 for 13.7 pounds absolute initial pressure give, on the 30-pound line 0.439, on the 50-pound line 0.336, etc. Thus a sufficient number of points are located to readily and accurately construct the curves.

The tables being worked down to 10 pounds absolute pressure, may be used up to 10,000 feet altitude, provided the inlet pressure does not start below 10 pounds.

The tables also show the approximate position (somewhere between the isothermal and adiabatic curves) of the piston, in percentage of its stroke, for any of the given pressures, and from the isothermal table may be seen the relative volume of air delivered at the given pressures as compared with the original volume, considered as 1, at initial pressure.

Table 3 shows the number of compressions that the initial absolute pressures undergo to reach the given gage pressures, and also represents the number of atmospheres (initial pressure atmospheric) in the given gage pressure.

Old Boilers Doomed by Modern Laws

By William Faulkner

These old vessels which had been moved from the land of the Michiganites to that of the Seattleites were condemned by the wise men of the latter place and a calamity thereby averted.

And it came to pass in the second year of the reign of President Harrison that various artisans, workers in iron and steel, gathered together in the land of the Michiganites and said: "Let us get some earth and turn it with fire and make iron so our craft may be known throughout the land, even from shore to shore." So they made iron and tested it and found it good and were well pleased. And behold, there came a captain of the craftsmen who were skilled workers in wood, and he said: "I am sore distressed because I cannot get sufficient horses to do my work."

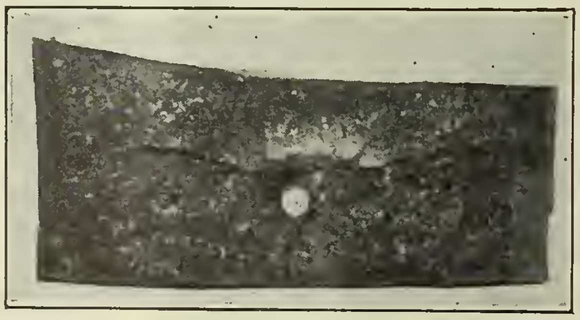
Then called he unto the captain of the workers in iron and steel and said unto him: "Make me a machine the same as James of the Wattites invented, and let it be equal to the strength of two hundred horses. And build me three vessels of iron in which water can be turned into steam."

So the captain of the workers in wood delivered unto the captain of the workers in iron and steel several bags of gold and said "Take this and deliver it to all your craftsmen who work diligently and when I return on the morrow I will pay thee in full." And there was great rejoicing in the land of the Michiganites. Then the captain of the workers in iron and steel sent for a scribe to draw a design for the three large vessels of iron, and he made a design for a vessel 192 inches in length, 60 inches in diameter and 3/8 of an inch in thickness, and he ordered that the sheets should be lapped and held together by two rows of rivets 13/16 of an inch in thickness, spaced 2¼ inches apart. The artisans then built three iron vessels according to the word of the scribe and they tested them with water and ordered that they should carry a working pressure of 100 pounds on every square inch.

Then came the captain of the workers in wood and looked upon the machine and the vessels of iron and he was well pleased.

Then came a great dearth of wood in the land of the Michiganites, so they sent messengers east and west and commanded them to find wood. And a messenger came from afar and he cried aloud and said, "Rejoice with me for I have found great amounts of wood in the land of the Seattleites."

And it came to pass that they journeyed to a far western country and dwelt among strange tribes that they might obtain wood with which to carry on their craft. So the captain of the workers in wood took with him all his machines and



Crack in Boiler Sheet

the three large vessels of iron and set them up in the land of the Seattleites, and they are there even unto this day.

In the second year of the reign of President Taft a number of wise men gathered together in the land of the Seattleites and said, "Behold, there are iron vessels in the country round about us which have been there since the days of our forefathers, and some have gone hence and the noise they made was like unto thunder and the people were much afraid."

So they appointed a number of skilled craftsmen to examine every vessel of iron and every vessel of steel and commanded them to test the vessels with water and with hammer and place their seal on all that were safe, and all that were unsafe they should condemn forever. And it came to pass that one appointed as examiner went to where the captain of the workers in wood had his iron vessels which he had brought from the land of the Michiganites in the year of President Harrison. And the examiner found a crack in one of the vessels of iron and he called unto him skilled workers and commanded them to cut out a piece of the iron vessel around about the crack, and when he measured the piece of iron it was found to be but 1/8 of an inch in thickness, so he condemned that vessel forever.

But the captain of the workers in wood was exceedingly wroth and he called the examiner before him and said unto him, "Would that I had the jaw bone of an ass that I might smite thee." And the examiner answered, "Knowest thou not that thou hast or thou wouldst not carry 100 pounds on each square inch of these old vessels and thereby endanger the lives of your craftsmen."

Then the captain of the workers in wood was much afraid and he shook with fear and said, "I must drink some wine; I pray thee come with me." And the wine softened his heart and he harkened to the words of the examiner and sent for laborers who rent the old vessels to pieces and modern vessels were placed in their stead.

Some week's ago, just after starting up the 13x18-inch engine in the planing mill of the Central Mill and Lumber Company, of Colville, Wash., the 16-inch belt was thrown, catching in the automatic governor and completely demolishing it, also breaking the eccentric and bending the connecting bar. A two weeks' shutdown was the result. The cause of the accident was an open drip from the exhaust. The night watchman was used to "cracking" the throttle early so as to warm up the engine, and on this particular morning neglected to close the drip on which there was an ell pointing toward the belt. Not much steam went out of this ell, but what did condensed and fell on the belt and froze there, where it remained unnoticed in the darkness of the morning until the load from the mill was thrown on. At this moment the belt slipped and did the damage previously mentioned.

Proper Use of the Term "Efficiency"

By A. C. Wilson

Although, fundamentally, the term efficiency represents the ratio of the energy supplied to the work done, it needs qualification in each particular case in order to avoid confusion.

Generally speaking, the efficiency of a machine is the ratio between the energy supplied and the useful work done, the difference between these two quantities being a measure of the waste or the loss of work in the machine. If W is the number of foot-pounds of work per minute required to drive a hoist and w is the number of foot-pounds of work done during the same time in lifting a weight, the efficiency of the hoist is

$$w \div W$$

and the work wasted is

$$W - w.$$

The amount $W - w$ does not disappear but is expended in overcoming friction and, being converted into heat, is consequently not useful work as regards the purpose for which the hoist is intended. There are two ways of measuring efficiency; W and w may be measured directly or either one of them and $W - w$ may be measured. Circumstances usually decide which method is the more convenient. In the majority of cases it is not easy to measure the waste work directly as this appears in the form of heat at the different bearings and the efficiency must be determined by measuring W and w.

It might appear from the foregoing that the efficiency of an engine or other machine is an absolute quantity and requires no further description, but, as a matter of fact, the term is used with reference to any ratio which is a measure of the economical performance in some sense or another and without further qualification conveys little or no information. The efficiency is always a ratio between the actual performance of a machine and an ideal performance, and to use the term without so qualifying it as to convey exactly what ratio is meant is either misleading or useless. Many trade advertisements and catalogs are full of examples of a vague use of the term efficiency. By common usage a number of ratios relative to the performance of steam engines, boilers, dynamos, pumps, etc., are described by prefixing a qualifying term, such as the thermal efficiency of a boiler, or the mechanical efficiency of a steam engine; and if this prefix is used, the ratio is immediately known, but where there is no such understanding it is necessary to state what ratio is meant, if the figures are to convey any meaning at all.

In a steam boiler the efficiency which is ordinarily desired is the ratio between the heat imparted to the water and the total heat in the coal put onto the grate. This ratio is usually known as the thermal efficiency and appears to be a sufficiently simple and straightforward thing to determine. There are, however, several opportunities for ambiguity, even here. The heat imparted to the water is the number of pounds of water evaporated per pound of coal fired, multiplied by the increase in the total heat per pound from that contained in the feed water pumped into the boiler to that of the steam leaving it. If the steam is dry saturated, the latter quantity can be ascertained from steam tables if the boiler pressure is known, but if the steam is wet, the degree of wetness must be measured by a steam calorimeter and if the steam is superheated, its temperature must be known. The total heat imparted to a pound of wet steam at a given pressure is less than that in a pound of dry steam at that pressure by an amount equal to the latent heat of that fraction which is in the form of water; that is, if steam is found to be 2 per cent. wet and the absolute pressure is 100 pounds the total heat per pound is

$$1186.3 - (0.02 \times 888) = 1168.54 \text{ B.t.u.}$$

measured from 32 degrees Fahrenheit. Similarly if steam is superheated in the boiler the total heat per pound is greater than the total heat of saturated steam at the same pressure by the specific heat of superheated steam multiplied by the difference in temperature between the superheated steam and that of saturated steam at the same boiler pressure, which latter may be found from steam tables.

The total heat in the coal is found by a laboratory test in a calorimeter and this may represent the heat in a sample after drying or in the same condition, as regards wetness, in which it was actually used. The amount of wetness in the coal as fired is also determined in the laboratory. If the chemist states the heat value of dry coal it is evident that an additional calculation will have to be made as the boiler test will have determined the evaporation per pound of wet coal. It is usual in scientific tests to give the results in terms of dry coal, and knowing the amount of wetness in the coal the evaporation per pound of dry coal is easily calculated. Suppose the boiler test showed that 7½ pounds of water were evaporated per pound of coal as fired and the chemist's figures show that the coal contained 10 per cent. of moisture; then the boiler really evaporated 7½ pounds of water from 0.9 pound of coal or

$$7.5 \div 0.9 = 8.33 \text{ pounds}$$

of water per pound of dry coal. Another equally correct method would be to calculate from the chemist's figures the heat value per pound of coal as fired as to the heat value of the dry coal and the amount of moisture; that is, suppose the heat value of the dry coal is given out as 13,000 B.t.u. per pound and the wetness of the coal as fired is 10 per cent., the heat value per pound of coal as fired is

$$13{,}000 \times 0.9 = 11{,}700 \text{ B.t.u.}$$

The important thing to look after is, that when the heat value of dry coal appears in the heat balance the evaporation per pound of dry coal must be used in calculating the heat imparted to the water and when the heat value per pound of coal as fired is used the evaporation per pound of coal as fired must be figured.

The available heat value of coal, having in view the conditions under which it is burned in a boiler, is not actually as much as the heat value ascertained by a laboratory test, for the reason that the hydrogen in the coal combines with oxygen to form steam and in a laboratory test this steam is condensed to water and the latent heat is given up. When burned under a boiler, however, the steam thus formed mixes with the other products of combustion and passes away as steam at a temperature above that of condensation; the latent heat in this steam is consequently not available and it is usual to deduct it from the heat value in the coal, calling the result the "lower" heat value. With ordinary coals the lower heat value is about 300 to 400 B.t.u. per pound less than the total heat value. It is customary nowadays to use the "lower" heat value in the heat balance for boiler tests and this, of course, makes the thermal efficiency higher than would be the case were the total heat adopted.

In considering steam-engine efficiency there are a considerable number of ratios each of which may be called the efficiency with respect to some standard of comparison, and it is again obvious that the term efficiency by itself means very little. Taking the general meaning of efficiency to be as stated at the beginning of this article, that is, the ratio between the energy supplied and the useful work done, the efficiency of a steam engine would appear to be the ratio of work done per pound of steam used divided by the total heat in one pound of the steam supplied, both being expressed in heat units. For example: let dry steam be supplied to an engine at 100 pounds absolute pressure and the steam used per horsepower per hour be 20 pounds. The total heat in one pound of dry steam is found from the tables to be 1186 B.t.u. and the work done per pound of steam used is

$$\frac{33{,}000 \times 60}{20} = 99{,}000 \textit{ foot-pounds} = \frac{99{,}000}{778}$$

$$= 127 \textit{ B.t.u.}$$

and the efficiency by this method is

$$\frac{127 \times 100}{1186} = 10.7 \textit{ per cent.}$$

This ratio, however, is not what is generally meant by the efficiency of a steam engine, as even in the case of a thermodynamically perfect engine the ratio would be less than unity. It is more useful, therefore, to compare the performance of an engine with that of the ideal engine working on some assumed conditions, the two most important of which are those known as the "Carnot" cycle and the "Rankine" or "Clausius" cycle. When the term thermodynamic efficiency or simply efficiency is used, the standard of comparison is the "Carnot" cycle, but if an ideal engine working on the "Rankine" cycle is the standard, the term "efficiency ratio" is used. The latter cycle is now generally accepted as the standard cycle for comparison and the "efficiency ratio" alone appears in the Institution of Civil Engineers' (England) standard method of tabulating steam-engine trials where the full formula for calculating this ratio is given.

Another important ratio relating to steam and gas engines but of a totally different nature is the "mechanical efficiency," which is the ratio between the work done on the piston and the useful work given off at the flywheel or the ratio between brake horsepower and indicated horsepower. The difference between these horsepowers represents work absorbed in friction in turning the engine, and the mechanical efficiency is a measure of the loss in obtaining power from the piston to the point where it is actually available for use and has no reference to thermodynamic considerations. To give an idea of the efficiency likely to be obtained in actual engines it may be said that, although the mechanical efficiency of a good engine may be from 85 to 95 per cent., the efficiency ratio lies usually between 0.5 and 0.6.

To turn to other machines it will be found that there is just as great a necessity to define what efficiency is meant when talking about their performance as is the case with engines or boilers. One sometimes sees tests of air compressors quoted where the efficiency without any qualification is given but where the volumetric efficiency is what is actually referred to. This is the ratio between the volume of air drawn through the inlet valves and the volume swept through by the piston of the air cylinder, and relates to the quickness in opening and closing of the valves or the lost motion in the machine and not the lost work. The lost work is measured by the mechanical efficiency and is of a precisely similar nature to the mechanical efficiency of an engine. In a steam-driven compressor the mechanical efficiency is the ratio of the indicated horsepower in the air cylinders to the indicated horsepower in the steam cylinders; and for a motor-driven compressor it is the ratio of the indicated horsepower in the air cylinder to the brake horsepower of the motor.

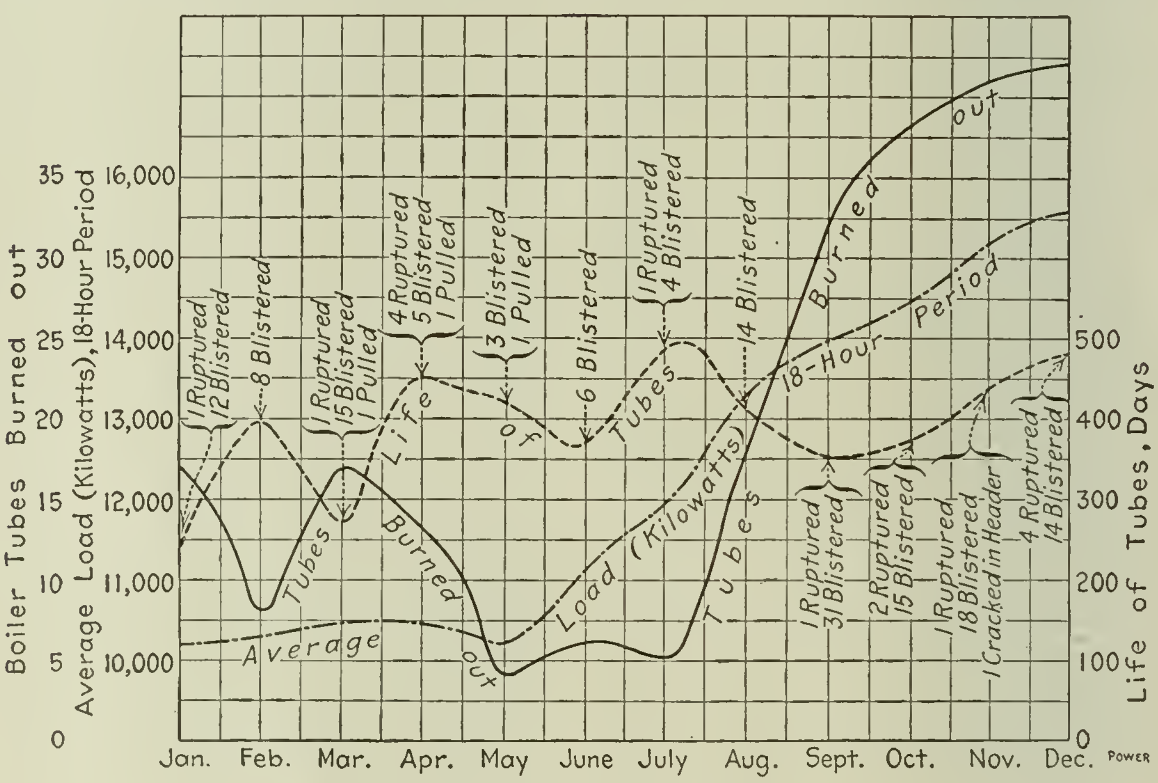
In considering the performance of an air compressor, however, there are other ratios which give useful information and enable different machines to be compared with an ideal standard, and as the term efficiency is often used in connection with these ratios it requires qualification. For instance, the power required to compress one pound of air from one pressure to another pressure when the temperature is maintained constant, that is, isothermal compression, can be calculated readily and is a convenient standard of comparison with the power actually found to be necessary in a compressor working between the same limits of pressure. The ratio of the work required for isothermal compression to the work actually taken is sometimes called the efficiency, but more correctly it is the efficiency compared with isothermal compression. For other purposes the power required to compress adiabatically, that is, without allowing any heat to be abstracted from or added to the air, is taken as the standard for comparison and the ratio obtained should be defined as the efficiency compared with adiabatic compression.

One could easily multiply instances of the various different ratios which are all called efficiency, but enough has been said to emphasize the point that it is a word which cannot properly be used without qualification.

Effect of Heavy Loads on Boiler Tubes

By Leroy W. Allison

Plotted from records of the past year's operation of a 15,000-kilowatt plant, carrying for the most part a railway load, the accompanying chart indicates the effect of peaks upon boiler tubes. The curves are deduced for 18-hour periods and are self-explanatory. The plant contains eighteen Babcock & Wilcox boilers, each rated at 550 horsepower and comprised of twenty-one sections of fourteen 4-inch tubes 18 feet long; the drums are 42 inches in diameter. To supply the three 5000-kilowatt units, the boilers are operated under a working pressure of 175 pounds, in groups of six; five are used for normal load, the sixth being held in reserve. Each boiler is fitted with a Peabody oil-burning furnace equipped



Effect of Load on Tubes

with three burners. These burners fire forward from the bridgewall and steam is used as the atomizing agent. The boilers are provided with Babcock & Wilcox superheaters, designed for 100 degrees superheat, and California crude oil is used as fuel. This ranges in density from 13 to 15 degrees Baumé, and has a value, as fired, of approximately 18,000 B.t.u.

The ingineer at the sawmill wus cleanin' the biler and puttin' a kag of stable manure in the manhed when Parson Goodman kim along and stopped to talk a bit. He watched the manure go in the biler and all of a sudden exklaimed: "I never new before now what was meant by horsepower. I recken if you had a stable of 100 horses you would have a heap more power." An' the ingineer scratched his hed for a while an lowed he would.

Dimensions of Riveted Steel Pipe

By N. A. Carle

Charts showing the thickness of plate for riveted steel pipes of different diameters with various pressures, tensile strengths, factors of safety and efficiencies of joint. Examples are given illustrating the use of charts.

Riveted steel pipe is generally used to carry water from the source of supply to the point where it is to be utilized, at which point the discharge pressure is greater than the inlet pressure, due to the difference in elevation; or it may be used if water under pressure is to be conveyed between two points. The strength of the pipe must be increased as the head increases, and, unless a large factor of safety is allowed, unusual care must be taken in protecting the steel plates and rivets from rust.

The formula for the strength of riveted steel pipe is

$$P = \frac{2\,T\,t\,e}{D\,f}$$

where,

P = Safe working pressure in pounds per square inch;
T = Tensile strength in pounds per square inch;
t = Thickness of steel plate in inches;
e = Efficiency of joint in per cent.;
D = Diameter of steel pipe in inches;
f = Factor of safety.

The accompanying charts show graphically the thickness of steel plate for various diameters of pipe, working pressures, factors of safety, tensile strength of the steel plate and efficiencies of joints.

Fig. 1 is for pipe up to 60 inches in diameter carrying pressures from 50 to 300 pounds per square inch with factors of safety from 2.5 to 6. The tensile strength of the steel plate ranges from 45,000 to 70,000 pounds per square inch with efficiency of the joints from 50 to 85 per cent.

Fig. 2 is for pipe up to 45 inches in diameter carrying pressures from 200 to 1200 pounds per square inch with factors of safety from 2.5 to 6. The tensile strength and efficiencies of joints are the same as for the chart in Fig. 1.

EXAMPLE—What thickness of steel plate of a tensile strength of 60,000 pounds per square inch and an efficiency of joints of 70 per cent. will be necessary using a factor of safety of 5 for a pipe line 42 inches in diameter and carrying a pressure of 100 pounds per square inch?

Using the chart shown in Fig. 1, start with 42 inches diameter of pipe and read up to 100 pounds per square inch working pressure, then across to a factor of safety of 5, then down to 60,000 pounds per square inch tensile strength and across to 70 per cent. efficiency of joint and down to 1/4 inch thickness of steel plate.

EXAMPLE—What pressure will a 30-inch pipe of 1/2-inch steel plate stand with a factor of safety of 4 if the steel plate has a tensile strength of 50,000 pounds per square inch and a joint efficiency of 80 per cent?

Starting with a 1/2-inch thickness of steel plate and using the chart in Fig. 2, read up to 80 per cent. efficiency of joint, then across to 50,000 pounds per square inch tensile strength and up to a factor of safety of 4, then extend a line horizontally across until it intersects the ordinate marked 30 inches diameter of pipe. The value of the working pressure at the intersection will be found to be 500 pounds per square inch.

EXAMPLE—A pipe line 1600 feet in length and 60 inches in diameter has a gradual drop of 200 feet throughout its entire length. What thickness of steel plate of 55,000 pounds per square inch tensile strength should be used if the pipe line is to have a factor of safety of not less than 5 and a joint efficiency as follows:

1/4 inch steel plate	70 per cent.
9/32 inch steel plate	75 per cent.
5/16 inch steel plate	80 per cent.

and what will be the corresponding lengths of pipe made up of 1/4-, 9/32- and 5/16-inch steel plates?

The pressure at any point will be that due to a head equal to 1600 ÷ 200, or 1/8 of the length of the pipe line from this point to the point of supply. Conversely, multiplying the head at any point by 8 will give the length of the pipe line from this point to the point of supply.

On account of the possibility of collapse from external causes, it is advisable that no steel plate shall be less than 1/4 inch for pipes of this diameter and for service of this kind.

Starting with 1/4-inch thickness of steel plate, Fig. 1, read up to 70 per cent. efficiency of joint, then across to 55,000 pounds per square inch tensile strength, then up to a factor of safety of 5 and then horizontally across to its intersection with the ordinate through 60 inches diameter of pipe. This gives a value for the working pressure of approximately 64 pounds per square inch, which is the limiting pressure for 1/4-inch steel plate of 55,000 pounds per square inch tensile strength with a joint efficiency of 70 per cent. and a factor of safety of 5.

This pressure is reduced to an equivalent head in feet by dividing by 0.434, which gives 147.5 feet head. Multiplying this by 8 gives the length of 1/4-inch steel pipe line as 1180 feet.

Starting with a 9/32-inch thickness of steel plate read up to 75 per cent. efficiency of joint, then across to 55,000 pounds per square inch tensile strength, then up to a factor of safety of 5 and horizontally across to its intersection with the ordinate marked 60 inches diameter of pipe. This gives a value for the working pressure of approximately 77.5 pounds per square inch, which is the limiting pressure for a 9/32-inch steel plate of 55,000 pounds per square inch tensile strength with a joint efficiency of 75 per cent. and a factor of safety of 5.

This pressure is reduced to its equivalent head in feet by dividing by 0.434 which gives 178.5 feet head. Multiplying this by 8 gives the length of pipe from the entrance to the end of the 9/32-inch steel plate as 1428 feet.

Starting with 5/16-inch thickness of steel plate read up to 80 per cent. efficiency of joint, then across to 55,000 pounds per square inch tensile strength and up to a factor of safety of 5; then horizontally across to its intersection with the ordinate marked 60 inches diameter of pipe. This gives a value for the working pressure of approximately 91.5 pounds per square inch, which is the limiting pressure for a 5/16-inch steel plate having a tensile strength of 55,000 pounds per square inch and a joint efficiency of 80 per cent. with a factor of safety of 5. This pressure is reduced to its equivalent head in feet by dividing by 0.434, which gives 210.8 feet head. Multiplying this by 8 gives the length of pipe from the entrance to the end of the 5/16-inch steel plate as 1686.4 feet. The entire length of the pipe line is 1600 feet; therefore, no steel larger than 5/16 inch need be used.

The lengths of pipe line for each thickness may be found from the following:

Length of 1/4, 9/32 and 5/16 inch	= 1600 feet
Length of 1/4 and 9/32 inch	= 1428 feet
Length of 5/16 inch	= 172 feet
Length of 1/4 and 9/32 inch	= 1428 feet
Length of 1/4 inch	= 1180 feet
Length of 9/32 inch	= 248 feet

"Casey," says Mike, fr havin' his first visit to the ice factory, "phwat kind of a ingine be that?"

Casey stuck his thumbs in the armholes of his vest and swelled up.

"That do be 'bout a four-cylinder gas ingine," says he.

"'Four-cylinder,'" says Mike, pointin' at the [illegible], "An' many of the cylinders be missin'?"

"Sure," explains Casey, "they're all o' them runnin' right, but wan of them is missin' most o' the time."

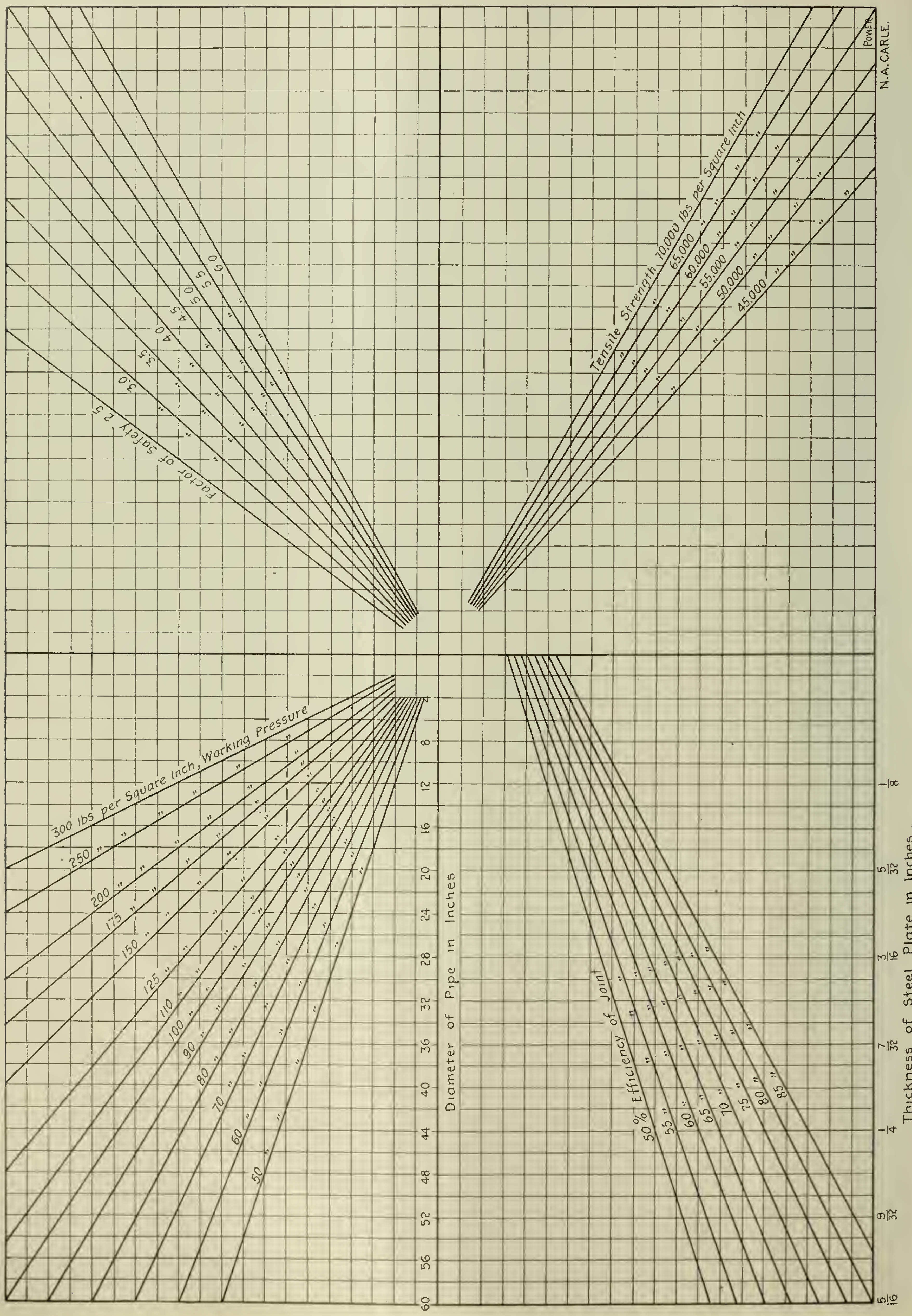


Fig. 1. Chart for Use with Pressures from 50 to 300 Pounds per Square Inch

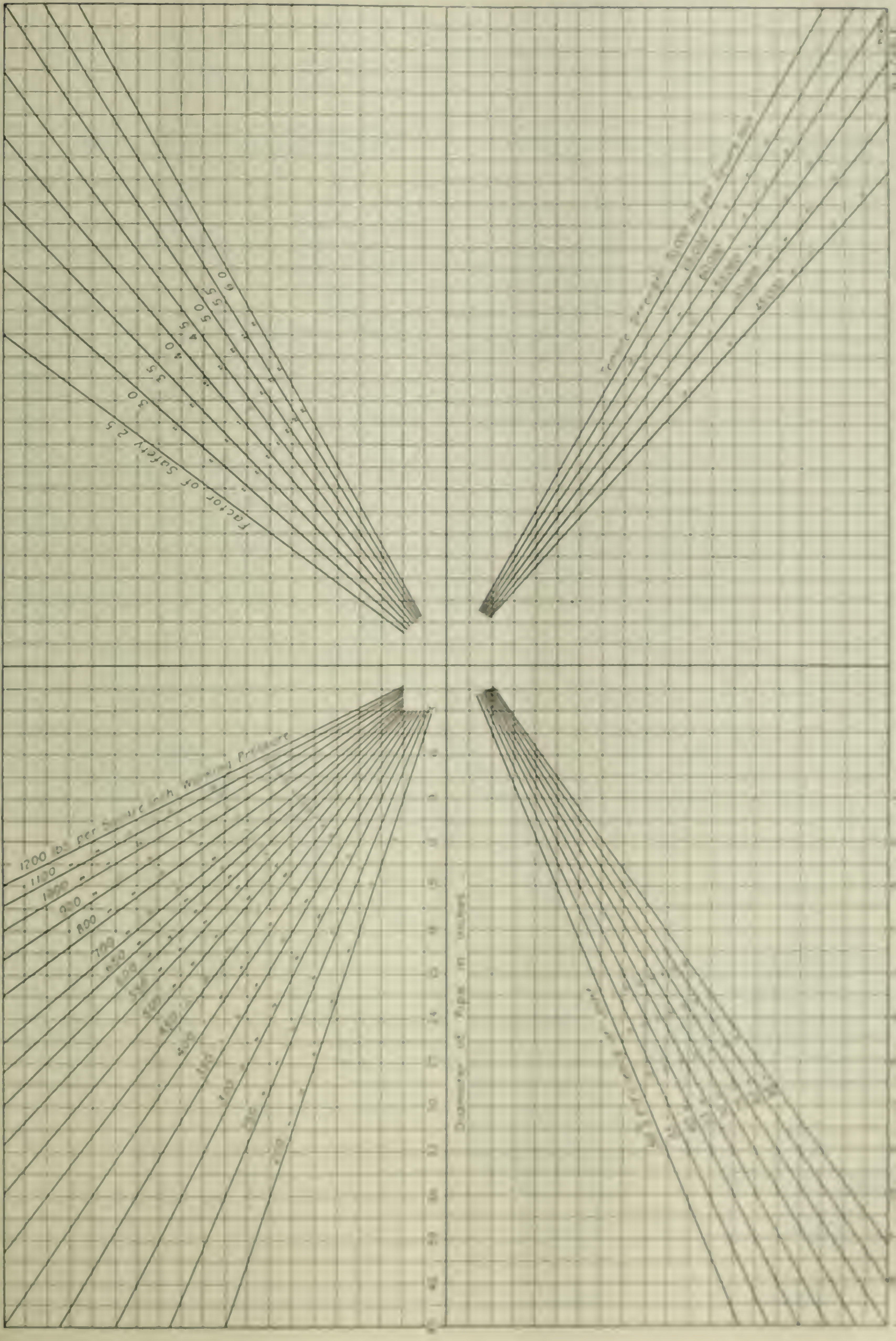


Fig. 2. Chart for Use with Pressures from 200 to 1200 Pounds per Square Inch

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Repairing Induction Motors

By R. H. Fenkhausen

Rotor Repairs

After the shaft and bearings have been put in first-class condition, the rotor should be carefully examined to see if the "winding" is damaged. The paper in the slots inclosing the rotor bars should be tried with a knife point, and if so badly charred that it chips off when

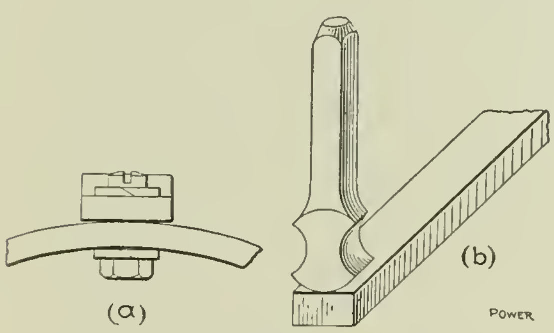


Fig. 14. Bar Connection

touched, it should be renewed. The mere fact that the paper was charred would indicate only a slight decrease in the starting torque, which would not be of any practical harm to the motor. Charred paper, however, is usually the effect of local heating at the joints between the bars and the end rings, caused by loose bolts, and as the repair of this trouble requires the removal of the bars in order that the contact surfaces may be cleaned, the renewal of the paper insulation on the bars entails only a very small amount of additional work and makes a proper job of the repair, instead of a makeshift.

The heating caused by poor contact

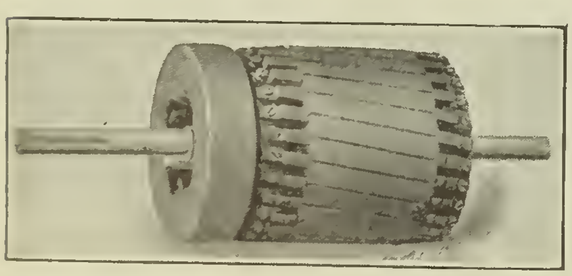


Fig. 15. Rotor with Skewed Slots

between the rotor bars and short-circuiting rings is liable to lead to serious damage to the entire motor if not corrected. The ends of the stator coils outside the slots lie very close to the rotor and are liable to be so badly charred as to necessitate a complete rewinding of the stator.

Squirrel-cage Rotors with Bolted Bars

The bolts should all be removed and the bars taken out of the slots. The short-circuiting rings should then be thoroughly cleaned with sandpaper and the outside circumferences "tinned." The solder should be applied to the ring while the latter is hot, and, after the entire surface has been coated, the "tinning" should be wiped with a piece of cloth before the solder has set. This will insure a coating of uniform thickness all around the ring.

The bars should be cleaned and all charred paper scraped off them and also

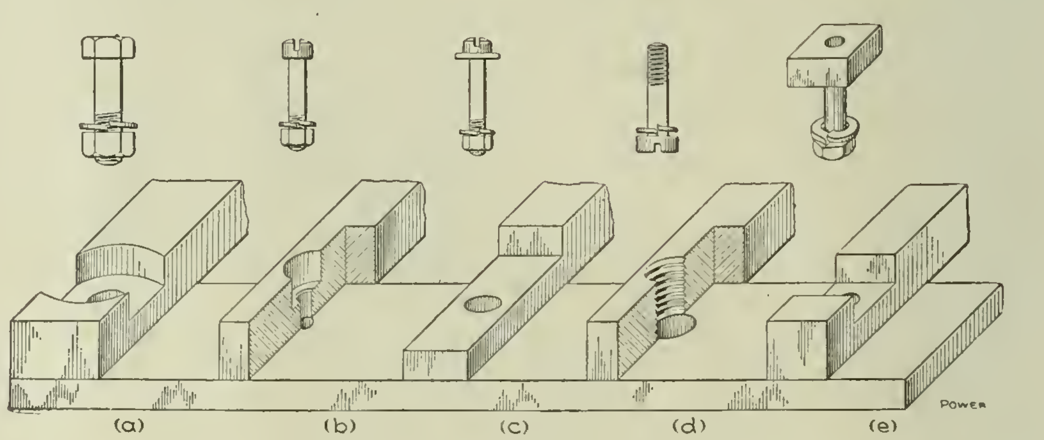


Fig. 16. Forms of Rotor-bar Ends for Bolting

from the walls of the slots in the core. The under surfaces of the bars should then be "tinned" at each end for a distance equal to the width of the short-circuiting ring, and wiped smooth, like the rings. The object of "tinning" the contact surfaces between the bars and rings is to prevent oxidation in case of any subsequent slight heating due to temporary overloads. The "tinned" surfaces tend to unite when heated and form a soldered joint.

Before "tinning" the bars the contact surfaces should be tried on the ring to determine whether the bar is concaved to fit the ring, or flat. Fig. 14 shows at *a* an exaggerated view of the scanty contact found in rotors when the makers do not take the trouble to give the bars the proper shape. Small motors having rotors of small diameter with comparatively few bars are most liable to trouble from this source. Large motors usually have bars of approximately the same size as those used in the smaller motors, but a much larger number of them, and, owing to the large diameter of the end rings, the amount of curvature under a single bar is practically negligible.

If the contact is found to be bad, due to this cause, a steel swedge should be made having a face curved to correspond to the curvature of the ring, and all the bars should be given a blow with this before "tinning," as indicated at *b* in Fig. 14, care being used that the swedge is held level so that the bar will be uniformly indented. For rotors having skewed slots, as shown in Fig. 15, a jig should be made before swedging in order that all bars may be held at the same angle that they will have with reference to the short-circuiting rings when the rotor is reassembled.

Methods of Bolting Bars

There are several methods of bolting the rotor bars to the short-circuiting rings, each of which has its advantages. The four methods in most common use are illustrated in Fig. 16. The method shown at *a* was formerly used on almost all motors. A large bolt with a nut and spring washer inside the ring gave ample clamping power without danger of stripping the threads on the bolt. Later designs of rotors are usually fitted up as shown at *b*, *c* or *d*. On account of the smaller bars now commonly used, there is no room for a large bolt, and a small 10/32 machine screw is usually employed.

It will be noted that the three joints shown at *a*, *b* and *c* are made with the nuts inside the ring and the bolt heads outside. This construction is the most accessible, except on large motors, but is open to the very serious objection that a loose, broken or burned-off screw or bolt will naturally be thrown outward by centrifugal force and will catch on the stator coils and seriously damage them. Cases are on record where a complete set of new stator coils has been necessary as a result of a broken screw. The construction shown at *d* is designed to eliminate this objection and is used on a large proportion of the motors now manufactured; two bolts at each end of each bar are used on the larger sizes of motors. The disadvantage of the latter construction lies in the fact that the thread for the screw is tapped into the bar itself, and as there is no room for a lock nut, reliance must be placed on a spring washer to prevent the bolts from becoming loose.

Fig. 17. Drill Bit

Where there is much vibration, trouble is experienced from loose bolts, which has led one manufacturer to upset the ends of the bolts. This effectually locks the bolt but when it becomes necessary to repair the rotor it is practically impossible to remove the bolts without stripping the threads out of the bars. The screws cannot be drilled out, owing to the difficulty of holding a drill central on a steel screw; it will run off into the softer copper. The limited diameter of the bars makes it impossible to retap them for a larger size of screw when stripped.

Two methods of repairing the rotor are available. The first is to counterbore the bars, as shown at *b*, Fig. 16, and use fillister-headed screws with nuts and spring washers inside the ring. A pin drill for counterboring is shown in Fig. 17; this can be easily turned up in a lathe out of a piece of tool steel. This method of repair, though the easiest, is open to the objection previously mentioned, that a loose bolt can damage the stator winding. A better method is illustrated at *c*, Fig. 16. The bars are sawed or milled out somewhat as shown at *c*, but instead of the screw head being outside it is placed inside and a special square nut fitted into the notch cut in the bar; a spring washer under the head of the screw serves as a lock. As the nut does not carry current it may be made of steel, and may be properly tightened without danger of stripping the threads.

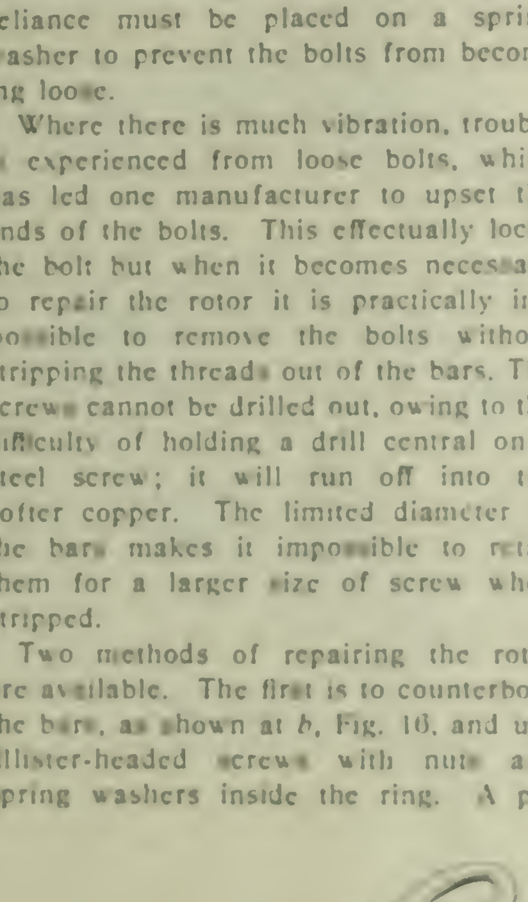


Fig. 18. Insulation Cutter

Paper Insulation

The new paper insulation should be of red rope paper or bond paper, 5 to 8 mils thick. It should be cut long enough to inclose the bar to within 3/16 inch of each end ring, and wide enough to cover five sides of the bar, which will give a lap on one side to allow pasting. The paper should be cut from the roll in strips wide enough to make the length of the individual bar wrappers, with the aid of a straight-edge, and then cut into the proper widths with a photographic print trimmer, such as that shown in Fig. 18.

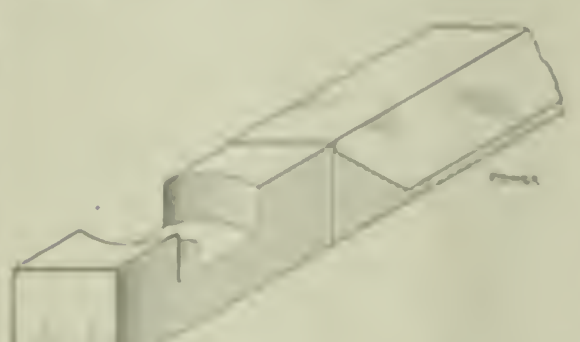


Fig. 19. Paper Sheath

Each paper cell should be creased and folded around the bar, and the corners clipped off as shown in Fig. 19 to facilitate the entrance of the cells into the slots, and prevent the corners of the paper from catching on the laminations of the core.

The overlapping ends of the paper cells should next be pasted into place and the bars inserted in the rotor slots. The double thickness of paper should be on the bottom of the slot to prevent the lapped ends of the paper from becoming loosened by centrifugal force and flying out into contact with the stator winding. This would, of course, do no damage, but would cause a rustling noise, very annoying in most locations.

After the bars are all in place, the end rings should be inserted, and two diametrically opposite bars bolted firmly to the rings at each end. A thin "feeler" should then be tried between the rings and bars to insure that a condition similar to that illustrated by Fig. 20 has not been brought about by too much paper in the bottom of the slots. If trouble from this source is found, the paper cells must be reversed so as to bring the double thickness of paper on top of the bar instead of underneath.

The bolts should then be drawn tight and the spacers which prevent axial movement of the bars inserted at equidistant points around the ring. These spacers consist of small sheet-metal strips clamped under the nuts which hold the bar, as shown in Fig. 21. It will be noticed that the squirrel cage is grounded at these points, but, owing to their location, the effect is negligible.

Fig. 20. A Poor Joint

Soldered Squirrel-cage Rotors

Owing to the soldered joints between bars and end rings, trouble from loose contacts is seldom encountered in this form of rotor, except as the result of extreme overloads such as occur in planing mills or other wood-working establishments, for which service the bolted construction is preferable.

In case repairs are necessary to this type of rotor, the short-circuiting rings must be heated with a gasolene torch until the solder melts and permits the rings to be pried off. The bars should then be cleaned, "tinned," reinsulated, as described in the discussion of bolted rotors, and replaced in the slots. The rings should be thoroughly cleaned and all paint removed before retinning. If this is neglected, the paint or varnish will run into the joints when the ring is heated and prevent the solder from making a good contact. After the rings have been cleaned and retinned all over, they may be slipped into place on the bars.

In the earlier forms of soldered end rings, the openings for the bars were punched out, leaving only a thin edge of metal available for the soldered joint. It is very difficult to make a good joint

Fig. 21. A Good Joint

with these rings unless the entire armature be dipped into the solder. This is best accomplished by the use of a shallow annular trough of clay, or of sheet iron lined with clay. The solder may be melted by means of several torches and the rotor dipped into the molten solder to the required depth, as shown in Fig. 22. Later forms of end rings have the metal only partly punched from the openings and bent back to form lips and spacers between the rings, as indicated in Fig. 23. These lips give a comparatively large contact surface for soldering, and the rings may be soldered with an iron, provided, of course, that one ring be placed at a time, in order to give access to all sides of the bars.

Riveted Squirrel-cage Rotors

In case it becomes necessary to remove the rivets from a rotor of this type, they should not be chipped out, because hammering a steel rivet in a soft copper bar will enlarge the hole and prevent proper contact with the rivet when the rotor is

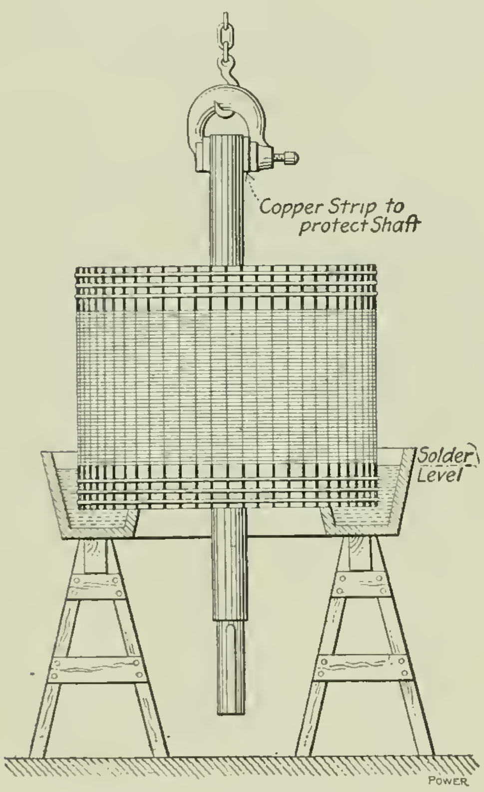


Fig. 22. Soldering Rotor Connections

reassembled. The rivets should be removed by filing off the heads, or by drilling out the countersunk heads if these be used. After "tinning" and reinsulating the bars, as previously described, they should be attached to the end rings by bolting, one of the methods shown in Fig. 16 being employed.

Wound Rotors

Although grounds on a squirrel-cage rotor are of little consequence, two or more grounds on a wound rotor may lead to serious trouble. Rotors of this type are almost invariably equipped with three-phase windings, usually "star" connected. The effect of grounds on a rotor of this type can best be illustrated by an extreme case. Suppose that three grounds should occur simultaneously, at the points *A*, *B* and *C*, Fig. 24; the entire winding would be short-circuited upon itself and run as a squirrel-cage rotor. It is evident that a change in the external resistors R_1, R_2 and R_3 will have no effect on the speed of the motor, which will run at full-load speed irrespective of the position of the controller handle.

Though this is an extreme case, the effect of two or more grounds, wherever located in the rotor winding, is to take the speed control of the motor out of the

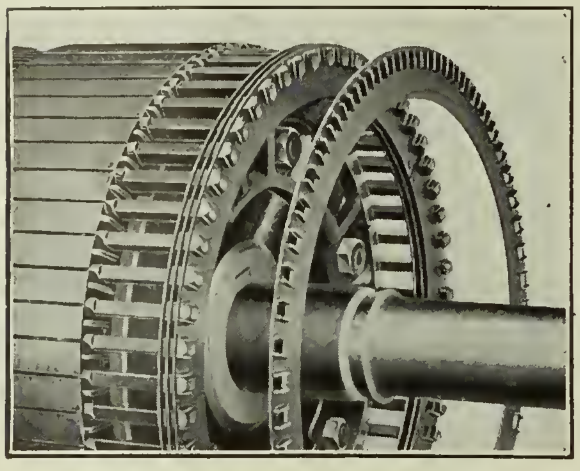


Fig. 23. Bolted Rotor Bars

operator's hands to a greater or less degree, depending on the amount of the winding short-circuited by the grounds. Whenever a motor runs above its normal speed for a given load and controller position it may be taken as evidence of grounds. As the slip rings and brush rigging are more liable to become grounded than the rotor winding, the leads from the winding to the slip rings should be disconnected before testing for grounds.

A short-circuit will produce an effect similar to that of two grounds; but it is a very difficult fault to locate, owing to the extremely low resistance of the wind-

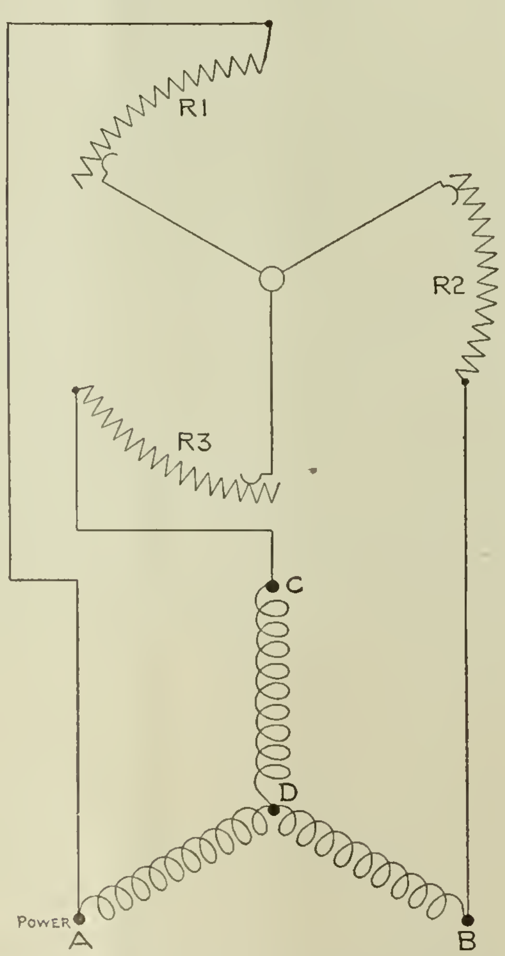


Fig. 24. Wound-rotor Connections

ing. It is most liable to occur between the two bars in one of the slots, where they happen to belong to different phases, and seldom results in a ground.

Open circuits are of rare occurrence, owing to the heavy conductors used, and even should one occur it could easily be located. When a short-circuit is suspected the common junction at *D*, Fig. 24, should be opened to allow testing for crossed phases. By measuring the resistance of each phase with a sensitive Wheatstone bridge, short-circuits can be detected.

Wound rotors for service requiring high torque or where the controlling apparatus is located some distance from the motor are wound with coils similar to those used on the stator, the only difference being that the rotor coils are

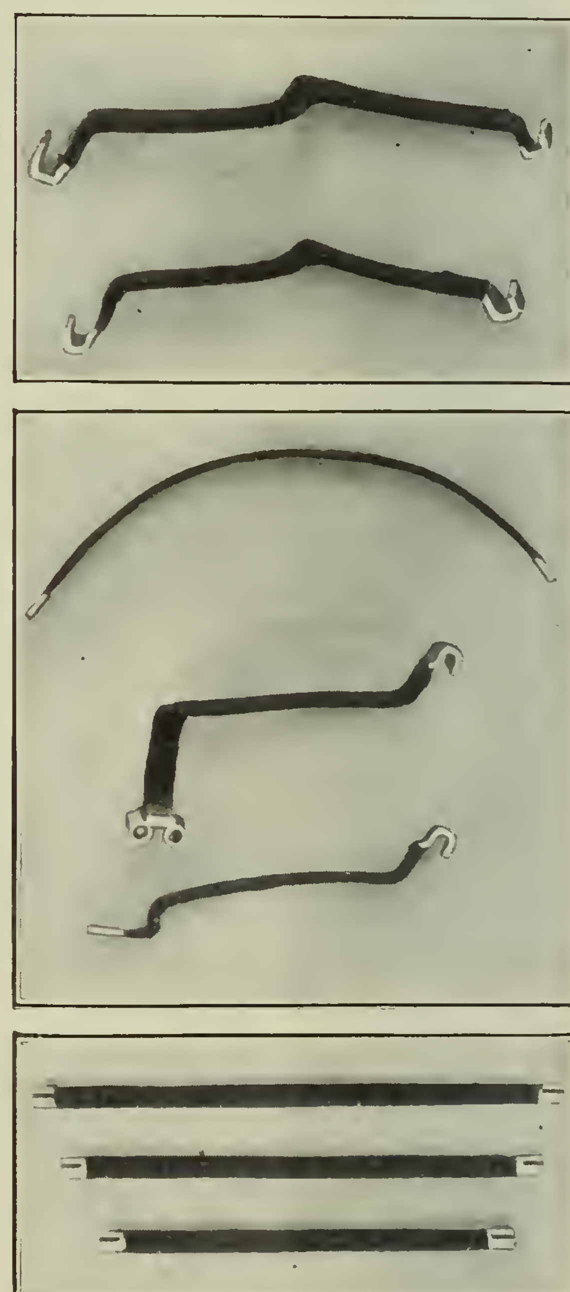


Fig. 25. End Connectors, Winding Terminals and Rotor Bars

placed in slots on the outside circumference of the core, while the stator coils are placed in slots on the inside circumference of the core. Coils of this type are of high resistance and many turns and the rotor voltage is often as great as that impressed on the stator winding. Owing to the similarity between a stator winding and a rotor winding of this character, the repair of such rotor windings will not be treated in this article; the full instructions which will be given in the article on the repair of stator windings will apply equally well to high-resistance rotors.

Bar Windings for Rotors

Most of the wound rotors for multi-speed service now in use are wound with heavy bars or strips similar to those used

FIG. 26. WOUND-ROTOR BAR "COIL"

in a squirrel-cage rotor, but two bars are usually put in each slot. These bars are connected at the ends into regular "coils" by means of pieces of copper strap, known as end connectors. This material is usually only half as thick as the bars which it connects; it is, therefore, made twice as wide in order to get the necessary cross-section. Fig. 25 shows long and short bars and end connectors and also the terminal leads for the winding. Fig. 26 shows the method of grouping two bars and a connector to form a one-turn coil. It will be noted

FIG. 27. A STATOR COIL

that the finished "coil" resembles the involute form of stator coil shown in Fig. 27.

The end connectors are soldered into slots cut in the ends of the rotor bars and the three free terminals of the winding are carried to the slip rings. As the repair of a bar-wound rotor of this type seldom calls for the renewal of anything except the insulation on the bars and end connectors it is merely a matter of replacing things and reconnecting in the original manner.

Balancing

After repairing a wound rotor it should be tried for balance; the less symmetrical character of the winding makes it more liable than the squirrel-cage type to be reassembled out of balance. The most accurate method is illustrated in Fig. 28. Two parallel rails are set up perfectly true and level on stout posts and the rotor is hoisted up and placed on the rails with a large ring slipped over each end of the shaft, as shown. These rings permit far more accurate balancing to be done, as they allow the rotor to revolve much more easily than it would if the shaft were laid directly on the parallel rails.

FIG. 28. BALANCING WAYS

The rotor will roll until the heavy side is at the bottom. A piece of wet clay should be pressed against the inside of the spider on the light side and its weight adjusted and location changed until the rotor shows no tendency to rotate, no matter in what position it is placed. Then the clay is weighed and a piece of metal fastened in its place by means of a tap bolt; the weight of the metal and bolt together must equal that of the clay.

Collector Rings and Brush Holders

Trouble at the collector rings is usually due to defective insulating bushings

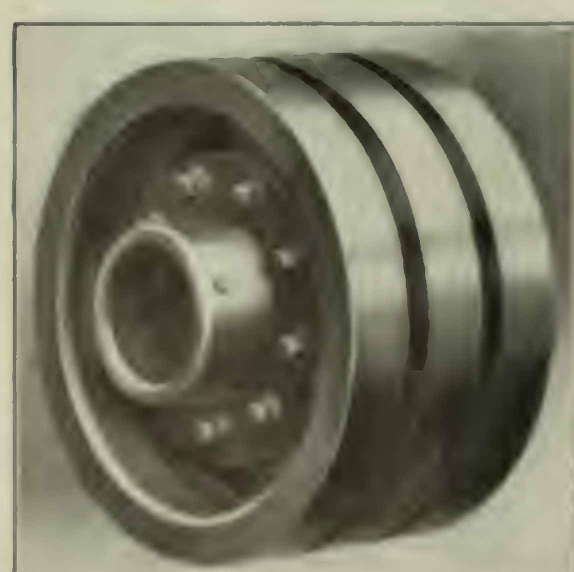


FIG. 29. THREE-PHASE SLIP RINGS

around the bolts which hold the ring structure together. It is usually caused by vibration, which loosens the bolts and allows them to "work," thereby wearing out the insulation. After renewing the bushings the rings should be drawn together tightly and lock washers placed under the bolts. Fig. 29 shows the construction of a set of rings.

Fig. 30 shows a typical set of pivoted brush holders. Flexible copper shunts or

FIG. 30. ROCKER-ARM AND BRUSH HOLDERS

"pigtails" are used to carry the current from the brush box to the terminals. If one of these shunts should be broken, the current would be forced to travel through the hinge pin, which will heat up until it sticks and prevents the brush from maintaining contact with the ring. The carbon brushes used with this type of motor usually have copper-wire gauze molded into the brush to increase its conductivity.

These brushes should be fitted to the slip rings with sandpaper in the same manner as those on a direct-current motor, but, owing to the fact that the long axis of the brush is radial to the shaft, a condition such as that illustrated in Fig. 31 may exist when the sandpaper is removed. If the sandpaper is 1/16

FIG. 31. INCORRECT BRUSH SETTING

inch thick, the hinge edge of the brush is liable to be over 1/32 inch clear of the ring, due to the position of the hinge.

To correct this it is necessary merely to loosen the clamping screw and slide the holder upward on the brush until both edges touch the ring as they must to obtain good contact.

When motors vibrate, hangers will get loose, allowing belts to pull the shaft out of line. This can be prevented by driving in a small lag screw at the heel of one of the hanger.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Repairing a Broken Engine Frame

By H. T. Melling

The breakdown and repair of a 50-horsepower gas engine came under the writer's observation some time ago. The engine was a single-cylinder single-acting one, working with a similar engine of 100 horsepower, both engines being connected to the same shaft by rope drives off the flywheels.

The engines had been at work about two years, giving entire satisfaction, when the accident occurred. The connecting-rod bolts on the big end of the 50-horsepower engine broke and, the piston being blown partly out of the cylinder, when the crank next came around it lifted the connecting rod so far that it broke through the top of the piston barrel and broke the cylinder liner and the front of the main frame. See Fig. 1.

It was first thought that the breakage of the main frame would necessitate a new casting because the front of it formed a water-tight expansion joint with the cylinder liner. However, it was decided to order from the makers only a new cylinder liner and piston.

The two broken pieces of the main frame were placed in position and a pattern made for a patch to cover the entire surface of the front end of the frame, as illustrated by Fig. 2; the casting was made of brass in order that it might be more elastic. This was bedded down to the surface over the broken part, six ¾-inch machine bolts on each side clamping it down to the main frame. Before the patch was put on, the new cylinder liner

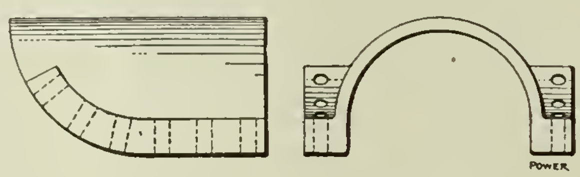


Fig. 2. The Frame Patch

was put in place, with a rubber ring on the end of the liner, which packed the expansion joint. The broken pieces of the main frame were then put in position, a thin coating of red-lead putty was smeared over the entire surface and the patch was drawn down to its place by the bolts.

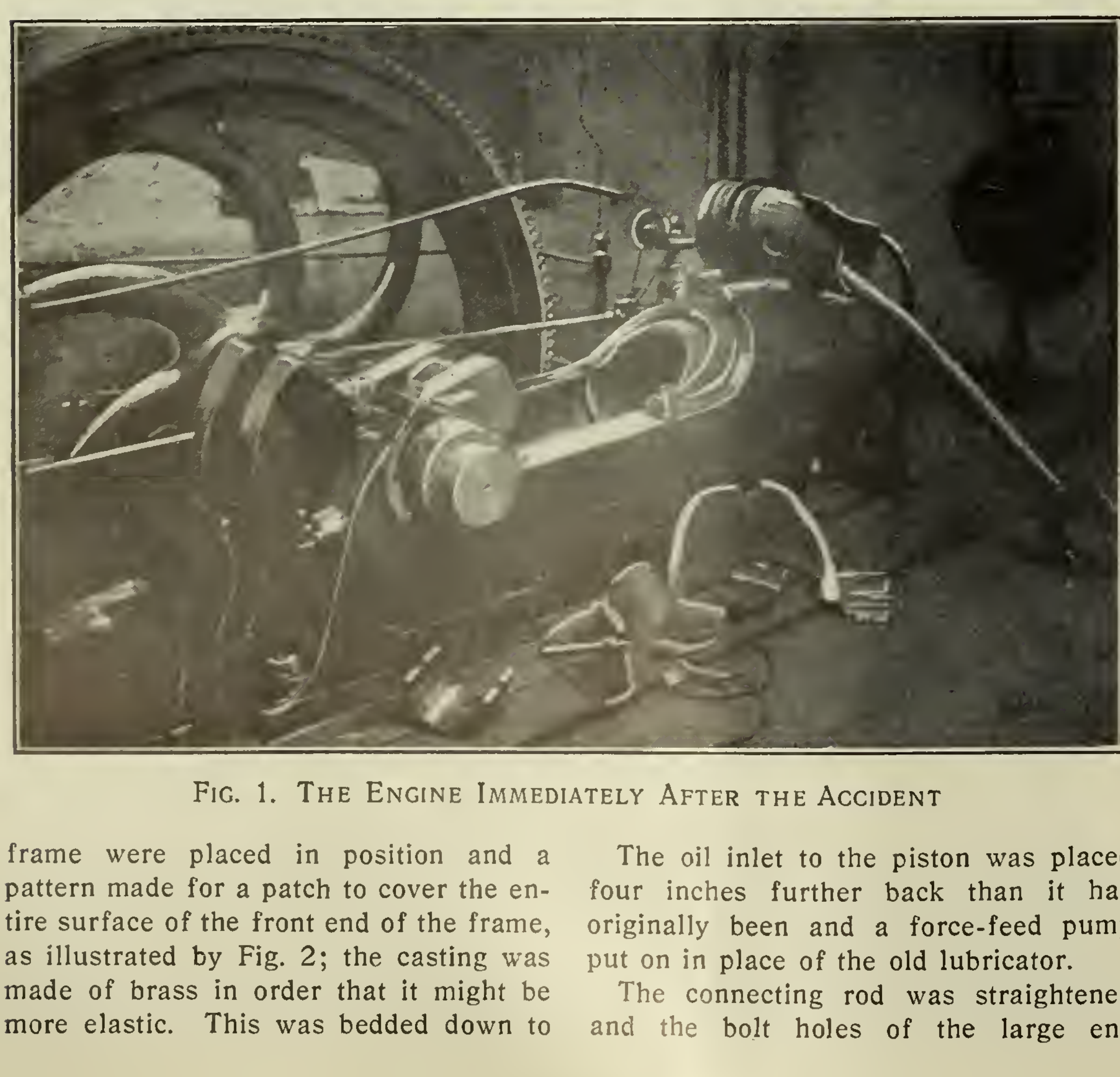


Fig. 1. The Engine Immediately After the Accident

The oil inlet to the piston was placed four inches further back than it had originally been and a force-feed pump put on in place of the old lubricator.

The connecting rod was straightened and the bolt holes of the large end reamed out larger. It was evident from inspection of the old connecting-rod bolts that they had been weakened by the constant knocking of the big end, causing them to stretch to their elastic limit and then broken, after crystallization, at the finish of the thread. The new bolts were made of the best hammered iron and instead of being made of uniform diameter were turned down as shown in Fig. 3 to the diameter of the bottom of the thread, to make them more elastic.

The practice of having both engines drive the one shaft was abandoned and each was given a separate load.

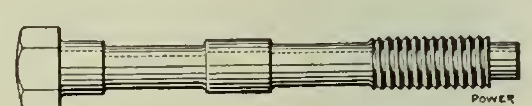


Fig. 3. Connecting-rod Bolt

After the engine had warmed up, the bolts on the patch were thoroughly tightened up and it was found to be a most satisfactory repair.

Rocker Arms for Poppet Valves

By A. M. Levin

Some time ago, upon examining the inlet valve of an 18x24 gas engine in order to ascertain, if possible, the cause for its general bad action and persistent leaking, it was discovered that the bore of the valve-stem guide had become badly worn out of round. Since the valve guides of engines of this class as ordinarily arranged do not usually wear perceptibly, and since everything pertaining to this valve gear appeared to be arranged according to common practice and to be in proper working order, it proved somewhat of a puzzle, at first, to think of a good cause for the abnormal wear. It was promptly observed that the little roller on the end of the rocker arm, which engages with the end of the valve stem in pushing the valve open, had become stalled on its pin; but, as these rollers frequently are and ordinarily can be stalled without bad effects, there was no suspicion at first that this circumstance had any bearing on the case.

Finally, however, after closer observation, it became clear that there might be a right and a wrong way of laying out the valve-rocker motion, or, perhaps more cautiously stated, two right ways, of which one is more liable to go wrong than the other, and that that little roller might have a material influence on the wear of the valve guide. The facts of the matter are very simple and evident, but as it often is the simple and evident things that are overlooked and apt to cause trouble, it may not be waste of time to dwell upon this little kink.

Figs. 1 and 2 indicate two ways for laying out the valve-rocker motion, both of which are apparently good. Fig. 1 represents the way in which the rocker motion was arranged in the case just cited. Observe how beautifully close to the center line of the valve stem is the force acting from the roller, in all positions of the valve. In Fig. 2, however, which represents the more common way of laying out the rocker motion, the force applied on the end of the valve stem shifts between the point *E*, corresponding to the closed position of the valve, and the point *H*, corresponding to its position when fully open. To all appearances the layout in Fig. 1 would be fully as suitable as that illustrated in Fig. 2, but there is a rub due to the friction between the roller and its pivot pin; because if it does not slide at all on the end of the valve stem the roller must, with the first layout, rotate through the angle *A—O—B*.

In estimating the pressure on the roller pin we find that a 8-inch valve, having a spring tension back of it of, say, 7 pounds per square inch of the valve area, calls for a maximum force of 200 pounds to simply open the valve slowly. To overcome the inertia of the valve at full speed there will be added to this force another amounting easily to 5 pounds per square inch of the valve area, or, in total, 125 pounds. We have thus, in all, a pressure of 325 pounds on the roller pin which would not be so bad excepting for the fact that the angle through which the roller rotates is, at best, hardly great enough to allow a proper lubrication of the pin.

The effect of the friction between the roller and its pin in the arrangement of Fig. 1 will be a force *c* or *d*, acting laterally at the end of the valve stem, and, of course, the greater the distance to the valve-stem guide, the greater will be the friction between the stem and the guide caused by this force. It can, therefore, be expected that the guide will wear appreciably if it should happen that the roller got stalled on the pin. Now, in the layout in Fig. 2 it is evident that the roller does not revolve on the pin; it simply rolls on the end of the valve stem. Strictly speaking, it should revolve or slide to the extent of compensating for the versed sine of the angle *A—O—N*, probably not more than 1/64 of an inch each side of the center line of the valve stem; but as that small amount is not much more than the side motion which the freedom of the valve stem in the guide will allow to the stem, there will, practically, be no motion between the roller and its pin.

The difference in principle between the arrangements in Fig. 1 and Fig. 2 is illustrated in Figs. 1-a and 2-a. The forces acting on the valve stem when in its top position resolve themselves, in Fig. 1-a, into the central force F_1, the lateral force *C* and the turning moment T_1T_1. In Fig. 2-a there are the central force F_1 and the turning moment T_1T_1. If, in Fig. 1, it is assumed that the roller, being stalled on the pin, slides on the end of the valve stem, and that the sliding friction becomes as great as 25 per cent. of the normal pressure, with a total valve pressure of 320 pounds, the force *C* normal to the guide becomes 80 pounds and the turning moment T_1T_1 approximately 70 pound-feet. The turning moment T_1T_1 would, under all circumstances, be approximately only 3 pound-feet. Under ideal conditions as to lubrication of the valve-roller pin, the arrangement in Fig. 1 would not be much worse off than that in Fig. 2, but as practical conditions effectively exclude such ideal lubrication, the second arrangement will be by far the safer of the two.

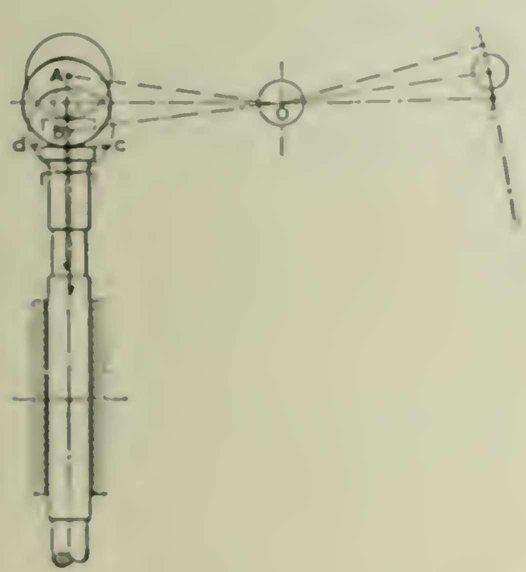


Fig. 1

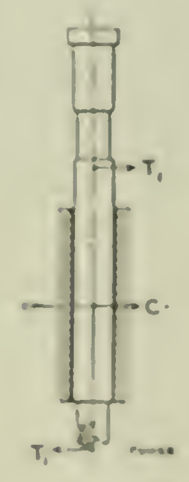


Fig. 1-a

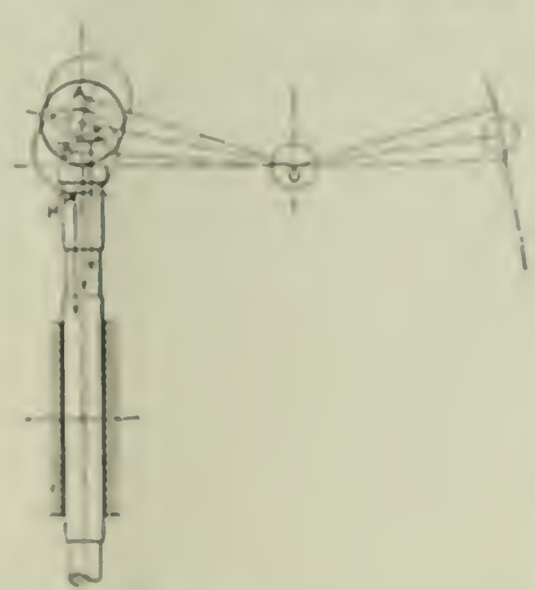


Fig. 2

Fig. 2-a

A Satisfactory Plant

By H. T. [illegible]

For the past four years I have been operating gas engines and suction and pressure producers, and my experience has been very satisfactory. The plant I am now running contains a suction producer and a two-cylinder vertical engine rated at 110 horsepower. Previous to the installation of the gas plant the works were driven by an automatic cutoff steam engine of the same rating as the gas engine.

Our load is very irregular. We have an air compressor rated at 48 horsepower working against 100 pounds pressure and it is cut off when the pressure reaches 100 pounds and cut in again at 90 pounds pressure. It goes on and off 200 to 300 times in a day. When the steam engine was driving the plant, the voltage at the switchboard would drop 12 volts every time the compressor went on. This made the lights so poor that we had to install another engine to drive the dynamo. With the gas engine, the voltage does not fall two volts when the compressor goes on, regardless of the other load.

The wrist-pin brasses in this engine have been tightened up only once in the last six months and the crank-pin brasses twice. We have a gage glass attached to the crank case, putting the level of the oil in full view of the operator all the time.

I will admit that it requires a man of more skill and ability to run a suction gas producer and engine than to run a steam plant, but a gas plant does not require as much attention while running as a steam plant. We have not had a breakdown, or even a stop to exceed 20 minutes, in the last 17 months.

The igniters are supplied with current from the dynamos at 110 volts and they run three months without changing.

My experience with the gas engine convinces me that a level head, good, clean gas and the right cylinder oil are all that is necessary to make it the cheapest and best prime mover so far devised.

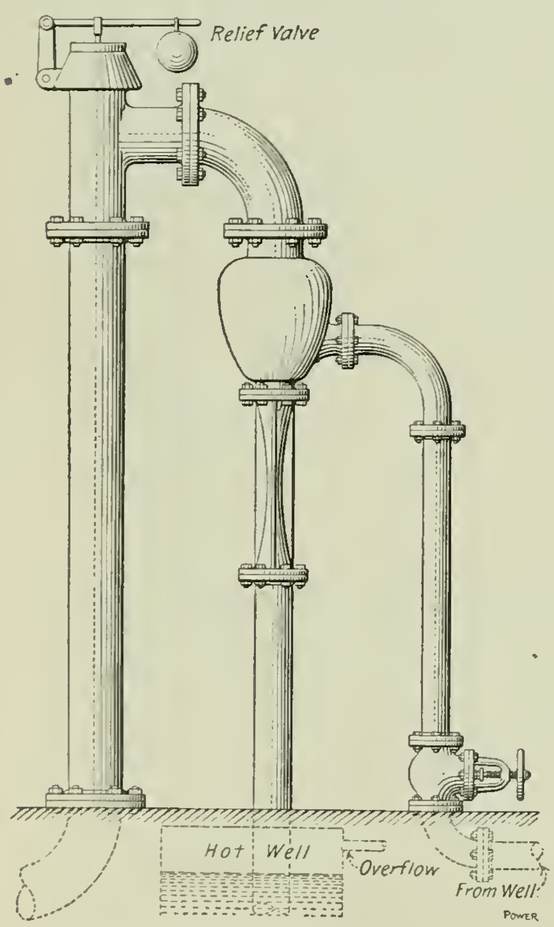
Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Pumpless Condenser Installation

In Greenwood, Miss., can be seen a condensing outfit requiring no circulating or vacuum pumps.

It is supplied with water from an artesian well which gives a pressure at the top of the ground of 30 pounds. This water is carried to the supply pipe and is controlled by a valve just above the ground. All that is necessary to start the condenser is to open the valve and start the engines. A vacuum of 23 inches is maintained without any trouble.



Piping of Condenser

I would like to know if anyone else has had any experience with this kind of a condenser arrangement.

H. T. Fryant.

Jackson, Miss.

Filing Power Articles

Various schemes for binding or filing the vast amount of data and information contained in Power have appeared in its pages, but none that I have noticed seem to fill the bill for my use. Binding the different volumes together is open to the objection that the data or information on any subject is difficult to locate. I have devised a system of filing the information contained in Power which is very satisfactory, as any particular article, or series of articles, is easily found.

Each magazine, after being read, is taken apart by removing the binding wires and all information or articles of interest are laid aside, and the remainder of the journal is thrown away. At the office outfitters' I procured an oak letter file about 14 inches square and 24 inches long, provided with drawer, folders to hold the letters and alphabetically lettered division cards, similar to an ordinary card catalog. All information or articles relating to any one subject, as, for instance, "direct currents," would be filed in a folder marked "Direct Current" and filed under "E," for electricity. Should two or more articles on different subjects appear on the same pages, the titles are written or printed on the first page and all held together by a wire fastener; then the group is filed under the subject of any of the articles.

I also keep a card catalog in which appears the complete title and author of every article on file. The different titles are separated under the several subjects as in the main file. The card catalog is necessary on account of numerous articles which do not appear in their proper folders, as explained. For example—there might be an article on fuels, another on heating and ventilating, and still another on refrigeration all on the same page, which could not be separated. These pages would all be fastened together and filed, say, under "Fuels" in "F." On the first page at the top margin would be written the title of the article on heating and ventilating and also of the one on refrigeration; then in the card catalog under "Heating and Ventilating" would appear the title of the particular article with reference to the folder on fuels, and likewise with the article on refrigeration.

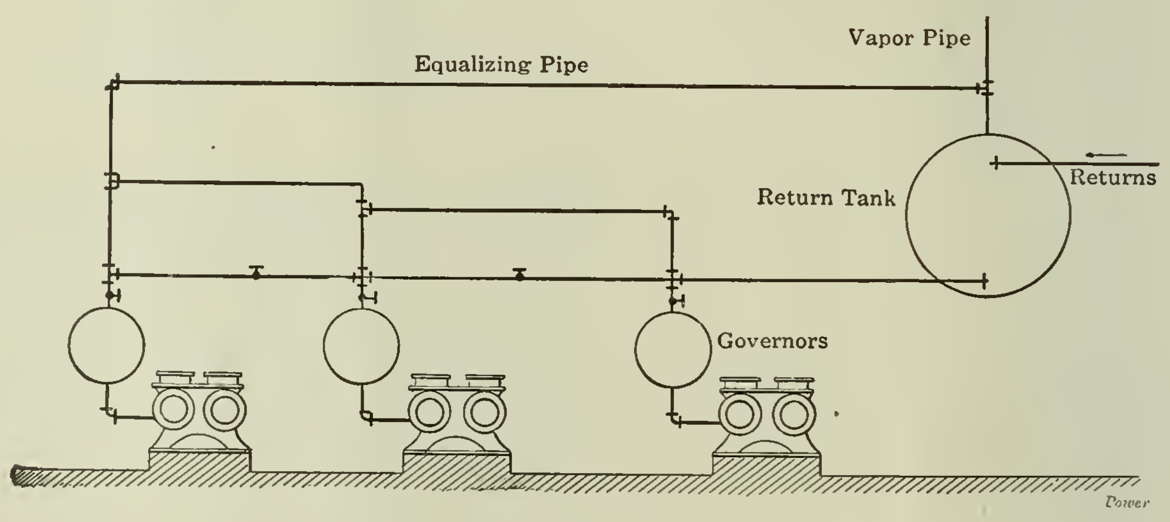
The letter file referred to may be obtained at almost any office outfitters' for from $3.50 up, depending upon the finish of the case. The folders are 9x11½ inches, necessitating trimming the pages of Power on two sides.

B. A. Parks.

Grand Rapids, Mich.

Defective Return System

I was recently called on to remedy a defect in the return system of a large heating installation, the trouble being that the condensation returned intermittently and at times filled the tank and flooded back into the heating returns. The plant is equipped with a receiving tank to which all condensation from the heating system and the various manufacturing processes is returned, and the three feed pumps force the water from the tank to the boilers.



Piping of Return System

Each pump has a receiver containing a float which controls a steam valve by which the speed of the pump is governed and as long as the condensation is returned uniformly one pump would do the work. However, at times the returns came back in large quantities and if the attendant was not near to start another pump an overflow occurred. A larger tank would have solved the difficulty, but this was out of the question for want of room, and the connection shown in the illustration was resorted to.

The valve on each pump governor was left open and those between them closed so that as long as the water returned at a normal rate only the first pump was in operation, but when it was taxed beyond its capacity the water would rise in the tank and pass over to the second pump and, if it continued to rise, would pass on to the third one, each starting automatically in its turn.

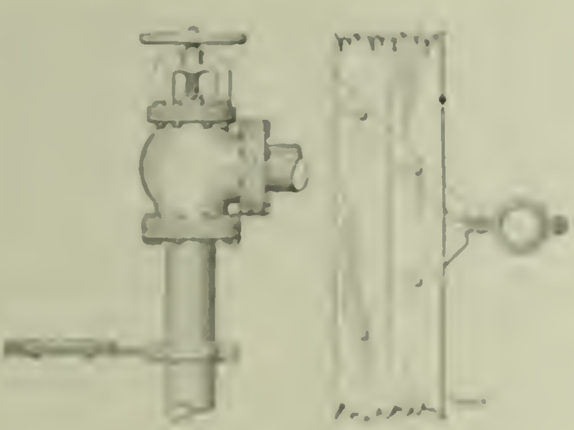
By closing the valve to the first pump governor and opening the one between the first and second governors, the last two pumps can be run in tandem, or the valves can be changed to operate any one alone. The piping, as shown, should be as large as the suction pipe out of the tank, but the "equalizer" only serves to prevent an air lock and may be very small.

LEWIS C. REYNOLDS.

Willard, N. Y.

Platform Attached to Pipe

Valves of various kinds are found rather hard to get at in steel mines when necessary.



DETAILS OF PLATFORM

The accompanying illustration shows how a platform can be attached to a pipe by means of a clamp, upon which a man can stand while at work.

E. H. MARIOLT.

Bellaire, O.

Topics for Discussion

Is water hammer due to the presence of water lying along the bottom of the lowest part of a line of piping, or is it due to a conflict between the cold air and the inrushing hot steam which causes the violent hammering?

Does air in pipes act as in the air chamber of a high-pressure pump, until equilibrium of temperature is established between it and the steam?

Is steam formed under or above the surface of the water?

How, and by what means, is a very rapid production of a large volume of steam produced after a violent and destructive boiler explosion?

JOHN W. PAYNE.

Detroit, Mich.

Piston Rings

Piston rings cut on an angle are not generally found in a new engine, but rings made at a local repair shop are

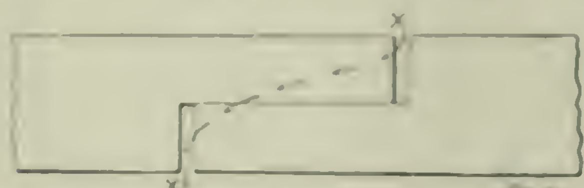


FIG. 1

usually cut in this way. Most engineers prefer the lap-cut ring.

By referring to Fig. 1 it is easy to see that after this ring wears any perceptible amount the joint is broken still more

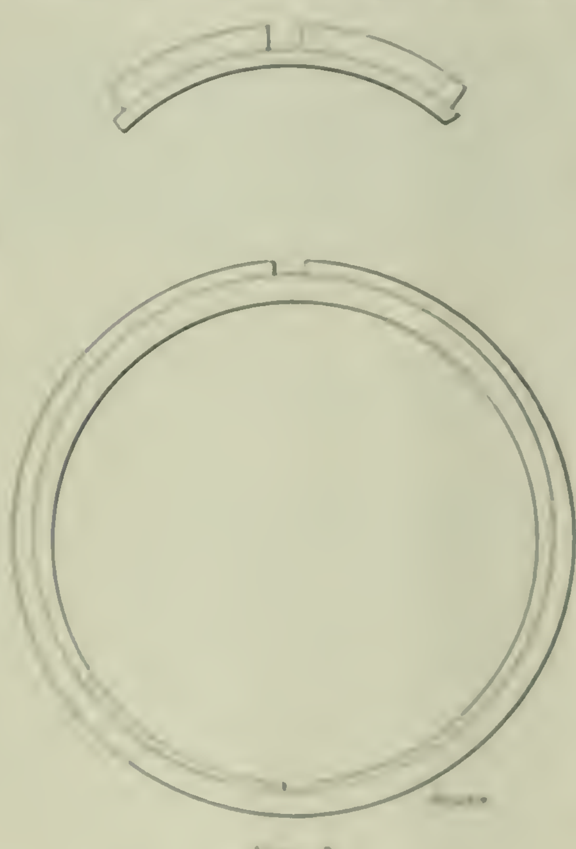


FIG. 2

at the joints X X and that steam will enter at X on one side, as indicated by arrow and, going under the lap, makes its exit at X on the opposite side. The advantage of this kind of a joint over the

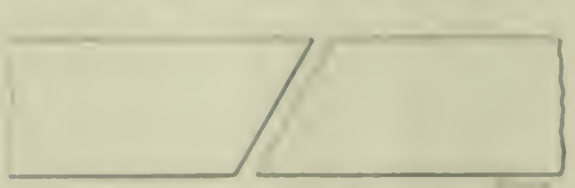


FIG. 3

diagonal joint is that the path of escaping steam is not so direct in the latter as in the former.

In order to remedy this leakage in the lap-cut ring it would be necessary to put a false ring inside with its cut at the opposite side to the cut in the outside ring or a short piece with a curved surface and tensioned, so as to bear against the underside of the joint to make it steam tight, as shown in Fig. 2. I prefer a whole inside ring as it takes care of itself better than a cover piece would.

The leakage of the angle cut cannot be remedied in any way. Fig. 3 shows the angle-cut ring joint open. Some engine builders use a single, sectional, lap cut under the covered ring, as suggested for a single cut ring.

LLOYD V. BEETS.

Nashville, Tenn.

Unexpected Happenings in the Steam Plant

One is so accustomed to having certain effects follow certain causes that, when the unexpected happens, a search for a reason or theory to explain it is begun.

In connection with a system of forced draft with which our boilers are equipped, there is a 10-foot piece of 4-inch pipe, capped on each end, the caps being tapped for ½-inch pipe connections. This pipe is fastened to the wall of the boiler room in a vertical position, and steam at boiler pressure enters at the top and is condensed for supplying pure water to operate the blower-regulating valves.

In order to do some repairs, I blew out the water and sediment from the pipe mentioned and disconnected a ½-inch union at the top, but being annoyed by hot vapor I stuck the nozzle of a hose into the hole and turned on the water, expecting it to condense the vapor inside the pipe and create a vacuum. Contrary to expectations, steam was generated in the pipe, which blew out the nozzle of the hose, and steam continued to come with much force and noise for about ten seconds.

All of our furnace-blower pipes take steam from the dome and come down at the front of the boilers, passing through the brick setting of the firebox to the blower jets at the back of the boilers, thence to the ashpit, thus superheating the steam which supplies the forced draft. That portion of extra-heavy iron pipe immediately over the fire was probably heated nearly red hot during the noon hour, and when the valve, which was a new one, was opened at 1 o'clock, the water of condensation which had accumulated above the valve was suddenly let into this hot pipe, and, flashing into steam, broke an elbow, notwithstanding that the jets were open.

Many years ago I ran an engine and boiler in a planing mill, firing with shavings, and sawing logs with full saws and heavy planing sometimes made me work in trying to keep up the steam pressure. At that time I recommended a surface blowoff pipe, but the manager thought that his homemade boiler compound was just the thing. It was formed in the boiler room and contained soda ash, glucose and extract of logwood. These were all boiled in a barrel of water and when the density got beyond a certain point, the concoction would not stop boiling even with the steam shut off, but would go all over the floor.

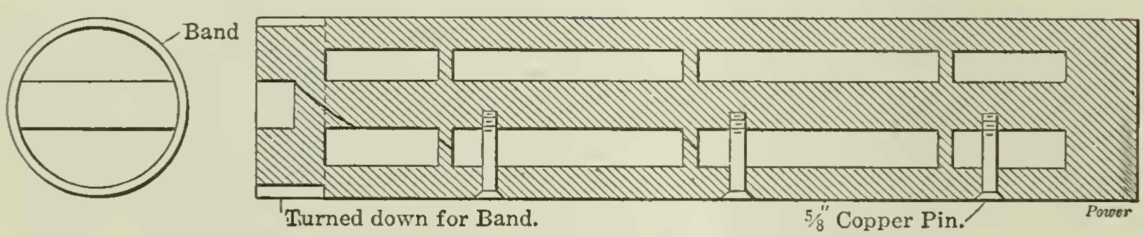
One day, when firing hard, the compound and mud suddenly got busy inside the boiler, and water and mud choking the engine caused the whole shop to tremble. Then the safety-valve lever flew up, and the valve did not stop blowing until half the contents of the boiler were on the roof, the sight of which convinced everybody that a surface blowoff was needed.

CHARLES HAEUSSER.

Albany, N. Y.

Repaired Corliss Exhaust Valve

The accompanying sketch shows a sectional view of a double-ported exhaust



SECTIONAL VIEW OF VALVE

valve of a 26x48-inch Corliss engine and how it was repaired. The valve cracked all the way through and nearly across, as shown. This was due to either an excessive flooding of water or the valve being allowed to run with an insufficient amount of oil.

The valve was quickly repaired in the following manner: The exhaust-valve bracket was taken down and the steam head measured, leaving enough play on either side of the valve to allow it to be turned down for a 3/8x3-inch band, which was shrunk on. The valve was bored, countersunk and tapped for copper pins, and turned off to conform with the curvature of the valve.

J. W. DICKSON.

Memphis, Tenn.

Piston Ring Gave Trouble

Some time ago a 26½ and 50 by 33 vertical cross-compound engine was installed and considerable annoyance was experienced, due to the low-pressure piston ring clicking.

The ring originally sent with the engine was made up of six sections and reinforced or held into position by twelve spiral springs, equally spaced.

After many close examinations a new solid ring was sent for, which proved a success.

The sectional ring had ¼-inch clearance between each section, and steam getting into the clearance next to the ports caused a shifting of these sections, which produced a sharp clicking noise, just as the crank passed over the centers, or at the point of steam admission.

FRANK W. BELLINGER.

St. Paul, Minn.

Burning Lignite

I have two horizontal return-tubular boilers set in common brick setting. The boilers are hand fired and the coal used is North Dakota lignite which contains: ashes, 2.47 per cent.; clinkers, 4.23 per cent.; moisture, 39.76 per cent., and 6029 B.t.u. per pound. The factor of evaporation is 1.06, and upon running an evaporation test I found the evaporation to be four pounds of water to one pound of coal and the efficiency 68 per cent.

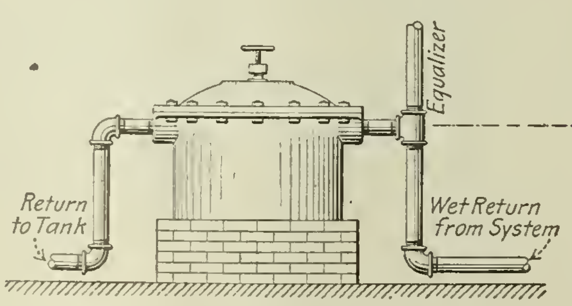
I would like to hear from POWER readers as to what they think of the economy of this boiler plant and if it could be improved in any way.

O. N. BERGMAN.

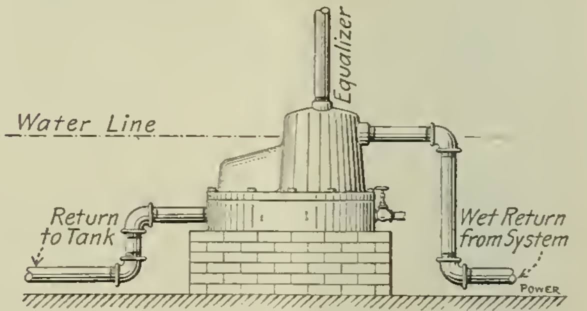
Dickinson, N. D.

Preventing Water Hammer at Trap Discharge

Recently a heating system was remodeled and the traps raised about 3 feet from the floor, and an equalizer pipe was connected from the joint where the return pipe entered the trap up to the steam main and the discharge changed from the sewer to the return line run-



OLD ARRANGEMENT



NEW ARRANGEMENT

ning to the power house, thus saving the water.

As soon as the new layout was put in operation, however, there was a complaint about the rattle made by the water every time the trap discharged, due to the cool water from the wet return meeting and condensing the steam in the equalizer pipe.

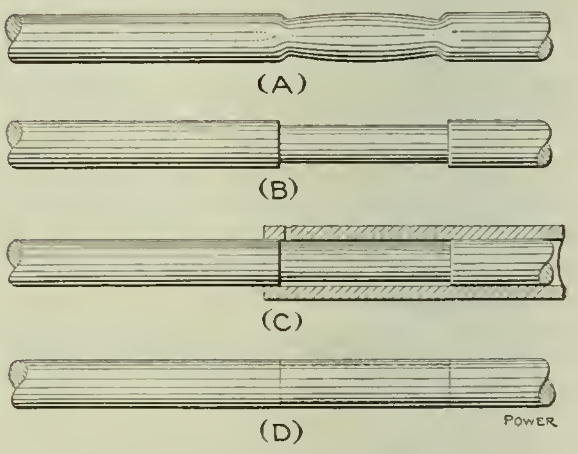
After trying several schemes, the trouble was solved in the manner shown in the accompanying illustration. The system is now operating noiselessly, as the steam comes only in contact with the surface of the water, heating it but slightly, and the discharge is constant.

W. T. MEINZER.

Brooklyn, N. Y.

Repaired Centrifugal Pump Shaft

A great deal of trouble is experienced with worn and grooved shafts which run in packing boxes, as in rotary, centrifugal pumps, etc., and this is especially true of shafts running at high speed, or when running under such high pressure that the packing has to be kept very tight.



SHOWING STAGES OF PUMP-SHAFT REPAIR

After a shaft has run for some time in a tight stuffing box in which hard packing is used, the shaft generally becomes badly worn and the expense of taking it out and replacing with a new one may be saved.

In one instance the shaft became badly worn, as shown at *A* in the accompanying illustration. It was taken out and filed down, as shown at *B*. A tube was then procured of the right size to be slipped over the shaft, as shown at *C*. A hole was bored in the tube, and babbitt poured in, thus filling the recess in the shaft, as shown at *D*.

The tube casing was then removed, and the babbitt finished smooth with emery cloth; the shaft was then ready for use.

If the shaft to be repaired operates under a very high pressure, it is well to sweat it with solder before pouring the babbitt, so that there will be no possibility of a leak starting between the shaft and the babbitt.

R. L. RAYBURN.

Kansas City, Mo.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

License Laws

The mere passing of a license law will accomplish nothing for, as has been shown by F. E. Albrecht, in the December 6 issue, the value of such a law may be entirely destroyed and, in fact, a state of danger may be created by its improper administration. Evidently, before the existence of the license law in the locality discussed by Mr. Albrecht, the plant owners were previously inclined to exercise some care in their choice of the men they placed in charge of their power plants; but since then these owners have naturally taken the path of least resistance and have accepted without further question the licenses issued by the examiners. Thus, the responsibility has been shifted to the examiners. If they meet it fairly then the results will be good; but if the examinations are farcial, the conditions resulting will be worse than those which existed without a license law.

On account of the good results that have been obtained within the jurisdiction of the Federal inspectors, A. A. Blanchard in the January 10 issue suggests that a Federal law bringing all engineers under its jurisdiction would be the best solution of the problem. It is possible that if a Federal license law for all engineers were placed in operation the results might be all that he desires. Certain it is that such a law cannot be constitutional.

It must be remembered that the United States is a combination of States, once independent, who by adopting the Constitution have delegated to a central authority only those powers in which their interests were identical, retaining all others to themselves. The powers thus delegated to the Federal Government are limited and even though the Supreme Court has generally been very liberal in interpreting the Constitution as applying to laws passed by Congress, there does not seem to be any method of securing a Federal law applicable to all engineers.

Federal jurisdiction over steamboat engineers and that proposed for locomotive engineers is secured through the article in the Constitution which delegates to Congress the power "To regulate commerce with foreign nations, and among the several States, and with the Indian tribes."

License laws, whether Federal, State or municipal, will not in themselves cure the evils from which the engineer is suffering, but they may be the source of some trouble and vexation to him.

The ultimate interests of the engineer can probably best be served by following the path that POWER has been advocating for years, that of the education of the engineer in the safe and economical production and distribution of power, and the education of the plant manager in the knowledge that an efficient engineer in the power house is a safe investment and a large dividend payer.

GUY WEST.

Philadelphia, Penn.

CO_2 Recorder and the Operating Engineer

Of all the interesting and instructive articles that have appeared in POWER recently regarding CO_2 recorders, there is probably as much value to the operating engineer of small plants in the nontechnical article recently contributed by our old-time friend, O. C. Winslow, and published in the issue of January 24, as in any of the very technical articles contributed by our "high-brow" brethren who tell us how much they know rather than tell us how to get results.

While I concede the value of the CO_2 recorder in the hands of a man who can apply the information which it enables him to get, such men are rarely found in the engine rooms of moderate-sized power plants and as it is quite probable that a large percentage of the readers of POWER and kindred publications are of this class, articles of the nature of Mr. Winslow's which they can digest and assimilate are of more value to them than the more technical articles.

I am led to express myself in this way by an occurrence of this morning. An apparent stranger stopped me and expressed his appreciation of an article that recently appeared in POWER on smoke prevention, yet he asked me the meaning of the term CO_2 which was used therein. I learned that this man was "firing" at the factory where the first test of the smoke preventer mentioned in the article was made some thirty years ago. Later on he secured an engineer's license and he has operated moderate-sized plants for the past twenty years or more.

This man is middle aged, perfectly satisfied with his present position and condition, has saved some money and owns his own home. He is sober, steady and reliable, just big enough for the job and the job is just big enough for him. There seems to be no incentive for him to climb. He is interested in reading of the experiences of other engineers of his class and I believe that there are thousands like him. I hope occasionally to contribute leaves from his own experience of over forty years in the belief that they will be interesting and beneficial to the men of this class. I believe that many a fact told in the form which Mr. Winslow used will stick, whereas if told in technical language they would make no impression.

But to return to the question of CO_2 recorders, I am quite sure that Mr. Winslow is in no way opposed to them. I take it that he looks upon them in the same way that I do upon the steam-engine indicator, a very valuable instrument for a special purpose in the hands of the true expert but a snare and a delusion in the hands of the novice.

I suggest that some simple and convenient method of weighing the coal and measuring the water be used. Then, with the quantities of coal and water to check against the output of the factory or mill each week or month, the value of any change made in the engineer's department can be estimated in a more practical manner than by means of any tests of a few hours' duration that could be made by any of our so called experts, unless such tests are made for a special purpose.

If the man in the engine room has the ordinary good sense and a sufficient experience to keep the boiler settings in a good state of repair, the steam-generating surfaces clean from both scale and soot, the fires neither too thick nor too thin, and to see that both pumps and valves are tight without undue friction, and the valves properly set and that all of what might be waste heat is utilized for some useful purpose, he need have no fear of what CO_2 recorders and steam-engine indicators may show, if he uses his ability.

W. H. [illegible]

[illegible], N. Y.

Flywheel Explosions

I have just read the editorial in the January 31 number under the above caption. With reference to the matter of flywheel inspection, I want to say that while an engineer and a piece of waste properly applied to the flywheel of an engine may not be an ideal combination, so far as apparently dignifying the engineer's position is concerned, it is otherwise an excellent one. I have contracts that do not mention work, only supervision, but I very often go over the flywheels and with a piece of waste in my hand make a close inspection of them. In this way faults may be discovered that would not be in any other way. There are too many men engaged in engineering work who are afraid of losing their "dignity" for the good of the profession, or humanity. I do not mean by this that the number is relatively great, but that even a very few are just so many too much.

There is nothing so assuring as to know that you have seen with your own eyes that everything is all right. If you depend upon others there are a good many ways in which you may be ill at ease. The other man may be deficient in knowledge, he might have been careless or negligent and, after all, you feel that you do not really know. If you look after such things yourself, you can feel that you do know, and that affords more satisfaction than the maintenance of any imaginary dignity.

Referring to governor troubles and inspection, I think the editorial "hit the spot" exactly. I recently went into a plant where an ammonia compressor was driven by a Corliss engine. This engine raced badly, and had been behaving erratically for a year or more. Within that year there had been a change of engineers. I started the engine and, true to its reputation, it started off like an impatient race horse. Had I opened the throttle wide, I do not know what would have happened. Although I opened the valve very slowly, the governor got hold of the engine even more slowly. I was suspicious at once from the sluggishness of the governor's action that the trouble lay there, and having had experiences of the same kind before, I went to the governor gag, or dashpot, and found it full of a mixture having a consistency between that of heavy cylinder oil and "taffy." With the bypass wide open it was almost impossible to move the plunger in the pot or cylinder. The only thing to do was to remove the heavy fluid from the dashpot and fill it with a light engine oil. After doing this the action was still too slow, and a part of the engine oil was removed and replaced with kerosene. After this, one could hardly cause racing had he wished so to do, the governor controlled the engine so well.

There can be no question as to the value of many automatic devices, but I can never get rid of the belief that a man with a watchful pair of eyes and an active mind behind them is one of the best safety devices ever invented.

The tendency of some men to overlook small things that give trouble, while looking for something great, deep and mysterious, is hard to understand. There are engineers who can talk engineering Latin and Greek so fluently as to make one feel real small, and yet when you get a chance to pry into their work, you often find such conditions as I have described. On the other hand, you will find some engineers who have so little to say that you are led to wonder how they happened to escape the "cows" so long, and yet when you get an opportunity to go over their work you find ample evidence that they have been more busy with their brains and hands than with their tongues.

WILLIAM WESTERFIELD.

Concordia, Kan.

The Engineer's Wage Problem

I was glad to see that Mr. Morton got his raise in pay (see the issue of January 17). If he had not, I would have half suspected that he was not worth what he was getting to begin with.

Seriously, too many of us compare ourselves with the wrong man. Values are all comparative. Mr. Morton's predecessor was evidently worth a number of dollars a day less than nothing. If he had been worth what he was getting, Mr. Morton would not have been able to get the job. Having gotten the job, it was up to him to give his employer his money's worth of service. To have saved $2 a day would not have entitled him to anything but discharge.

The engine and boiler were adequate in size—Mr. Morton admits it. His employer evidently knew it and would have fired one engineer as quick as another until he found a man who could produce results. If he could have found a man who was able and willing to get results and who was willing to work for 25 cents per day less than Mr. Morton, he would have been glad to do so. Evidently, this particular employer had his mind made up to save about $11 per day by paying $1.75 for the service. If Mr. Morton had saved $15 a day, very likely his employer would have thought twice before he gave him a raise as small as 25 cents.

Here we come to another question. How much did Mr. Morton ask for? Eleven chances out of ten he did not go to the boss and lay out the proposition on paper and prove to him how much he deserved. Probably, it took him a week to screw up his courage to ask if he could have more money. The boss saw that he was afraid to call his soul his own and raised him a "quarter" because it salved his conscience and did not cost much.

It must be conceded that an operating engineer drawing less than $3 a day and with no money in the bank is in little better than a state of slavery, particularly if he has a family dependent upon him. Statistics show that in New England the average family is only two weeks from starvation. A man who asks for more pay cannot usually prove that there is no one more competent who will take the place for the same money. The employer is apt to assume that there is such a man available at least until the present incumbent packs up his kit to go. By that time, if both sides are bluffing, they both are so mad that they have no further use for each other.

They both suffer. The engineer, by loafing until he hits another job at a few cents a day less than he was receiving before and a promise of a raise of 10 cents a day if he saves $10. The employer, by losing $100 a day from his product at a loss to himself of the profit on that amount. The difference is that the employer is usually better able to stand the loss than the worker. Consequently, he has the upper hand.

I wonder if it has ever occurred to other readers that this country's prosperity is absolutely at the mercy of wage earners.

There is, somewhere, about $36 in actual money in circulation for every man, woman and child in the land. Assuming that one person in ten is a wage earner, which is on the safe side, this would be $360 for each wage earner, or approximately 30 weeks' wages for each one. If every wage earner should suddenly decide not to spend any money for 30 weeks and to put it all in the old teapot or hoard it away anywhere, immediately a money stringency would begin and in less than two months these wage earners would have the whole country at their mercy. Of course, the fact that the average family is only two weeks ahead of the game precludes the possibility of this thing being done. Also, men who are in any way thrifty do not hoard away money. They deposit it in banks and the banks put it in circulation again.

The moral of all this is that a bank account large enough to live on for two or three months is worth all the sacrifice it costs. It is all very well to own a house, but it has the drawback of not being edible. The "long green" can be relied on for sustenance at any time or place short of a desert island. The man with a very modest bale of it in cold storage can go to the boss and treat him like an equal when he says, "I am earning more money than I am getting. You cannot get a man to fill my place that will really fill it as I do. I have not bothered to look up another job, because I know you cannot afford to lose me."

That puts the thing on a business basis where it is up to the boss to show cause why the aforesaid service that has been rendered is not worth the money demanded.

After all, why should not the man with something to sell put a price on it? A few years ago the purchase of a pair of boots was a matter of artistic haggling or bargaining. Today, we fight shy of a shoe store where the prices are not marked in plain figures. I am inclined to believe the working people are practically being sold at auction all the time and only for the lack of a supply of money to carry them over a few days of idleness. If a shoe dealer has to raise money he does not sell his shoes at auction, except as a last resort. In the first place, he does not buy shoes up to his last dollar. He saves a little money to do business with. If that is exhausted he borrows, but he does not cut the price of the shoes to raise money. You may think he does by reading his advertisements, but you can safely bet that he marked them up the day before.

Now, a wage earner ought to take example from this. Having set his price he ought to stick to it. In fact, he has no right to come to me and ask me $2.50 a day and then go over to Jones across the street and go to work for $2.25, because Jones scares him into it. He ought to treat us all alike.

E. F. HENRY.

Worcester, Mass.

Handling Men

The discussion in several of the late copies of POWER relative to the chief engineer having "pets" about the plant has been read with interest by the writer. During my experience I have failed to find a chief who was not accused of having pets, especially if he has a number of men under him.

The crew of men never existed that did not have some members who were more ambitious and studious than others. These men the average chief will aid in any way he can; consequently they become more friendly and intimately acquainted. Other members of the same crew do not take as much interest or perhaps think they are too well posted to consult with the chief. Eventually they will become "sore-heads" and think the chief is showing partiality.

Regarding the equal division of work among the men, I think that nine times out of ten the so called pet is willing to do more than his share. The writer does not uphold any tale bearing; on the contrary, it is better to dispense with the services of such men.

EARL E. WEBSTER.

Phœnix, Ariz.

Baseball Problem

Some things are just as clear as mud and that is the condition in which the baseball problem (December 20 and 27 issues), conceived by Prof. A. S. Reeves and elucidated into a state of opaqueness by Uncle Pegleg, now exists.

The high jinks which Professor Reeves, D. E. (Doctor of Entropy) can cause a simple—save the mark—molecule to perform when touched up by a little heat would scatter the brains of a Socrates. He has now invented a "manless something" to hold the stop watch on the earth as it goes round. What next?

But let's to the game and the problem. From the technical terms he uses it is evident that Professor Reeves is trying to qualify as a baseball expert. Uncle Pegleg who—to tell the truth and shame the devil—has more sense than legs, can hardly be expected to play ball, so we will make him umpire.

The pitcher takes his stand on the equator with the ball in his hand and faces east. Earth, pitcher, ball and everything else are going 300 feet each one-fifth second, but no energy is going into the ball. The pitcher now goes down in his "jeans" or his anatomy or some other place of concealment about his person and digs up 18 foot-pounds of energy. In one-fifth of a second, just as he whizzes by the manless something, he delivers the 18 foot-pounds to the ball. Behold! The ball now has 918 foot-pounds of energy more than it had before. Where did the 900 foot-pounds come from? They tell us that it is due to the earth having gone 300 feet in that one-fifth of a second. Well, has not the earth been going 300 feet each one-fifth second ever since we have been talking? It never succeeded in getting 1 foot-pound into that ball before—much less 900. The bug under the chip, and the nigger in the wood pile are not anything to this.

The pitcher picks up another ball and faces the west. Everything going 300 feet each one-fifth second same as before. No energy going into or out of the ball. Down into the "jeans" again and 18 foot-pounds more of energy fished up. Round comes the manless something. Into the ball in one-fifth second goes the 18 foot-pounds. Speed of the ball now, 1440 feet per second. If the curious figure this out, they will find that the ball has lost 882 foot-pounds of energy.

Perhaps these scientific figurers will tell us that *this* was because the earth went 300 feet in *that* one-fifth second. Gain or loss, it is all the same to them. Same old explanation. If the earth was to stop moving it is hard to tell what these figurers would do.

Hold 'em off, Uncle Pegleg!

J. C. MORRIS.

New Orleans, La.

A Mechanical Engineer's Experience with the Cornell System

Natural laws, theory and engineering rules practically proved, demonstrated and accepted by the engineering world have been set aside and declared all wrong and worthless by a modern prodigy from the staid city of Philadelphia, who has convinced some erstwhile conservative business men and mechanics that he has invented and perfected an apparatus which when applied to a boiler at $10 per horsepower will save from 42 to 60 per cent. of the coal used.

Why it will not save 60 per cent. all of the time has not been explained.

Results of tests made by a convert to this wonderful system show a commercial evaporation per pound of combustible on March 10, 1909, of 11.27 pounds and on March 11, 1909, of 11.28 pounds before fitting the boiler with the system.

The same boiler equipped with the *system* produced on March 23, 1909, an evaporation of 15.03 pounds; on March 25, 1909, 16.60 pounds; on March 26, 1909, 18.01 pounds, and on February 10, 1910, 16.14 pounds, a variation of 20 per cent. in the efficiency of the system and a saving of from 42 to 60 per cent. over the original equipment.

A test which I made on the same boiler equipped with the same *system*, fired by the same fireman, on April 28, 1909, showed a commercial evaporation of 10.80 pounds per pound of combustible.

The inventor kindly informed me that the reason for my failure to obtain a higher evaporation was that I followed the rules recommended by the American Society of Mechanical Engineers, which is not the correct way to test boilers and that anyone who could not obtain the same results with his system as his convert had, was not a capable testing engineer.

He also informed me that computations which I made, showing the impossibility of creating heat available for commercial use, by decomposing steam and burning the resulting gases as he claims to do with his system, were not correct, but as he could not point out wherein they were wrong, he would have his consulting engineer analyze the figures and advise me regarding same.

He has had my figures several months now, but I have never had the advice promised.

A partial analysis of the results of one test published for advertising purposes presents claims as follows:

Test of March 26, 1909, using fuel having an actual heat value as determined by chemical analysis, of 14,803 B.t.u. per pound.

B.t.u. necessary to evaporate 18.01 pounds water	17,[illegible]
B.t.u. necessary for loss due to radiation, [illegible]	[illegible]
B.t.u. total necessary to obtain [illegible] claimed	[illegible]
B.t.u. [illegible]	[illegible]

From the foregoing it will be seen that to obtain the results claimed it would be necessary to create heat from steam, available for the evaporation of water, to an amount equal to 56 per cent. of the total amount of the heat contained in the coal used.

George P. Gilmore.

Fall River, Mass.

Automatic Nonreturn Valves

The remarks by E. H. Lane in the January 24 issue regarding nonreturn valves are worthy of note for at least two very good reasons.

In the first place, equipment of this kind in the boiler room makes for the greater safety of the employees; and, secondly, it often obviates the necessity of shutting down the whole boiler plant should one or more tubes blow out in a boiler. The instances which he cites are not the only ones in which valves of this kind have amply justified their installation, for I have heard of a number of others and know personally of one case where a tube was blown out and the nonreturn valve operated instantly, thus cutting out that particular boiler.

A nonreturn valve operates, however, only when there is a break or sudden drop in pressure on only one side of it. While it is perhaps more common to have a tube blown out than to have a break in the header or on the other side of the valve, such things have been known to occur. In a case of this kind a simple nonreturn valve would, of course, be useless.

I recommend, therefore, that a step further be taken in the adoption of a triple-duty valve. With a valve of this kind it would make no difference on which side a break occurred as it would close immediately and thereby cut out the boiler. The reader is, no doubt, familiar with this type of valve; it will operate no matter on which side the break and consequent pressure drop occur, and, in addition, it can be closed by means of a handwheel and stem just like an ordinary stop valve. That is why it is called a triple-duty valve.

In addition to such a valve, it is a good plan to have an ordinary stop valve—perhaps preferably a gate valve—located between the former and the header with a drip cock in the pipe between the two valves so that anyone going into the boiler will be absolutely safe from scalding, due to a leaky valve.

This would be appreciated very much by the boiler inspector. The drip cock, of course, is only intended to prevent any building up of steam pressure between the two valves, should the stop valve leak.

In conclusion, I wish to say that I am heartily in accord with Mr. Lane in wishing to see such installations made compulsory, for the safety of the workmen should be of paramount importance in every boiler plant.

Everard Brown.

Pittsburg, Penn.

Boiler Inspection Laws

The Pittsfield explosion awoke some to the realization that the lap-seam danger is not the only one that confronts us here in Massachusetts. On the other hand, there were those who were not in the least surprised. They may not have been "telling you so"; but they have been expecting it. And, if a few more explosions should happen tomorrow, it would not cause them much wonder. Massachusetts has been getting too smugly complacent. Because it has the best laws of any State in the country, its people have been strutting around with pride, when they should have been treading with circumspection. We have been looking at the disasters abroad and have overlooked the dangers at home. Because we have the best laws is no reason why they cannot be improved; and laws are not sufficient—there must be rigid enforcement. There are too many dangers that yet threaten.

"Agricultural" boilers are outside the law, though one finds no reason for this exemption. An old lap-joint boiler condemned for factory work, may be sold to a florist and set up in a greenhouse within ten feet of a busy highway, and any pressure to suit the ignoramus of a greenhouse man may be put upon it. A road-roller boiler must be inspected and must be under the care of a licensed engineer; but a threshing-machine boiler need have neither. Bring the farmer into line. He needs safety as much as the shop worker.

Not long ago I entered the engine room of a factory and about the first thing that I noticed was that the engine was slowing down. The speed came down almost to a stop, then speeded up again. Upon investigation I learned that the governor was out of commission and that the engine was running with the throttle "set" for the ordinary load. It would have cost possibly $5 to repair the governor and the increased production of the machinery would shortly have paid the bill; but the boss would not see it. The owner holds a license to "cover" the plant and hires a fireman to do the work. One does not enjoy picturing what might happen to that flywheel if several big machines should let go at once when the fireman happened to be out. The treatment that the boiler gets may be imagined from the fact that one day when the waterwheel gave trouble they got up steam from cold water in 45 minutes.

Another "engineer" in another town boasted to the writer of having done the trick in 35 minutes.

In another case, a power plant had been shut down during the winter and was about to be started again. A slow fire was put under the boilers, but as no pressure showed on the gages it was in due time increased and later urged to a good, hot fire. Then, suddenly, the safety valves opened. The gage pointers were still anchored. The engineer claimed that an enemy of his had loosened the gage hands and put them back of the pin. Perhaps that was so, but no real engineer will ever be caught in that way. What if this "enemy" had also seen fit to screw down on the safety valves?

In another plant the engineer frequently leaves his boiler and engine running and goes uptown on a shopping trip or over home for a lunch. I was once requested by my employer to go on an errand to a neighboring factory. This would have left the engine and boiler without an attendant. At another time a request came down to "help clean up the cellar." Of course, I did not do either, but the incidents are cited to show how ignorant some factory owners are of the engineer's duties. There are many engineers who are doing such things nearly every day. Happily, the inspection department is waking up to this danger and is taking steps to abate it. Let us hope they keep at it. The employers need enlightenment and the engineers need starch.

In another case a crack was found in a cast-iron flange of a 12-inch steam header. The chief engineer proposed to cover the thing up again and let it go. He had an assistant, however, who would not stand for such tactics, and the flange had to be replaced. When men will take such chances to save a few cents and make a record, why wonder that accidents happen?

A few days ago in a plant not far from Boston, the safety valve stuck and the pressure ran up far beyond the blowing point. The engineer was in a distant part of the factory. The fireman ran. The superintendent, one of the know-it-all-butt-in type, mounted the boiler and lifted the valve. Luck was on his side; there was no explosion. It was just one more of those many narrow escapes that we all know about. It might be urged that those engineers who know of these things should report them to the State inspectors, and it may be said that they sometimes do. But, too often there are leaks in the office. The "strictly confidential" report is so treated that the guilty party learns the name of the person who made it. Corporations can cause a man considerable inconvenience and expense if they wish, and a man often hesitates to report things against them for fear his name will be turned over to them. This is not right. A man should be able to report dangers without running personal risk.

Here are a few hints of lines along

which progress is possible. Let us quit boasting and do something to boast about. Let us "look forward, not back."

WILLIAM E. DIXON.

Malden, Mass.

Setting Us Straight

C. H. Parson, in the issue of February 7, says that the use of a steam jet under the grates prevents clinker, but says also that his experiments, "absolutely disprove the statement * * * that the temperature of the fire must be reduced in order to prevent the formation of clinker." He gives no reason, however, why the steam prevents clinker, or in what other way it can act, if it does not reduce the temperature. If steam does prevent clinker, there must be a reason.

As a matter of fact, steam does reduce the temperature of the fire to some extent, even if the steam is not decomposed. A formula for the theoretical temperature of the fire is given on page 786 of the eighth edition of my Mechanical Engineers' Pocketbook, as follows:

$$T = \frac{146C + 2200H - 1170\,O - 33W}{f + 0.02W + 0.18H}$$

where, T equals temperature of fire above temperature of the atmosphere and C, H, O and W, respectively, the percentages of carbon, hydrogen, oxygen and moisture in the fuel; f equals pounds of dry gases of combustion per pound of fuel. When steam is delivered with the air under the grate bars, it is practically equivalent to moisture in the coal as far as its effect on the temperature of the fire is concerned. Assuming a dry fuel containing in the combustible portion 0.90 C, 0.05 H and 0.05 O, the formula gives an elevation of temperature of 3107 degrees Fahrenheit, but if 10 per cent. of water is added, making the analysis 0.81 C, 0.045 O and 0.10 water, the temperature elevation is only 2710 degrees, or about 13 per cent. less. Even if allowance is made for the heat carried in by the steam, about 100 B.t.u. for 0.1 pound of steam, the temperature would not be raised 100 degrees.

A greater cooling takes place, however, at the bottom of the fire, close to the grate bars, if any of the steam is decomposed into oxygen and hydrogen. The dry coal used in the illustration has a heat value of 15,800 B.t.u. per pound of combustible. The hydrogen in 0.1 pound of steam is 0.0111 pound; the unburning of which absorbs

$$0.0111 \times 62{,}000 = 690\ B.t.u.,$$

or over 4 per cent. of the heat value of the fuel.

That it is possible to decompose steam when it is mixed with, say, 20 times its weight of air, by blowing the mixture into white-hot carbon, I do not think has been satisfactorily shown by experiment. If carbon at a very high temperature has a greater affinity for hydrogen than it has for the oxygen in the air, it may decompose the steam and form water gas,

$$CO + H_2$$

which will burn to $CO_2 + H_2O$, reforming the same amount of steam just as quickly as the gases CO and H become mixed with enough oxygen from the air, and generating again the heat that was absorbed in the decomposition. If it takes some appreciable time for the sequence of reaction to take place, then there may be a cooling of the fire by the decomposition of the steam immediately above the grate bars, and a recomposition higher up in the fuel bed or above it. This possible action was pointed out many years ago by Dr. R. W. Raymond, in the *Transactions* of the American Institute of Mining Engineers.

WILLIAM KENT.

Montclair, N. J.

Somewhere, someone has written something about consistency being a jewel.

In the February 7 issue, under the above heading, Mr. Parson makes a number of the most inconsistent statements that could well be imagined.

He first objects to a suggestion that the flue doors be opened to check the draft through a horizontal return-tubular boiler when it is banked, on the score that doing this would cause cold air to be drawn through the tubes. Anyone who knows the difference between a horizontal return-tubular boiler and a cross-compound steam engine, must know that there is no more certain way of preventing cold air being drawn through the tubes when banking the fire than by closing off everything else and opening the flue doors.

Mr. Parson suggests that the flue doors be left closed and a part of the grate bars; this would certainly be about the best way to pull cold air through the tubes, and could only be exceeded in this respect by opening the fire doors. He also objects to opening the flue doors at night because this will cause them to leak during the day; he certainly must have gained his experience with flue doors constructed along very peculiar lines.

His principal objection to the leaky flue door is that it is a great detriment to the economical production of steam where natural draft is used. The only result that can be produced by a leaky flue door is an impairment of the draft and if there were sufficient draft, notwithstanding such leaks, there could be no practical effect on the efficiency.

The second grievance of Mr. Parson is in regard to the use of steam under the grates. In the third column of his article he shows his inability to render consistent his objecting strenuously to the editor's statement that steam admitted below the grates reduces the temperature of the fire and then immediately admitting that he tested with a pyrometer and found that steam does reduce the temperature. A little further on he states that the steam does not materially reduce the temperature of the fire but in many cases improves it. It is difficult to tell what Mr. Parson really believes about this matter, but it appears that what he wants is to make himself and others believe something which experience indicates is not correct. Steam admitted under the grate is one of the most effective and most used methods of preventing clinkers.

It would seem that Mr. Parson should at least have struck it right in one out of his three criticisms, but the third one is apparently as far off as the first two. To show just what was stated, the question and answer will be repeated.

"What is the correct number of square feet of heating surface to be reckoned for a horsepower in different types of boilers?"

Answer. "Ten square feet of heating surface per horsepower has always been the standard used by the makers of water-tube boilers, and from 12 to 15 the standard of the makers of other types. But recently the opinion has prevailed that the heating surface in other types is as efficient as that in the water-tube, and 10 square feet of heating surface per horsepower is now the rating for all types of boilers."

Mr. Parson objects to the rating given for a horizontal return-tubular boiler on a basis of 10 square feet of heating surface per horsepower because the inquirer was talking about a boiler which was already built and states that it should not be rated like one that was being made at the present time.

If there is any valid reason why horizontal return-tubular boilers of the same size and number of tubes built during the spring of 1905 and the fall of 1910 should be rated on different bases, the engineering fraternity would doubtless be under lasting obligations to Mr. Parson for an explanation of the reasons. The New England boiler manufacturers adopted a basis of 10 square feet of heating surface per horsepower for rating horizontal return-tubular boilers about 1907 and there is no reason why it is not perfectly proper.

J. L. JONES.

New Haven, Conn.

The Parliamentary Commission, which was appointed some time ago to consider the expediency of holding a universal exposition in Paris in 1920, has presented a report to the Government in favor of this project. The proposed date of the exposition will coincide with the completion of the extensive program of works for embellishing Paris.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

A Catch Question

A boiler has been made using tool-steel rivets with extra large heads so that they will not pull through and it is not possible for them to shear. The plate must fail by crushing in front of the rivets. If, after this boiler had been tested it was found that the metal in front of two of the rivets had disappeared, what became of it?

T. T. P.

Boiler rivets are made of soft steel or iron and never, even for a test, of tool steel, and the question is one to discover how much is known of the character of the materials used in boiler construction. The reference to the supposed disappearance of a part of the sheet is inserted to draw the attention from the main question, which, put in plain English, would be: Of what material are boiler rivets made?

Stress on Boiler Stays

Figure the stress between the stays and give proper pitch of 1-inch stays, 54,000 tensile strength for a working pressure of 155 pounds.

S. B. S.

Staybolts $1\frac{1}{4}$ inches diameter or less are allowed 6500 pounds per "net section." The area of a 1-inch staybolt having V threads 12 to the inch is 0.575 inch

$$6500 \times 0.575 = 3738 \textit{ pounds}$$

allowable stress on one bolt. For 155 pounds pressure

$$3738 \div 155 = 24.24 \textit{ inches}$$

of surface to be supported by the bolt. To find the pitch extract the square root which gives 4.923 inches pitch. In this the area of one staybolt hole has not been deducted.

In close calculations the area of the hole may be deducted, but Massachusetts rules do not require this. In practice the pitch woud be either $4\frac{7}{8}$ or $4\frac{15}{16}$ inches. As the stress on the plate would be supported by the stays, it would not enter into the calculation.

The plate for 155 pounds pressure and above pitch should not be less than $\frac{3}{8}$ inch thick, whether flat or circular furnace.

Weight of Castings

How can I estimate the weight of iron and brass castings?

I. B. C.

An approximation may be made by weighing the patterns and multiplying the weight by 19 for brass and by 17 for iron if the patterns are made of pine.

Equalizing Piston Clearance

How is the piston clearance in an engine cylinder equalized?

E. P. C.

By disconnecting the connecting rod and pushing the piston to one end of the cylinder until it strikes the head; make a mark on the guide at one end of the crosshead and then move the piston to the other end of the cylinder and mark the guide as before. Lengthen or shorten the distance between the connecting-rod brasses until the crosshead travels equally between the marks on the guide.

When the piston rod screws into the crosshead, the total clearance may be found, and with the crank on the back center the piston rod may be screwed in or out until it is equal at both ends.

Inspection of Boiler Plates

Suppose the owner of a power plant came to an engineer and said in regard to a new boiler that had been ordered, "I have been talking to the boilermaker about that boiler and he says he has some plates that are all right. I have told him that if you said the plates were all right he could build me the boiler." Now, what would the engineer look for? The plates are all right in regard to tensile strength and chemical tests and are rolled nice and smooth and free from blisters and so forth.

B. P. F.

If in Massachusetts, the engineer would look for nothing at all, as the boiler to be installed must comply with the requirements of the Board of Boiler Rules and any observation or investigation on the part of the engineer would be supererogatory. In any other State he should measure each plate with a micrometer at various points on the four edges to ascertain the exact thickness and reject all plates of less than the proper thickness; require mill-test affidavit of chemical and physical tests and check the heat number of each sheet.

Safety Valve Calculations

Please give in plain English without algebra or formulas the rules for calculating the pressure, length of lever, weight of ball, distance from fulcrum, etc., of lever safety valves.

L. S. V.

To find the pressure per square inch which will balance a valve with a given weight at a given distance from the fulcrum, the effective weight of the valve, valve stem and lever being known.

RULE: Multiply the weight by its distance from the fulcrum. Multiply the weight of the valve and the effective weight of the lever by the distance of the stem from the fulcrum, and add this to the former product. Divide the sum of the two products by the product of the area of the valve multiplied by its distance from the fulcrum, and the result will be the pressure in pounds.

To find the distance from the fulcrum at which the weight must be placed to balance a given pressure per square inch.

RULE: Multiply the area of the valve by the pressure, and from the product subtract the effective weight of the valve and lever. Multiply the remainder by the distance of stem from fulcrum, and divide by the weight of the ball. The quotient will be the required distance.

To find the effective weight of the lever, valve and valve stem.

RULE: Multiply the actual weight of the lever by the distance between its center of gravity and the fulcrum, and divide by the distance between the fulcrum and the stem. To the quotient add the actual weight of the valve and the stem.

Engine Running Under

What are the advantages, if any, of running an engine "under"?

R. U. E.

When an engine runs "over," the lower guide bears the weight of the crosshead, part of the weight of the connecting rod and one-half the weight of the piston rod in addition to the pressure due to the diagonal thrust of the connecting rod. When the engine runs "under," the diagonal thrust of the rod forces the crosshead against the upper guide with a pressure which is reduced by the weight of the crosshead and rods, which reduces the friction load of the engine.

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Contents

Graft

The practice of accepting considerations from salesmen of engineering supplies for influencing the purchase of their goods is belittling and corrupting to the man who does it.

Amos Skeg, whose communication upon this subject appears in Power for February 14, is a good engineer and an upright man. We do not believe that he would buy or recommend the purchase of any machinery or supplies because the sale meant a commission to him, and we do not believe that, having recommended a thing because he thought it was the best and cheapest, he would demean himself by accepting a tip for which he had rendered no service.

The waiter, or porter, or barber has an excuse for the tip which is given him in supposedly special personal attention and extra service. The engineer has no justification for accepting gratuities for which he has rendered no service, even if he is willing to put himself into the tip-receiving class.

No amount of sophistry or argument will justify the practice and we deplore the aid and comfort which those who practice it will derive from Amos Skeg's communications.

It may be true that there is more temptation to find a justification for grafting on the part of a man who, as Mr. Skeg says, views the subject from the edge of a coal pile while cogitating on the dismal fact that the grocery bill will have to go over another week in order that the kiddie may have a new pair of shoes, than on the part of one who considers it from an office chair with the assurance of a comfortable income; but the fact that one needs the money is no justification for a practice otherwise questionable.

The fees and commissions of a professional engineer are not graft when he earns them. He may undertake to do the planning and oversee the installation of a plant for a fixed fee or for a commission or percentage of the cost. So long as this is the agreed method of payment and is abided by, there is no graft. But, if he abuses the power of recommendation and purchase with which the commission endows him by accepting commissions from the sellers of apparatus in addition to the fee or commission which he is accepting from the purchaser, he is a grafter, and he is just as much a grafter if he leads himself to think that his judgment is not influenced by the commission, or that the purchaser is paying no more than the market price and that the commission would stay in the "bulging pockets of the salesman" if he did not collect it.

When we mentioned the high ideals of the professional engineer, however, we had in mind the operating, not the consulting class. Society orators will harp upon the manifold attainments, the highly specialized knowledge, the weighty responsibilities, the executive ability which raise the man in responsible charge of the modern steam plant to the professional plane, and go behind the boiler the next day and sell themselves to an oil peddler for a two-dollar bill.

Two good tests to apply to a transaction are to ask if it will stand daylight, and what would happen if everybody did it. You, who are taking tips from your supplyman, would you be perfectly willing for everybody to know it? Do you let your employer know how much you got for dealing out his patronage? And, if he, trusting in you so absolutely that he believes these tips make not a bit of difference in the cost to him or the quantity or quality which he gets, is willing for you to accept them, do you make the salesman understand that the orders would come just as promptly and just as regularly whether you got the tip or not? Do you let your friends, who look upon you as a responsible salaried man, know that a part of your income is composed of gratuities from supplymen? If you earned an extra twenty-five dollars by indicating the engine of a neighboring factory or by testifying in court upon some mechanical question, you would be rather apt to talk about it. Is your reticence concerning your gratuities induced by an unadmitted sense of shame?

Mr. Skeg asks if the acceptance of the premiums offered for the securing of subscribers to Power or the premiums offered by advertisers for the purchase of their goods or the acceptance of a consideration for writing an article, consigns him to the blacklist.

The premium for getting a new subscriber is legitimate pay for a legitimate service, as is the money which is paid for accepted articles. If you purchase goods with somebody else's money for the purpose of getting the premium for yourself it is graft.

On the B.t.u. Basis

An old gentleman in a Western city had invested his savings in a power building and for years had lived comfortably upon the rents, given his girl a good education and sent his boy to the State university. Upon graduating, the boy set out to administer the property in accordance with the latest developments of the art. One of his first moves was to summon the coal man.

The latter knew what was coming, and had come prepared. "Now, look here," he said, "I know we sell you a lot of coal but we sell it to you right. Your father was one of our first customers and we've always looked out for him like a friend of the family. He gets the best there is and at a price that won't stand talking about out loud. Now, you just let the thing run along and don't go to stirring things up or you'll break up a deal that it will be hard to get back into."

"That's all right," returned the young fellow, "but we are going to run this thing on a business basis. We want to know what we're getting. What per cent. of moisture is there in this coal that you're giving us?"

"What's that —?"

"How much moisture does it contain? How much water is there in it?"

"Water! There ain't no water. It's good, dry coal—dry as a cracker."

"What per cent. of ash has it got?"

"Ashes? There ain't no ashes in it. It's good, clean coal I tell you; the prettiest there is mined."

"How many B.t.u.'s are there in it?"

"Not a d——d B.t.u."

Publicity of Operating Costs

In everyday life there is little which, if viewed abstractly, conveys much meaning, but when compared with some familiar object or incident its value and significance assume definite proportions. This is particularly true of engineering practice.

To one unfamiliar with the performance of steam engines the mere statement that a certain engine has a water rate of fourteen pounds conveys little information, although the definition of the term "water rate" may be thoroughly understood; but when it is known that this figure very closely approaches the best performance of engines of this type and size, its significance is at once apparent.

Similarly a person having access to no test data would fail to differentiate between a boiler efficiency of seventy-six per cent. and a generator efficiency of ninety-six per cent.; and, taking the higher figure as a standard, would class the performance of the boiler as poor, whereas it would be exceptionally good.

In engineering, theory and mathematics are useful, but they serve principally as a guide or check to empirical rules. The real foundations of engineering practice are based upon experience.

Developments along engineering lines are so rapid that the standards of practice are constantly changing; but, in order that widespread benefit may result, it is essential that everybody concerned shall contribute his own experiences, whether success or failure, to the common cause.

The managers of plants making exceptionally good records often refuse to give out any figures for fear that the public will think they are making too great a profit. On the other hand, many plants that are making a poor showing will not disclose any facts concerning their operations for fear of being criticized. Both are assuming an attitude tending to impede progress; the former by refusing to aid its neighbor, and the latter by practically refusing to accept aid.

Speak Up

Human nature is composed of a peculiar mixture. Many people have such an ingrained fear of being criticized or ridiculed by their fellows and associates that they are deterred from expressing their opinions no matter how sure they feel of being correct. To every question there are two or more sides, and in the words of Wendell Phillips, "He does not really believe his opinion who dares not give free scope to his opponent." Once, during a "dinner-pail" talk, a certain operating engineer's veracity was seriously questioned because he stated that the shaft of the De Laval turbine rotates at thirty thousand revolutions per minute. The expressions of disbelief were even more forcible when he stated that this was a moderate speed when compared with that used in grinding small holes.

The recanting of Galileo at the command of the Inquisitators did not stop the rotation of the earth upon its axis, but the fear of the derision of his fellows has deterred many a man from that development and progress which was within his grasp. It is an extremely fortunate thing that the great minds which now stand symbolized by certain human names did not bow their necks to the storm of derision expressed by their contemporaries.

As it is in the large and grand arena of a world entire, so it is within the circumscribed limits of the workshop. Success comes, not at the beck and call of one's fellows and associates, but at the demand of the mind of the individual who has the will to be responsible for himself. The man with a message to his fellows is, fortunately for the world, in most cases the one who is determined to deliver it. It is to be regretted, however, for their own sake as well as the world's, that many fail.

"Be sure you are right, then go ahead"—and let them howl!

American Institute of Boiler Inspectors

Among the many organizations born during recent years there are few which will be watched with keener interest by those engaged in the generation and transmission of power than the Institute of Boiler Inspectors.

When the responsibilities resting on the boiler inspector are considered, the value and the possibilities for the accomplishment of good by a society of this nature become apparent. On him devolves the duty of deciding the ability of a boiler to withstand the effects of the pressure of the confined steam which with the stored energy in the highly heated water is productive of such destruction when an explosion occurs. This demands on the part of the inspector a thorough knowledge in detail of all types of boilers, besides the technical training that is absolutely necessary to enable him to decide constantly arising questions of strength of materials, of methods of construction and operation.

With education along lines leading toward increasing and spreading the social and technical advantages resulting from coöperation as its keynote, the society is bound to succeed in placing itself in the front rank of beneficial organizations.

It would seem to be a simple matter to weigh the coal fed to a battery of boilers, and the water which they evaporate, and determine how much water is evaporated per pound of coal. There are a lot of ways that one can fool himself, however, in this apparently simple operation. Try it under similar conditions and see how careful you must be in order to get consistent results.

Officials of several boiler-insurance companies have told us recently that their losses from "safety" water-tube boilers exceed those from all other classes, even taking the number insured into account. The failures seldom attain to the importance of an explosion, and usually escape notice in the press, but the aggregation of losses from tube rupture is becoming serious.

Have you had any trouble with boiler tubes? If so, how do they fail? Do they open in the weld, thin out and burst, or do pieces drop out of them?

If all of the little things about a plant are given "first aid" when needed, there will be no large one to add to life's burden.

Usually a man's reputation is good until he gets into trouble. Bluff does not count for much when an emergency arises.

Congratulations to San Francisco. Now show them what a real exposition is like.

A New Boiler Feed Water Treatment

Several months ago it was announced in the Australian technical press[1] that a revolutionary method of treating feed water had been discovered in that country. The treatment consisted simply in allowing the water to flow over inclined aluminum plates in the presence of sunlight. Under these conditions the molecular or intermolecular conditions of the scale-forming elements are so changed that instead of forming a hard crystalline scale on the boiler tubes, the deposit is a powdery amorphous mass which can either be washed out of the tubes, or is blown out of the mud drum when blowing down the boiler.

The Australian Apparatus

As used at the Broken Hills Proprietary Company, the apparatus consisted of two aluminum sheets, each 2x4 feet in size, fixed in a frame at an angle of 59 degrees and facing the sun. The water to be used in the boilers was then flowed over these plates from a perforated pipe along their upper edge. As the process was only supposed to be effective during the daytime, storage was provided for the water to be used at night.

In all 197,750 gallons of water were treated and used in a specially cleaned boiler, the test lasting 54 days.

The boiler was then opened, and instead of the hard adherent scale which is normally observed after a run of this length there was either simply a whitish powder or a brittle loose scale, while a portion of the boiler had no deposit in it.

The time of cleaning was reduced from 3½ days to eight hours.

American Installations

Several somewhat similar installations have been made in America recently. In these installations, however, a corrugated plate, or a series of aluminum channels has been used. The equipment is being tried by several important industrial organizations; for example, at the Long Island City plant of the Standard Oil Company, and an installation by the West Shore Railroad at Newark, N. Y., the water in this instance being used by the locomotives. These installations have not been in use long enough to give a definite opinion as to the value of the operation, but the important character of these two corporations indicates that the matter may be worth following up.

It may be noted in this connection that the Watson-Stillman Company, of New York, is putting on the market a compound claimed to be a natural mineral product "consisting mainly of iron, alumina and silica," which is fed into the boiler in suitable quantity at each stroke of the feed pump. It seems to be the general assumption that aluminum hydroxide is partly responsible for the results obtained, as suggested under the idea of protective colloid below.

On Feb. 23, 1911, Thomas R. Duggan, of London, lectured on this new process before the Society of Chemical Industry, adding somewhat to the information already made public. The form of the apparatus shown was that with corrugated aluminum plates, but the corrugations are apparently more to insure thorough distribution of the water than for any other reason. There is a hopper at the top, from which a number of small nozzles, one to each trough, feed the water to the plate. The hopper is furthermore provided with a screen to keep large pieces of dirt and grit from choking the nozzles.

The plates should be open to the air and although more active by day, have some activity at night, apparently due to the small amount of ultraviolet radiation even at that time. The plates in the northern hemisphere should face south; in the southern hemisphere, north. It is essential that the pipes and storage tanks used after the water is treated should be, as far as possible, of nonconducting material, and the water should be used as soon as possible after treatment, and should be used by the seventh day, as a maximum. It is also essential that the plates should be given a rest occasionally; where hard water is being treated, every plate is allowed to rest one day per week.

It is stated that the plates become positively charged and the water negatively, and this, when considered in conjunction with the fact that the plates should face either north or south, and that a nonconducting material should be used for the storage tank, leads to the belief that some fundamental change in ionization is responsible for the results. However, a minute amount of the aluminum dissolves, and researches with the ultra-microscope show that it remains in colloidal solution, though whether as a mixture of aluminum and aluminum hydrate, or the latter only, seems open to question. Whichever of these it may be, the explanation of protective colloids seems also possible.

The apparatus is made in units about 6 inches wide, one 6-inch unit having a capacity of about 1000 gallons per hour. The advantages claimed for the treatment are: It is automatic, continuous and uniform; no chemicals or heat used, hence low treatment cost; it has no action itself on the boiler, and by a deoxidizing effect on the water is a preventer of corrosion; hard scale is prevented and the time of cleaning the boiler much lessened, thereby getting more hours' work from a given plant; by the elimination of hard scale the efficiency and life of the boiler are claimed to be increased.

Any water is amenable to this treatment except that containing ferrous sulphate or carbonate. With saline waters the length of the plates is increased beyond the usual 5 feet, or the water run back over the plates several times. Boilers under this treatment must be blown off frequently, particularly during early stages, as old scale often loosens and settles into the mud drum during the first few weeks.

The process is the invention of Herr Brandes, and is patented in most civilized countries, the rights for the United States being held by the Luminator Water Company of America, with offices in New York.

[1]Aust. Min. Std., Sept. 21, 1910.

Congress of Technology

A congress of technology will be held in Boston on April 10 and 11 in celebration of the fiftieth anniversary of the granting of the charter of the Massachusetts Institute of Technology. In line with this idea, the fifty or more papers which will be presented at the congress will be written by graduates of the institute, and will thus serve to record the part the alumni of the institution have taken in the development of scientific industry.

As the titles of these papers are sent in by the writers, it is becoming evident that the managers of the congress will succeed in their effort to make the proceedings show from another point of view the general industrial advance that has taken place during the past fifty years under the guidance of trained engineers. The papers will cover a wide range of subjects, from architecture to sewage purification, and the names and professional standing of the writers show that they will together discuss authoritatively every important problem of modern industrial technique and management. It is already clear that this record is not limited to any narrow activity within merely technical lines, but that it covers the broader problems of the relations of science to industry, and the place of the engineer in creating a more efficient type of industrial management.

The point is made that by a slight change in the arch of a furnace under a tubular boiler much can be done to prevent smoke. The proper length and form of the combustion arch depends upon many variable factors and perhaps is best determined by experiment under the given conditions. A station was equipped with a pair of [illegible] boilers, and it was thought they were installed exactly alike. One was making smoke and the other did not. On taking measurements it was found one arch was 8 inches higher than the other. The high arch was lowered 8 inches and the smoke stopped. If the draft had been a great deal more the arch might have had to go up.—F. S.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Samson Transmission Rope

This rope is composed of a special crucible cast-steel wire rope coated with a rubber compound over which is braided, under heavy tension, a cotton cover comprising about four-fifths the area of the rope. The compound in the rope is vulcanized, which causes it to expand and harden into the interstices of both the cotton and wire ropes, firmly binding them together, also waterproofing and lubricating that portion of the rope most subject to deterioration. A final operation is to treat the cotton with a penetrating finish, binding its fibers together and increasing its resistance to wear. Fig. 1 shows the construction of the rope.

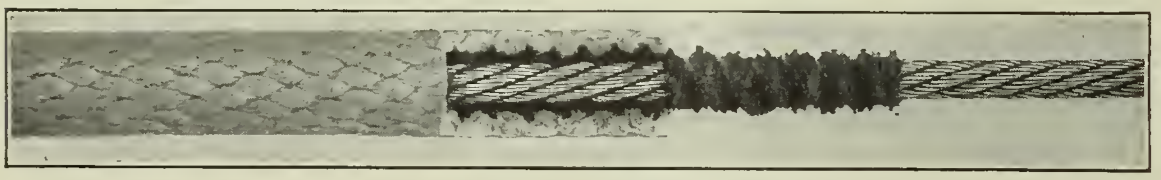


Fig. 1. Details of Construction

The method of splicing this make of rope is such that every wrap can be fitted with a coupling to exact length, by any mechanic at any convenient bench, and then coupled or uncoupled in working position on sheaves. This makes it possible to cut spare ropes at the exact length required and fit them with the coupling ready to be attached. Unlike rope that requires splicing, it is not necessary to make each rope endless in working position while the drive is idle, nor is it necessary to shorten it up after installation.

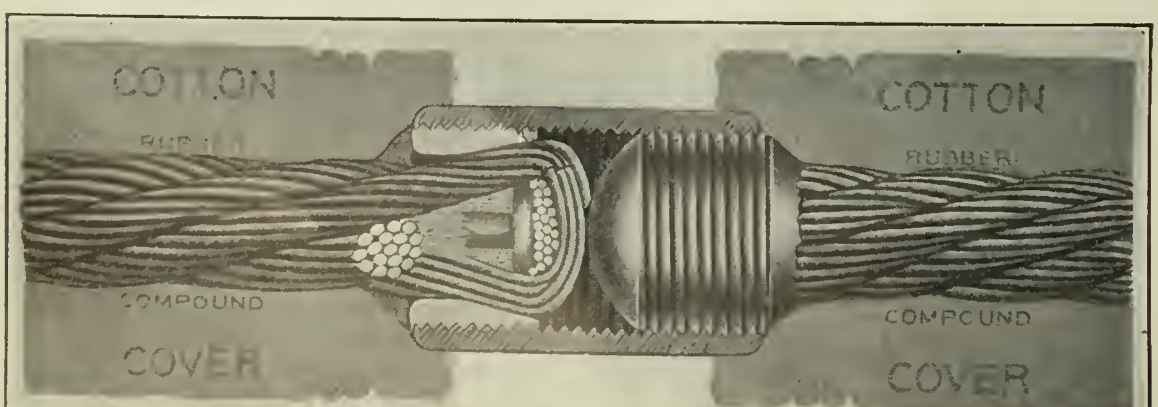


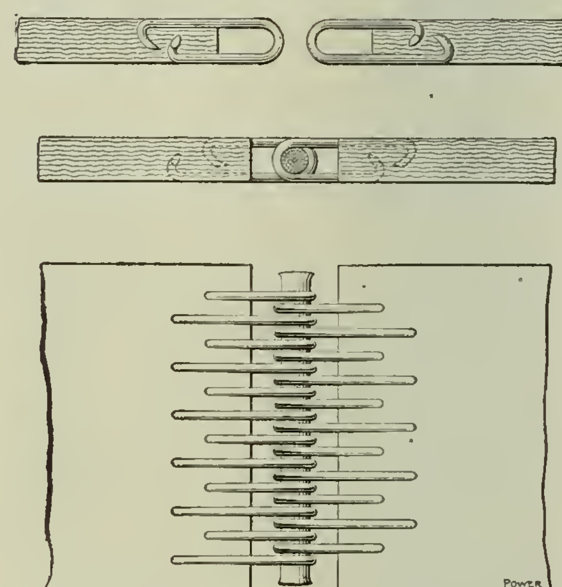
Fig. 2. Coupling Joint

The rope coupling is composed of two thimbles and a connecting sleeve, as shown in Fig. 2. Each end of the rope is cleaned bright, then passed through a thimble and expanded by driving a rivet, and turning the wire ends into the socket, after which all space between the wires is filled with solder. It is claimed that a ¼-inch coupling will resist a ton strain. The coupling and wire center, which carry the strain, never come in contact with the sheaves, as the cotton cover protects them.

This transmission rope and coupling is made by the Samson Cordage Works, 88 Broad street, Boston, Mass.

Clipper Belt Lacing

This lacing constitutes a simple and effective means of fastening belts, and is easily and quickly applied. The lacing is done with a series of hooks of a size corresponding to the amount of power to be transmitted, these hooks hinging on twisted rawhide pinions. The lacer itself consists of a solid steel base and anvil, with lacer part of bronze metal, and a solid lignum vitae mallet. The advantages claimed for this lacing are that both sides of the belt are perfectly smooth, it uses hooks having a long and short side, thus equalizing the strain, the joint is flexible, with no chance of crystallization of the hooks if they are properly driven into the belt flush with the surface, and no short ends of belts are wasted in making the lacing. Any width or thickness of belt may be laced with the same tool and as it is portable it is easily taken to the point where the work is to be done, making it unneces-



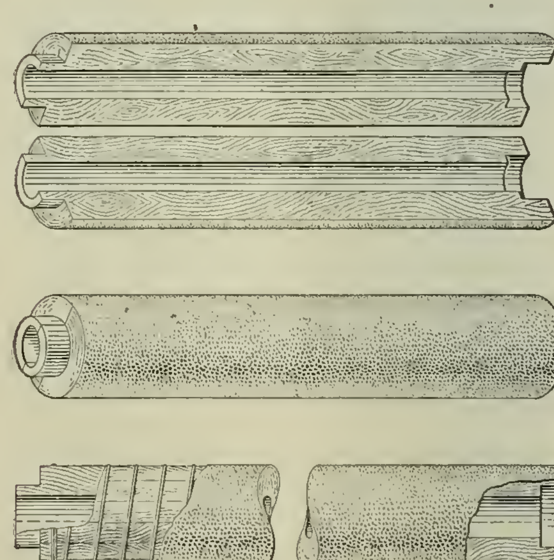
Clipper Belt Lacing

sary to take the belt off the shaft or pulleys.

The Clipper belt lacer is manufactured by J. B. Stone Company, Grand Rapids, Mich.

Improved Steam Pipe Casings

An efficient nonconducting covering is made by the Michigan Pipe Company, of Bay City, Mich. The casings are made of staves, which it is claimed have



Steam-pipe Casing

proved successful in every respect. The stave casings, which are illustrated in the accompanying drawings, are made in sections up to 12 feet in length, of Michigan pine and tamarack. The inner and outer surfaces of the staves are curved to conform respectively with the inside and outside circles of the pipe and the sides are fitted with a double tongue and groove, running the full length of the pipe. The staves are thoroughly inspected, and assembled in a cylindrical form, after which the sections are spirally bound with galvanized wire from end to end, under heavy tension, with a double wrap at each end, thus making them of uniform strength and as rigid as the solid log. A mortise is then put in one end and a tenon on the other, after which the outer surface is heavily coated with an imperishable cement.

Smaller sizes of casings are made of solid logs which are bored and then finished the same as the stave casings.

The Kilgour Boiler Setting

Barristers hall in Boston is so situated that its smokestack is one of the prominent features of the view from the smoke inspector's window. As a consequence Dwight Kilgour, the mechanical engineer in charge, made numerous involuntary excursions to the court where violations of the smoke ordinance are tried, each entailing considerable unpleasantness, not to mention the expense incurred in the shape of lawyer's fees and time. Convinced that the only way to stop the arrests was to stop the smoke, he directed his activities to the production of a smokeless furnace.

If one sits in a room with a lamp having a chimney like that shown in Fig. 1, he will soon be sensible that the lamp is there. If the chimney is extended into the usual converging nozzle, the combustion will be complete and the flame bright and steady. Mr. Kilgour compared his smoky furnace with the smoky lamp and concluded that it needed its chimney lengthened, not the tall brick stack beyond the boiler which carries off the products of combustion, but the firebrick inclosure in which the combustion should be completed before the gases

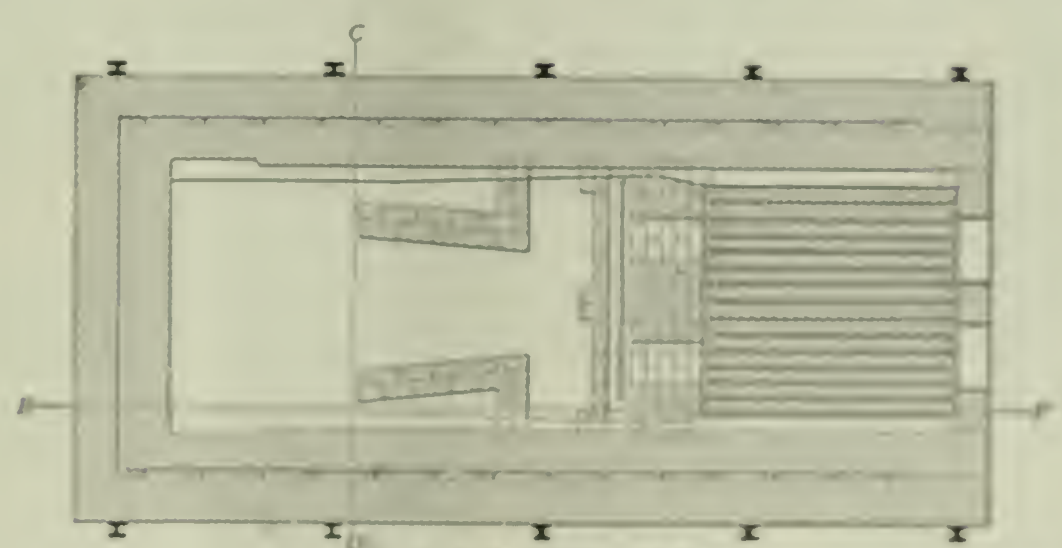
FIG. 1. A CASE OF CHILLING THE FLAME

reach the cool boiler plate and tubes.

He therefore threw up a firebrick curtain *M* behind the bridgewall and led the converging firebrick tube or arch out of it as shown in the views of Fig. 2. The bridgewall was made hollow, and cast-iron ducts *N* with perforations pointed toward the rear of the boiler discharge finely divided streams of highly heated air into the gases as they stream over the bridgewall.

One observer said that he had simply changed the ordinary brick arch from the furnace to the combustion chamber. Even so, he gets away from that disadvantage of the furnace arch that it radiates heat upon the firebed with such intensity that it accelerates the throwing off of the volatiles which already come off from freshly fired fuel faster than they can be burned. With the arch located back of the bridgewall, all the products of the furnace, including the volatiles, have to pass through it; and, if they are hot enough, if there is oxygen enough present and if the mixture is sufficiently intimate, the combustion will be complete.

After the furnace has been running for a while the mass of brickwork becomes incandescent. The gases coming directly from the furnace and with no chance of losing heat except to the shell directly over the furnace, can easily be kept above the point of ignition while passing through the passages of red-hot brick. The presence of sufficient oxygen may be secured by the admission of air above the bridgewall, and as this comes



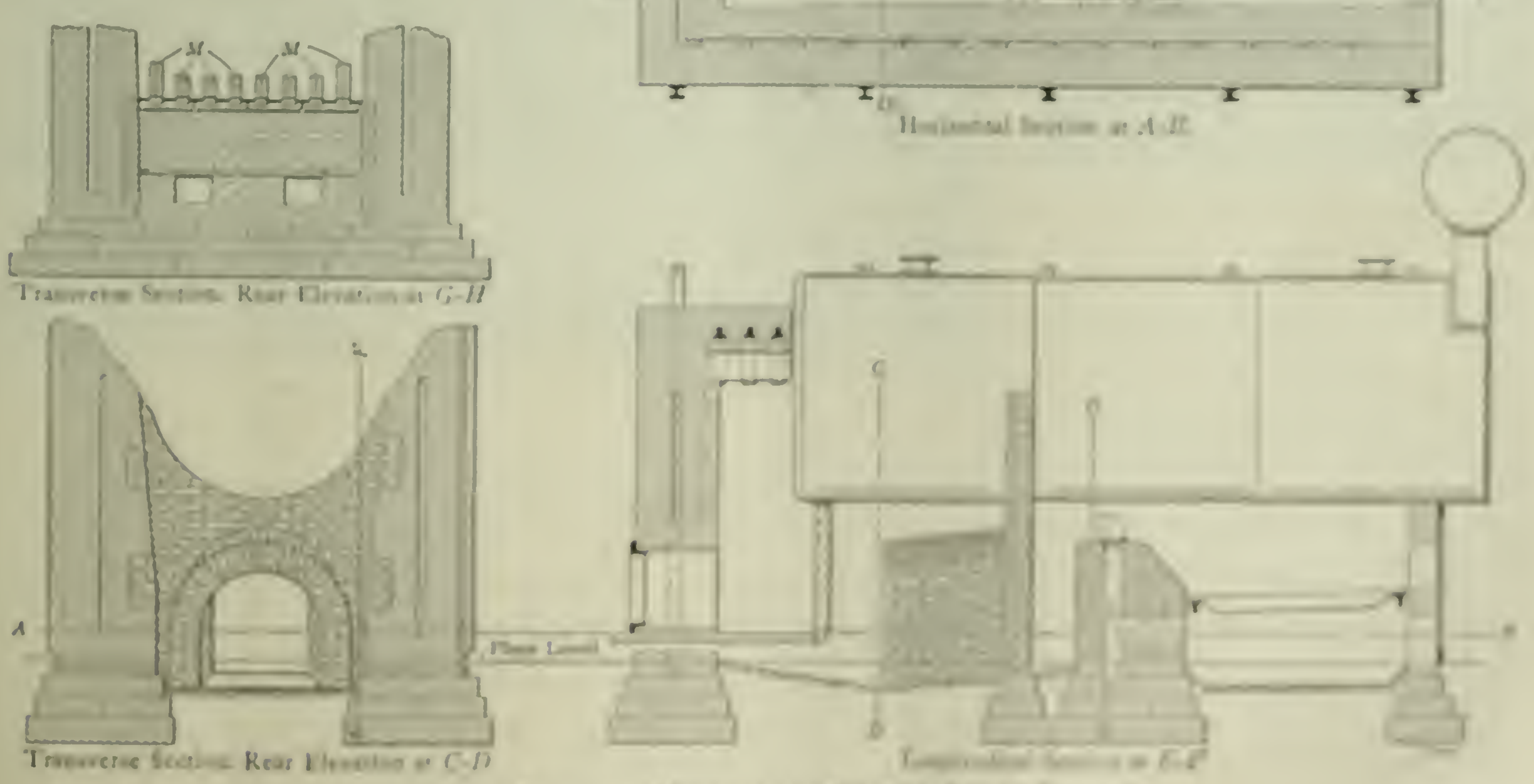


FIG. 2. SECTIONAL VIEWS OF THE KILGOUR BOILER SETTING

in a highly heated condition its introduction does not cool the gases below the temperature at which they will unite. The diffusion of the air in numerous jets tends to an intimate mixture, which tendency is enhanced by turning the sheet of gases which is flowing over the bridgewall in a sheet the width of the furnace, so that they pass out through a passage which is quite some higher than it is wide. This change from a horizontal to a vertical plane produces a swirl in the current which is very pronounced as their combustion in the extension tube is watched from the rear. There is no impingement of the flame upon the shell, and yet no loss of efficiency in the heating surface, for the shell above the arch receives radiant heat from it as it would from an equally hot mass of glowing coal.

C. E. Cotting is the trustee of numerous estates owning large buildings, and Mr. Kilgour is his mechanical engineer. He has therefore had an exceptional opportunity to try out his ideas under various conditions. I saw them at the Exchange building carrying fires of soft coal piled nearly to the top of the fire doors. I watched at the back connection while they put on fresh fuel and sliced the fires. Each shovelful of coal as it was fired produced a rush of flame in the arch as though a jet of gas had been turned on momentarily. The slicing filled the whole back connection with a roaring mass of flame, which, however, cleared up instantly. The stack showed a very thin gray smoke at intervals, evidently when the fires were disturbed.

They have burned as high as 25 to 30 pounds of coal per square foot of grate, and after three years of use the arches are in good condition with no rebuilding or repairs. The perforations in the iron retorts require drilling out from time to time. The brickwork becomes covered with a black vitreous crust to which clusters of slag attach themselves, which may, however, be picked off with the fingers. The furnace has been patented and adapted to water-tube as well as to shell boilers. Henry W. Buhler, 251 Causeway street, Boston, is licensee of the Kilgour patents and controls the manufacture and erection of the setting.

Annual Banquet of the Combined National Association of Stationary Engineers Associations of Manhattan and the Bronx, New York City

New York Engineers Hold Annual Dinner

Saturday night, February 25, at the Broadway Central hotel, a gay scene was presented when about two hundred ladies and gentlemen sat down to the second annual dinner given by the general committee of the combined associations of the National Association of Stationary Engineers of Manhattan and the Bronx.

John Mahr acted as toastmaster and introduced each speaker and singer in turn with words both pointed and pertinent.

Edward H. Kearney, national vice-president, was the first speaker. He dwelt on the history, aims and triumphs of the National Association, ascribing a good measure of the success attained to the coöperation of the wives, sisters and sweethearts of the members. So eloquently did he portray the effect of this influence that few, if any, of his audience realized that his experience in feminine coöperation had been conducted entirely on the absent-treatment plan.

Charles A. Wilhoft, president of the Supplymen's Association of Manhattan, read letters of regret and of felicitation from prominent members of the national association from various parts of the country, and made a few brief remarks as to the history, aims and scope of the supplymen's organization.

Past National Presidents Carney and Reynolds added gems of mixed wit and wisdom to the occasion and very considerately cut their parts short in order to give all the time possible to Billy Murry and Jack Armour.

Promptly at 12 o'clock dancing began and was continued far beyond the usual "wee sma' hour."

It was the consensus of opinion that the event was both pleasant and profitable and the best ever.

The Newly Elected President of A. S. M. E. for 1911

On May 30, 1841, Edward Daniel Meier, who is now president and chief engineer of the Heine Safety Boiler Company, was born in St. Louis, Mo. A scientific course at Washington University in St. Louis and four years at the Royal Polytechnic College in Hanover gave him a solid foundation on which to build his engineering career. After seeing much active service in the Civil War, Colonel Meier entered the Rogers Locomotive Works, at Paterson, N. J., remaining one year. From 1867 to 1870 he was associated with the Kansas Pacific Railway, first as assistant superintendent and then as superintendent of machinery, leaving there to become chief engineer of the Illinois Patent Coke Company. In 1872 he became manager of the Meier Iron Company, building its blast furnace, and from 1873 to 1875 directed the machinery department of the St Louis Interstate Fair. During this time he became actively interested in the St Louis cotton industry and designed machinery for baling cotton, first with the St. Louis Cotton Factory and then with the Peper Hydraulic Cotton Press. In 1884 he organized the Heine Safety Boiler Company for the development in the United States of the water-tube boiler of that name, and has been its president and chief engineer ever since. He was also responsible for the introduction of the Diesel motor into the United States and until 1908 was engineer-in-chief and treasurer of the American Diesel Engine Company.

Col. E. D. Meier

Colonel Meier has been active in a number of professional organizations. From 1881 to 1884 he was treasurer of the St. Louis Engineers Club and president from 1890 to 1891. During the latter period he was also secretary of the American Boiler Manufacturers' Association, and in 1898 to 1900 he was president of the association and also of the Machinery and Metal Trades Association.

In the American Society of Mechanical Engineers, Colonel Meier has been active on many committees and has been twice elected vice-president, serving his first term from 1898 to 1901, and beginning the second in 1910, so that he was still holding this office at the time of his election as president.

Low Water Caused Explosion on the "Delaware"

It is reported by the daily press that the boiler accident on the battleship "Delaware" on January 17, which killed nine men, was caused by low water in the affected boiler. According to the findings of the court of inquiry, appointed by the Secretary of the Navy, the water tender, who was killed, was responsible for the condition of the water in the boiler. At the Navy Department it was said that the findings will result in an attempt to devise a plan by which the responsibility for maintaining the water at a proper hight will not be intrusted to water tenders alone, but will be shared by others of the boiler-room force.

Steam Boiler Inspectors Organize

On the evening of February 21, following a dinner at the Victoria hotel, New York City, the steam-boiler inspectors employed in and around the city, organized a society which adopted the name of the American Institute of Steam Boiler Inspectors. The dinner was attended by a large number of inspectors employed by the several insurance companies, railroads, etc., in and around New York, together with representatives from a similar society of Boston, Mass., including its vice-president, J. F. Mullen, who outlined the value of the society and the good work that is being done. James G. Shaw read a paper defining the purposes and aims of the institute.

After an informal discussion a constitution was adopted and the following officers elected: President, T. T. Parker; vice-president, J. N. Wixted; secretary, Robert A. Thomson; treasurer, T. McGowan.

An executive committee of five was chosen, and the organization will be completed at an early date. The list of charter members contains thirty-six names, but it is expected that when the purposes of the society are fully understood by the inspectors not present, the membership will be greatly increased and embrace practically all those in the immediate vicinity of New York.

The society is for steam-boiler inspectors employed by Federal, Dominion, State and city governments and the insurance companies of the United States and Canada, but the charter list is open to actual boiler inspectors only.

The object of the institute is to promote the educational and social interests of its members, and, to this end, meetings for presentation and discussion of papers will be held at regular intervals.

This is the second society of this nature formed in this country, but owing to the success of the Boston organization, steps are being taken to make the institute one which shall include in its membership all of the reputable boiler inspectors in North America.

The address of the secretary is 1 Madison square, New York, N. Y.

SOCIETY NOTES

The Oregon Society of Engineers has been organized with a charter membership of 160. All branches of the engineering profession are included in the membership. The territory has not been limited to the State of Oregon, but includes all the Greater Northwest. D. C. Henny, 605 Spaulding building, Portland, Ore. (consulting engineer for the United States Reclamation Service), has been elected president, and G. L. Bliven, 407 Buchanan building, secretary. The present headquarters of the society will be located at 407 Buchanan building, Portland.

The ninetieth meeting of the National Association of Cotton Manufacturers will be held at the Massachusetts Institute of Technology, Boston, Mass., April 12 and 13, 1911. These dates have been selected because they immediately follow the Congress of Technology which will be held on the preceding days, in celebration of the fiftieth anniversary of the charter of that institution, and it is expected that many of those present will remain to attend the meeting.

President Maclaurin, of the Massachusetts Institute of Technology, will speak at the opening session and during the meeting papers are expected on the following subjects: "Arbitration on Cancelation of Orders," "Byproducts in Cotton Manufacture," "Doffing Machines and their Relation to Child Labor," "Electric Power Transmission to Cotton Mills," "Executive Management of the Textile Plant and its Relation to the Market," "Gas Producers and Gas Engines for Cotton Mills," "Illumination," "Law of Moisture in Cotton and Wool," "Methods of Cost Finding in Cotton Mills," "Moisture in Cotton," "Renaissance of the Waterfall," "Rewinding Weft Yarn," "Sandwich Island Cotton," "Textile Education from a Manufacturing Standpoint," "Weaving Shed Roof Construction."

Also reports on standard specifications and other subjects by special committees.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

INTERNAL COMBUSTION ENGINE. Geo. F. Murphy, Jersey City, N. J., assignor to Fuel Oil Engine Company, Providence, R. I., a Corporation of Rhode Island. 984,695.

ROTARY ENGINE. Ambrose Everts Greene, Pueblo, Colo. 984,901.

ROTARY ENGINE. James Henry Watson, Riverton, Wyo. 984,983.

ROTARY ENGINE. Karl Wittig and Emil Wittig, Zell, Wiesenthal, Germany. 985,091.

BOILERS, FURNACES AND GAS PRODUCERS

WATER-TUBE BOILER. John E. Bell, New York, N. Y., assignor to the Babcock & Wilcox Company, New York, N. Y., a Corporation of New Jersey. 984,880.

FURNACE. Joseph Harrington, Riverside, Ill. 984,910.

SMOKE-CONSUMING FURNACE. William E. Ludlow, Washington, and Henry J. White, Augusta, Ga. 984,979.

POWER PLANT AUXILIARIES AND APPLIANCES

BOILER-TUBE CLEANER. Thomas S. Waller and John V. Carr, Detroit, Mich., assignors to Raphael Herman, Detroit, Mich. 984,622.

LUBRICATOR CUP. Robert M. Stevenson, Olean, N. Y. 984,713.

FINE FUEL-FEEDING APPARATUS. Geo. L. Swift, Chicago, Ill. 984,715.

VALVE. William Gavin Taylor, Waterbury, Conn. 984,718.

ENGINE INDICATOR. Max Arnot, Aix-la-Chapelle, Germany. 984,732.

VALVE MECHANISM. John W. Ledoux, Swarthmore, Penn. 984,820.

LUBRICATOR. Oscar H. Neiman, Freeport, Ill. 984,839.

PISTON-PACKING EXPANDER. George Christenson, Nevada, Mo., assignor to H. W. Johns-Manville Company, a Corporation of New York. 984,888.

NOISE MUFFLER FOR EXHAUST PIPES. Daniel W. Dudderar, Mount Airy, Md. 984,890.

BOILER FLUE-CLEANER SYSTEM. De Los E. Hibner, Dubois, Penn., assignor to the Vulcan Soot Cleaner Company of Pittsburg, Penn., Dubois, Penn., a Corporation of New Jersey. 984,919.

SAFETY DEVICE FOR STEAM ENGINES. Walter B. Kollar, Lansing, Mich. 984,935.

SEPARATING GRATE. Nicholas Colgen, St. Charles, Minn. 985,007.

BOILER FEEDER. George C. Miller, Fitchburg, Mass., assignor to the Leominster Machine Supply Company, Leominster, Mass. 985,050.

PISTON HEAD. Frank Pienie Roesch, Douglas, Ariz. 985,065.

ELECTRICAL INVENTIONS

ELECTRIC HAMMER. Hilary F. Whalton, Key West, Fla. 984,984.

ALTERNATING-CURRENT MOTOR. Burton McCollum, Lawrence, Kan. 984,582.

ELECTRIC WELDING MACHINE. Lafayette M. Pryor and Jesse L. Trapp, Frankfort, Ind. 984,603.

VAPOR ELECTRIC APPARATUS. Max Von Recklinghausen, New York, N. Y., assignor to Cooper Hewitt Electric Company, a Corporation of New York.

ELECTROMAGNETIC APPARATUS. John P. Coleman, New York, N. Y., assignor to the Union Switch and Signal Company, Swissvale, Penn., a Corporation of Pennsylvania. 984,748.

VARIABLE SELF-INDUCTION COIL. Allyne Clark Hovey, Pittsburg, Penn., assignor of thirty-one-hundredths to Walter Rosenbaum and thirty-one-hundredths to Herman S. Heymann, Pittsburg, Penn. 985,009.

POWER PLANT TOOLS

WRENCH. Hiram Mendenhall and Bertel R. Wonsmos, Audubon, Iowa; said Wonsmos assignor to John Weighton, Audubon, Iowa. 984,691.

WRENCH. Eugene Green, San Marcos, Tex. 985,028.

Engineering Societies

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City. Spring meeting in Pittsburg, May 30 to June 2.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York. Next meeting in New York City, May 29 to June 2.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Commander U. T. Holmes, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., O. P. Chamberlain; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., Walter Riddle; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Pres., R. P. Bolton; sec., W. W. Macon, 29 West Thirty-ninth street, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June 5-10, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting at Detroit, Mich., January, 1912.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION.

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

POWER

NEW YORK, MARCH 14, 1911

SOME months ago there was a cartoon on this page showing that while the engineer was dozing over his work the central-station solicitor was busy and succeeded in getting public-service wires into the building.

To those who saw the picture it was just as evident that the heating company had also got a foothold, and its steam-supply pipe was just as ready for service as the electric wires.

But the picture told more than this.

It told how the wires from the central station and the pipe from the steam heating company found an opening through which the building could be entered. It was made by the engineer himself while asleep on duty.

He walked about in his sleep, attending to the routine work of the plant and nothing else. Neglect and mental indolence so clouded his brain that the invasion of his field was not noticed until it was too late. Another engineer went out into the world to enter the ranks of the unemployed and by his competition help to force still lower the standard of wages and living of that class of skilled workmen whose remuneration should be the highest paid to any workers in the country.

But he slept. His obvious duties were perfunctorily performed, while the more important factors of his vocation were neglected.

He knew how to shovel coal enough into the furnace to generate what steam was wanted. But he did not know whether he was using too much for the work or only enough.

He knew when he saw the switchboard how much current was being used at that moment. But he did not know how much that current cost per kilowatt-hour.

He knew how to read the water meter through which the water went to the feed pump. But he did not know whether leaking steam valves and pistons in pump and engine were wasting a third of the water that went to the boiler.

He could attend with apparent skill and intelligence to every detail in the operation of the plant. But when the proprietor showed him the central-station and the heating-plant figures, and asked if he could meet them with the present equipment, he was dumb.

He had been sleeping on the job in fancied security, while the men who wanted his plant were awake and busy.

They knew how much coal was burned, the amount of the water bill and the size of the payroll for this department. It was all, every item, on the tips of the solicitors' glib tongues. They could tell the owner everything; he nothing.

It is certain that the immediate interests of a greater number of people will be better served by the use of isolated plants for heat, light and power in a great majority of modern office, store and apartment buildings. But to continue in service those already installed and add to their number as buildings are erected, the engineer must be the character implied by the name: alert, intelligent, courageous, aggressive and, above all, a master in his vocation.

Everybody is ready to help the bottom dog in a fight if he fights. While but few have either respect or sympathy for a "quitter."

New Power Plant of Amoskeag Mills

By Warren O. Rogers

This plant contains sixty-four 300-horsepower Manning boilers set in a single row in a boiler room 500 feet long. The boilers consume 130,000 tons of coal per year and supply steam to 42,300 horsepower of engine equipment and for manufacturing purposes.

The Amoskeag Manufacturing Company, Manchester, N. H., employs 15,000 men and women, and uses 50,000,000 pounds of cotton and 15,300,000 pounds of wool per year. This requires 65,700 nominal boiler horsepower and 42,300 engine horsepower, of which 17,500 horsepower is developed by steam turbines. The steam necessary to operate these engines in addition to that used in the process of manufacture demands an annual consumption of 130,000 tons of coal.

When present plans are completed, the power necessary to drive the machinery in these mills, and the steam used for other purposes, will be generated in three central power plants, dividing the mills into three sections, each section having its own central station. Two of these power plants have been running for several years, but the third is just being put into use.

The initial idea, when the new plant was proposed, was to furnish power for the new Coolidge mill, built on the opposite side of the river. This mill requires about 4000 horsepower; the machinery is motor driven and the electrical current is carried across the river by means of wires supported by towers placed on an island in the center of the river and on the two banks. The wires start from the wire tower above the switchboard.

Steam Turbines

This new power plant contains two of the first horizontal type of Curtis turbines made, each of 3500 kilowatts capacity. They are set side by side at one end of the turbine room, as shown in Fig. 3, on a concrete foundation that is built on a solid ledge base. There is room enough between the turbines and the end wall of the building for the switchboard gallery, and enough floor room has been provided for several more turbines, should they be required. The turbines under a steam pressure of 175 pounds per square inch run at a speed of 1200 revolutions per minute.

Fig. 1. Cleaning Side of the Manning Boilers. The Hand Lever in Front of Each Boiler Controls the Air Supply in the Air Duct

Although rated at 3500 kilowatts, each unit will be made to develop 6000 kilowatts continuously, or nearly double the rated capacity of the machne. Each generator is kept cool by means of a fan blower attached directly to the turbine condensing nozzles arranged as shown in Fig. 4. No circulating pump is used, as the condensers are started and operated by the condensing water itself and a vacuum of from 26 to 27 inches is maintained.

priming pipe. As the lift of the condensing water is but 2 feet, the water in flowing from the priming pipe to the discharge pipe of the jet head creates enough vacuum to lift the condensing water, which, when once started, main-

Fig. 2. The Sixty-four Manning Boilers Equipped with Jones Stokers

shaft. Air is taken from the turbine room and discharged into the room again through the top of the generator casing.

Condensers

Each turbine is piped to a Bulkley type of condenser, and each head has three

A 52-inch flume conveys the condensing water from a point above a dam in the Merrimac River to the basement under the turbine room, and the drop of the pipe provides of a 33-foot head at the lower end. Each discharge tube of three jet nozzles is fitted with a starting or

tains a steady flow to the condenser. The water of condensation and cooling water is allowed to go to waste by the river, there being no necessity in saving it. The feed water is heated by the exhaust steam from the feed pumps and auxiliaries in a closed heater after which it passes through economizers. The condensers are set outside of the turbine room and discharge into a hotwell from which the water runs to the river.

There is fitted, at the top of each condenser, an atmospheric exhaust pipe. When first installed these condensers gave trouble at starting, because of water backing up in the cone chamber and flooding back into the turbine exhaust pipe. The cones were removed and bored out from 6½ to 7½ inches in diameter, which increased the opening in them 40 per cent. A piece of 48-inch pipe, the size of the exhaust pipe leading from the turbines, 6 feet 6 inches long, was inserted between the top head of the condenser and the main riser pipe. A similar length of pipe was also inserted in each of the pipes leading from the head to the nozzles. These changes eliminated the trouble as the water must now lift 11 feet before it can overflow into the exhaust pipe. Fig. 4 shows the former and present arrangement of the condensers. The cooling water is controlled by three valves in the supply pipes which are located in the turbine room.

Piping

The steam pipe leading to each turbine is 12 inches in diameter, and branches from a 20-inch main leading from the boiler room. All steam pipes are placed in the basement under the turbine room, the 20-inch main rising to a level with the top of the boilers after it has passed to a point under the pump-room floor. Owing to the large exposed surface of the exhaust pipe of each turbine, considerable condensation takes place at light loads of 1500 kilowatts or under, and in order to keep these exhaust pipes free of water a Strong vacuum trap is used on one and a receiving tank and duplex steam pump on the other. Fig. 6 is a cross-sectional view of the turbine room and also shows the arrangement of the condensers.

Exciters

On the switchboard platform there are two motor-driven exciter sets of General Electric make and on the ground floor is a turbine-driven set which is used as an emergency unit. There is also a motor-driven direct-current generator which supplies current at 250 volts to the motors operating the coal-hoisting and conveying machinery.

The switchboard is of slate and contains the necessary apparatus to control the electrically operated oil switches, which are placed on the turbine floor directly beneath the switchboard. The feeder cables drop from the switches to iron-pipe conduits, suspended from the ceiling of the basement, and are carried to the various points of distribution through iron-pipe conduits set in concrete piers. These iron conduits, after they leave the cement piers, are encased in concrete work, which extends from the power plant to the nearest factory building.

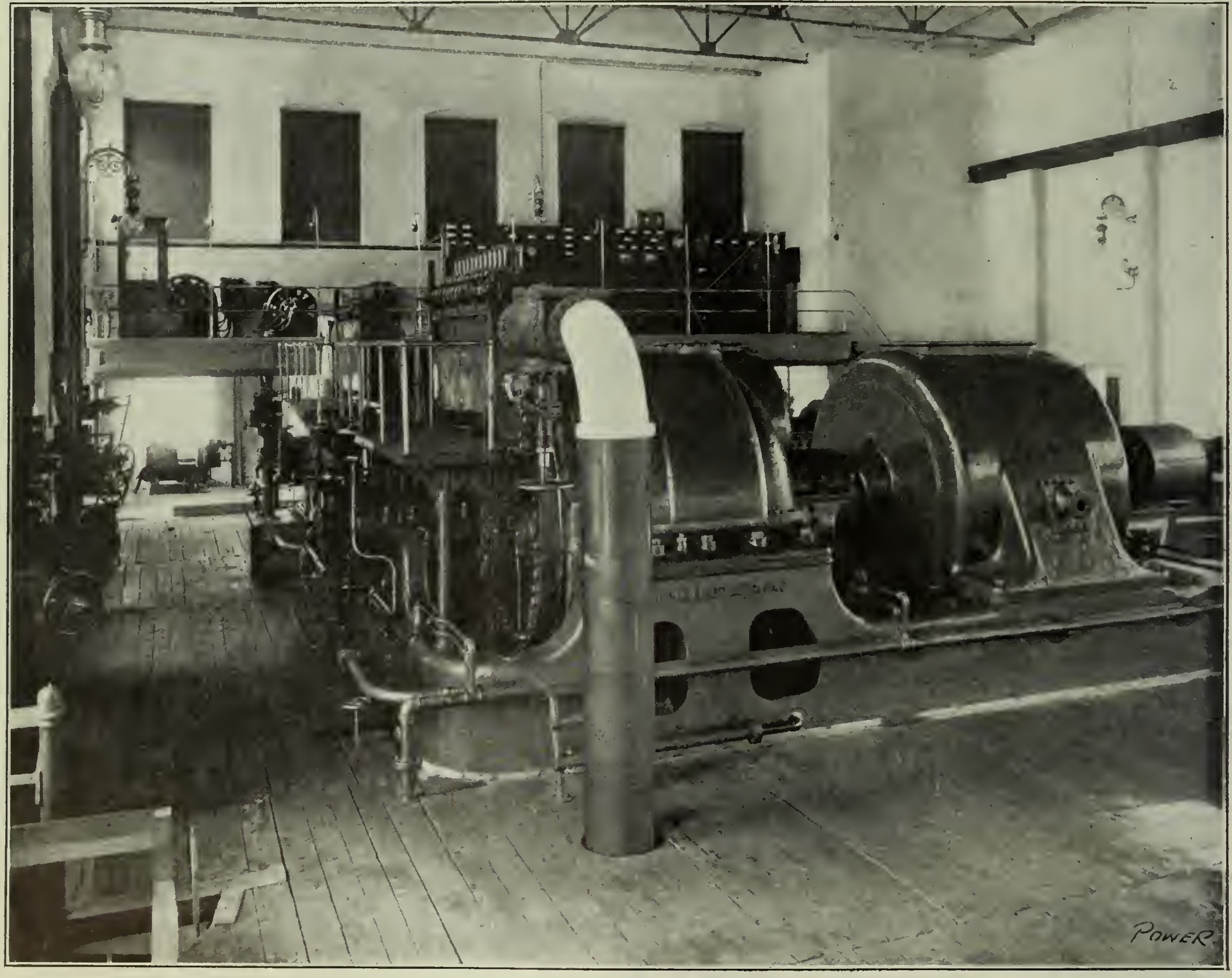


Fig. 3. View of the Two 3500-kilowatt Horizontal Curtis Turbines. The Permanent Floor Has Not Yet Been Laid

Boiler Room

The boiler room is worth going some distance to see, for it is not often that one can view 64 boilers set in a single row in a boiler room 500 feet long. These Manning boilers are each of 300 horsepower capacity, or a total of 19,200 horsepower. They are set in four batteries of 16 boilers and each battery is connected to a separate smoke flue. Figs. 1 and 2 show the cleaning and stoker sides of the boilers.

Beginning at either end of the boiler room, the brick-lined smoke flue extends the length of the first battery of 10 boilers and at a hight that will permit the smoke connection from each boiler to be made above the center line of the flue. The flue from each end battery then rises to permit the flue from each middle battery to form the lower half of a double smoke flue, which carries the gases to the stack, located outside and midway of the building. The smoke flue from each boiler is provided with a damper which is kept open while that boiler is in operation.

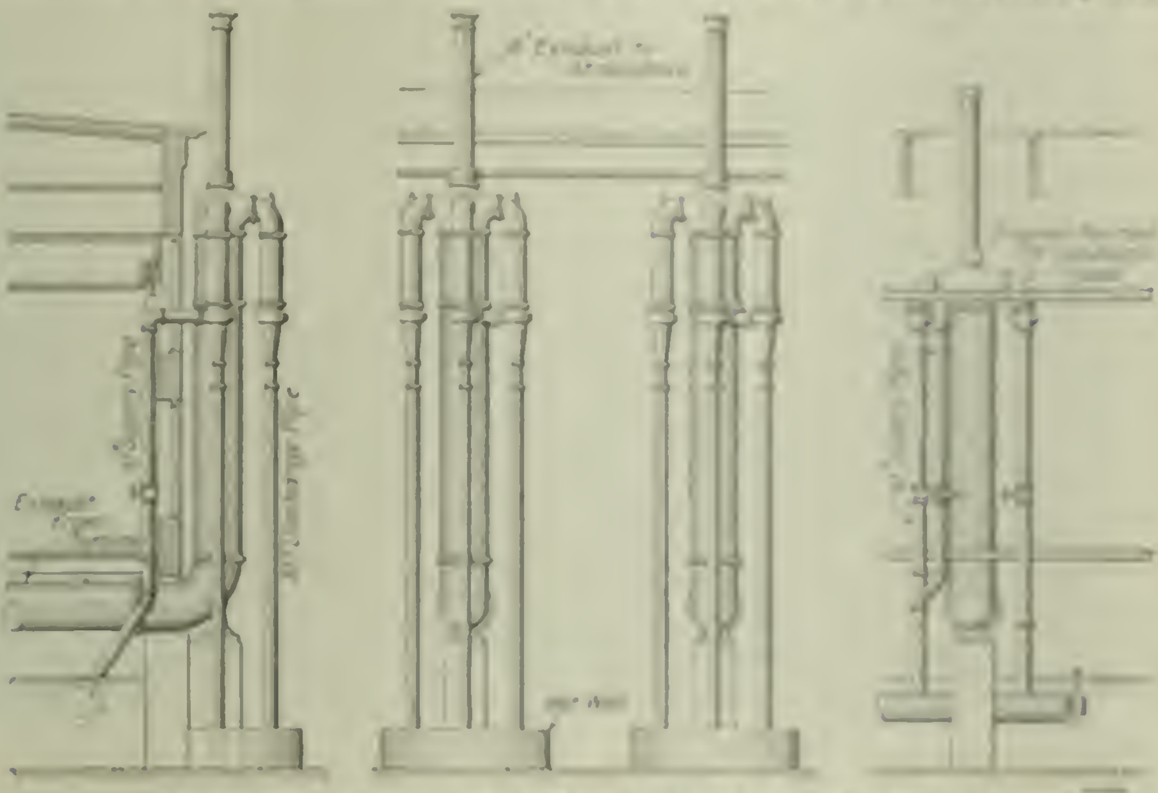


Fig. 4. Showing How the Condenser Head Was Altered

Forced Draft

Forced draft is used, and each battery of boilers is supplied with air by an 8-foot 8-inch fan blower driven by an 8x10-inch Sturtevant engine. The air is driven through a duct to the main air duct that extends the entire length of the battery which the blower is serving. A branch duct conveys the air to each boiler. The air is controlled by a swinging damper, one for each boiler, which is regulated by a hand lever attached to an extension rod and placed convenient for the fireman to operate.

The steam pipe of the blower engine is fitted with a Foster reducing valve to control the speed of the engine, shutting off the steam as the pressure in the boilers increases and admitting the steam as the pressure decreases. With this means,

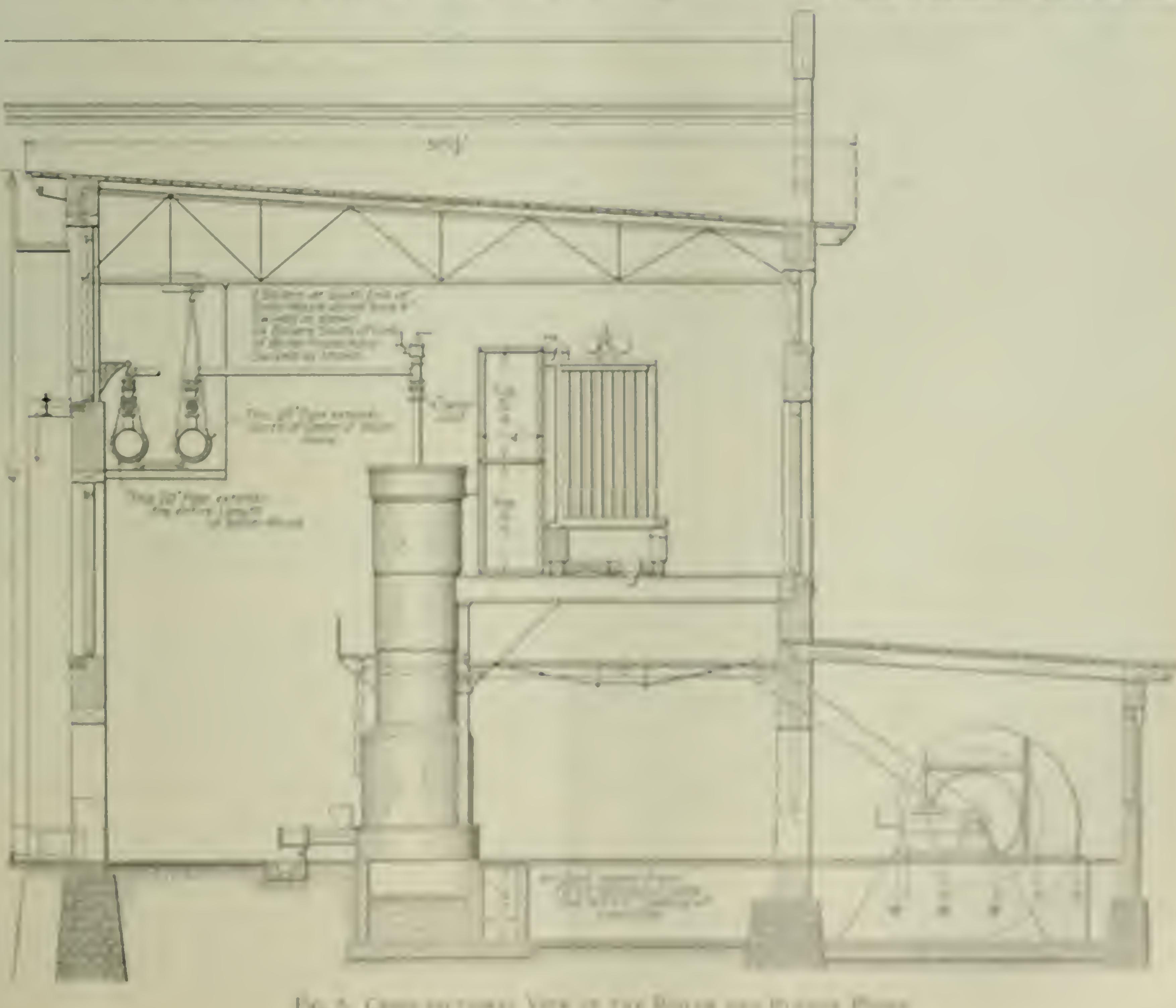


Fig. 5. Cross-sectional View of the Boiler and Blower Room

of draft regulation, the variation in steam pressure is between three and four pounds.

Stokers

The apparatus controlling the steam valves that admit steam to the cylinders of the Jones stokers for each battery of boilers, is driven from a cam shaft by means of sprocket wheels and a chain belt. As the speed of the fan decreases the speed of the stoker apparatus is decreased; when the pressure drops the speed of fan and stoker increase. With the blower engine running at full speed the stokers feed once per minute, but with a slow-speed and high-steam pressure the stokers feed but once in four minutes. Usually the stokers do not feed at all during the period that the blower engine is running at reduced speed.

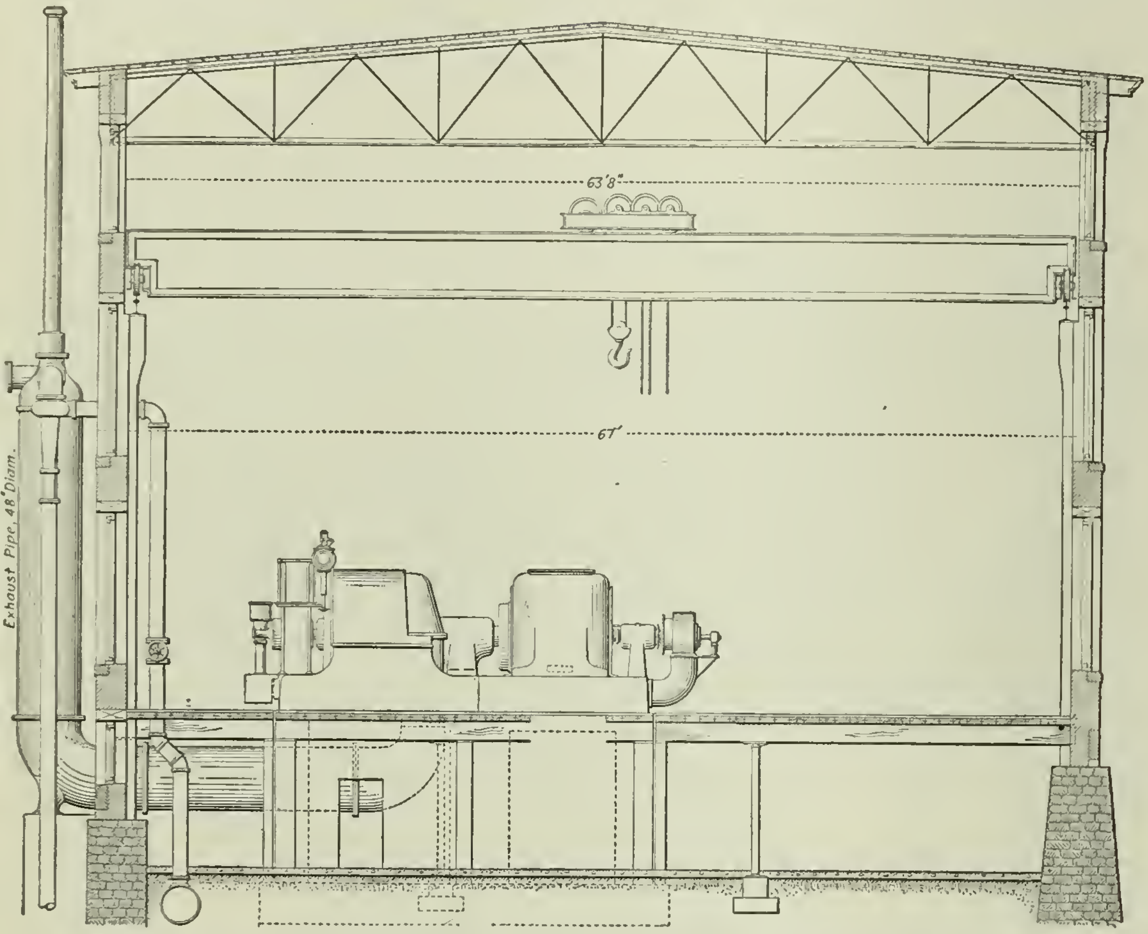


Fig. 6. Sectional Elevation of the Turbine Room

A Jones stoker is fitted to one side of each boiler furnace; the other side of the furnace is fitted with a cleaning door through which the fires are cleaned and kept in proper shape. One man handles six stokers, the work being that of keeping the hoppers filled with coal. One man cares for four fires on the cleaning side and one man wheels coal for eight boilers. When the entire boiler room is in operation, one man will be required per boiler, which includes the hopper man, the day and night boiler-room attendants and coal passers. A passage way has been left between each set of eight boilers, making it convenient for the men to pass from one side to the other without walking the length of sixteen boilers to do so. The boiler room has a concrete floor sloping toward the side wall so that after cleaning fires the fine ash and dirt can be washed to a trench next to the wall and out through a drain pipe into the river. Fig. 7 shows a plan and elevation of the boiler room. Fig. 5 represents a cross-sectional view of the boiler and blower rooms.

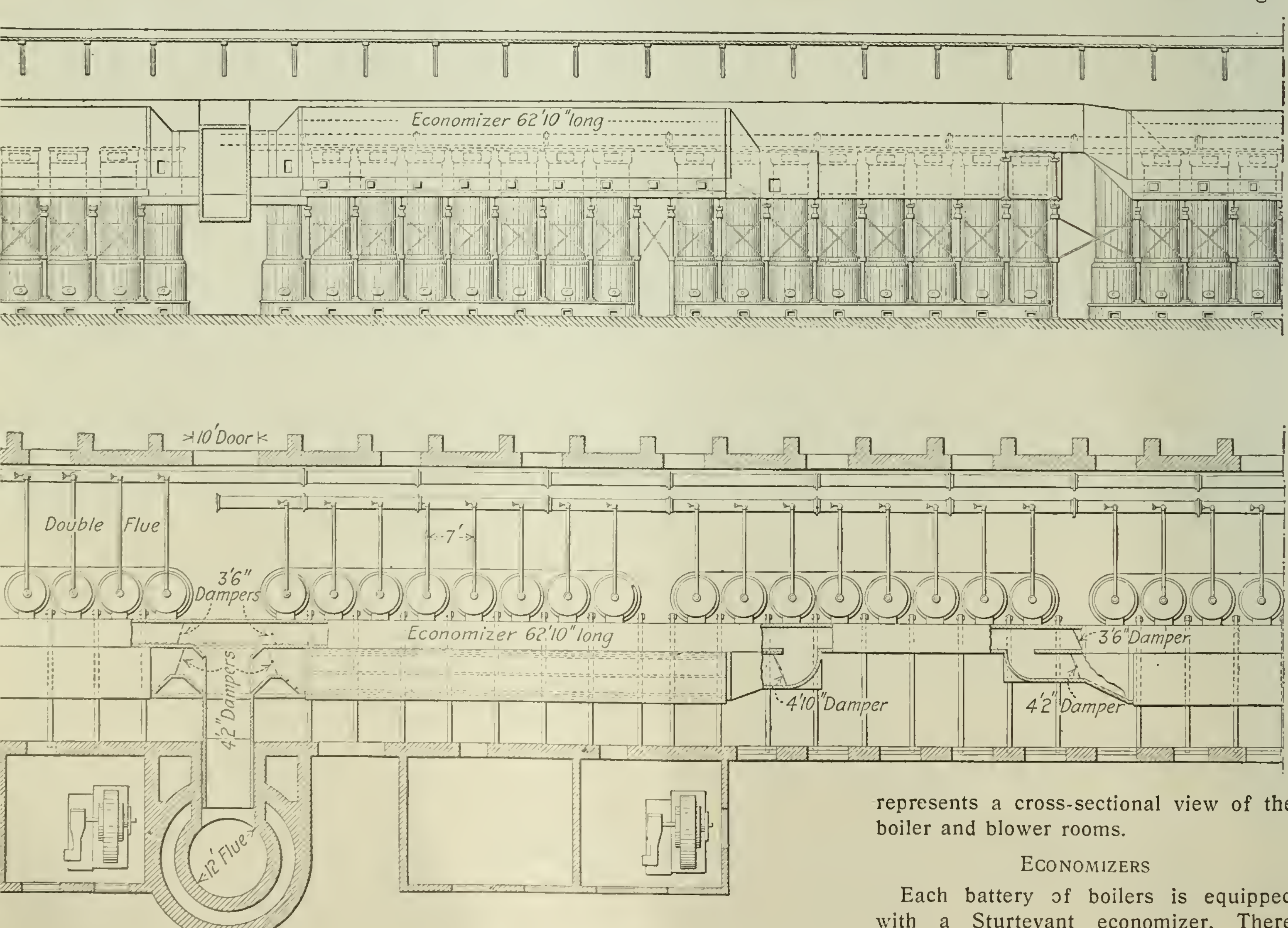


Fig. 7. Plan View and Elevation of Left Half of Boiler Room.

Economizers

Each battery of boilers is equipped with a Sturtevant economizer. There are four in all and the scrapers are driven by one motor from a shaft attached to the side wall of the boiler room. These economizers can be cut out from the main smoke flue by means of suitable dampers, and the water passing through the tubes can be bypassed direct to the boilers, entering them at the temperature obtained in passing through the feed-water heater; this is about 130 degrees, and passing the water through the economizer raises its temperature 70 degrees.

Fig. 8. Partial View of the Pump Room

Pump Room

In the pump room, which is located between the boiler and turbine rooms, and illustrated in Fig. 8, are two Worthington 14, 20 and 12 by 15-inch duplex boiler-feed pumps, pumping against a pressure equal to 190 pounds. There is also one 12 and 7½ by 10-inch duplex pump, which is used when but few boilers are under steam. The exhaust from these pumps and the blower engines go through a Reilly multicoil feed-water heater and then through an open heater. The feed water passes through the heaters in a direction opposite to the flow of the steam, so that the hottest water receives the heat from the hottest steam.

Boiler-room Piping

All overhead pipes throughout the boiler and the pump rooms are suspended from wall brackets by means of chains and hook bolts, as shown in Fig. 7. In some instances two pipes are suspended from the same bracket by means of an extension piece, as shown in Fig. 8. This method of pipe suspension is very flexible, as the hook bolt can be adjusted so that a pipe may have any desired pitch. It also allows the free movement of the pipe when under expansion or contraction stresses. The two main steam pipes expand 1 foot in their 300 feet of length. Both are anchored about 30 feet from the end next to the turbines and the expansion is all toward the other end. In order to overcome undue stresses in the pipes leading from the boilers to the main steam pipes, swivel joints are used on all of the boiler connections with the exception of the first nine boilers nearest to the pipe anchor. The swivel joints consist of a sleeve having a flange the size of the pipe connection at one end and a smaller flange at the other. Over this flange a two-piece gland is fitted, and this is followed by a collar. Square packing of suitable make is placed between the split gland and the ring washer which fits over the smaller gland on the sleeve. One section is secured by means of flange bolts to the outlet pipe of the boiler, the large flange of the sleeve is secured to the pipe leading to the main by means

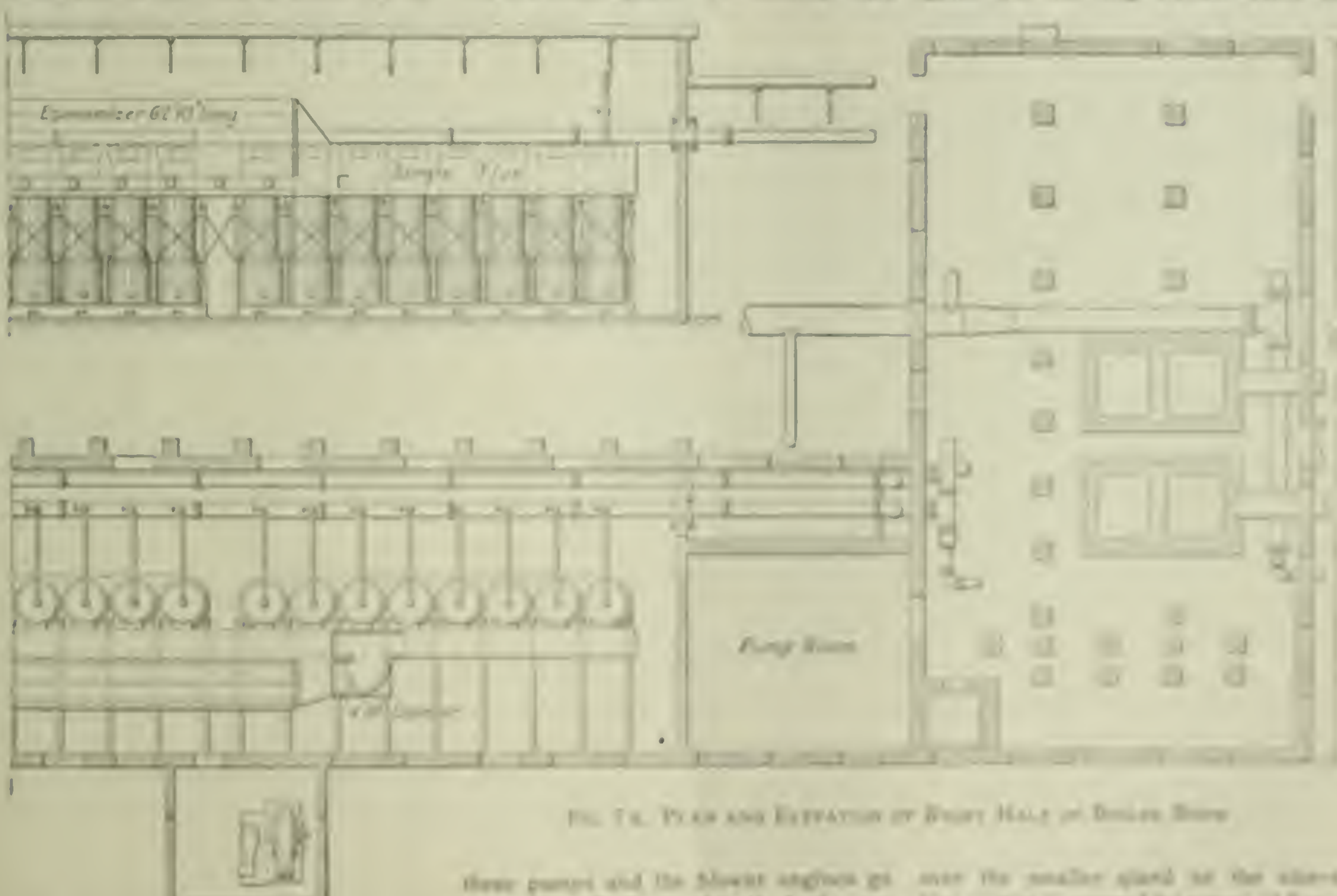


Fig. 7a. Plan and Elevation of Right Half of Boiler Room

of bolts, while the two-piece gland and washer is secured to the upper gland. This allows the pipe and sleeve to turn in either direction. The first set of thirty-two boilers is connected to one steam main and the second set is connected to the other steam main. In order to permit steam to be used in either main in case of accident, the first eight of the second set of thirty-two boilers are connected to both steam mains, the upright pipes of each boiler being fitted with two of these expansion joints. This allows the top pipes to turn in one direction in case the main is cold, and the lower pipes to turn in the other direction when the other main is hot.

The feed pipes are divided into four sections, one for each battery of boilers, and are placed on brackets on the rear side of the boilers; the live steam and exhaust pipes from the stokers are also suspended from these same brackets. The live and exhaust steam pipes from the blower engines are suspended from brackets running along the outside wall of the boiler room. At a convenient point on the stoking side of the boilers, an iron walkway is provided for the water tender. Hand regulation of the feed water is maintained.

Handling the Coal

One idea in having the boiler room of such length was to make it convenient for handling the coal from the storage bins to the boilers. These storage bins have a capacity of 16,000 tons. The coal is brought to the plant by rail and is unloaded to the bins by means of a clam-shell bucket, which is operated from a traveling coal conveyer. This runs on a track, one rail of which is supported by concrete piers and the other rail by the brick piers, forming a part of the boiler-room wall. This bucket is capable of handling one ton of coal each lift and besides being used for the unloading from the cars to the coal pile it is also used to convey coal from the outside edge of the pile close to the boiler-room doors in case the coal supply becomes low. All the coal consumed in this plant is wheeled in coal cars, each having a capacity of 500 pounds. The ash is also handled in the same manner.

Stack

Midway of the building and on the outside, is a 200-foot brick stack which has a 12-foot flue. Owing to the forced draft, considerable fine coke and ash is carried to the base of the stack through the smoke flues, it being too heavy to go out at the top. It is necessary to remove this about three times a week, the total amount of accumulation being about 15 cubic yards per week. A rather unique idea has been worked out for removing this ash. An 8-inch pipe is built into the base of the chimney, extending level with the concave bottom. In this pipe a small ¾-inch air pipe is inserted with a U-bend on the inner end. When it is necessary to remove the accumulation of fine coke and ash, air is turned on this small pipe at a pressure of 100 pounds per square inch. The air passes to the U-bend, where its direction of travel is reversed, and as the air escapes from the end of the pipe, a partial vacuum is formed, which draws the accumulation to the base of the stack and discharges it through the outlet of the large pipe into the river. This eliminates the necessity of handling the fine ash deposits by means of manual labor.

This power plant was designed by and erected under the supervision of Capt. Charles H. Manning, mechanical engineer of the Amoskeag company, from which the foregoing data and accompanying illustrations were obtained.

Engine Room Mismanagement

By Hubert E. Collins

Several instances in which outside help had to be called in to solve difficulties which could have been overcome by the exercise of common sense on the part of the engineer.

In a certain hospital in New York City the operating conditions were very bad. Investigation showed that all high-pressure drips led through leaky traps into the sewer. About half these traps were not working at all and the steam was bypassed direct into the sewer. The cylinder and steam-chest drips on each of the engines were connected together and led to a leaky trap. One of these engines was operated continuously and the other two were operated during the winter from four to six hours each evening. The engineer in charge operated the engines with these drips wide open all the time. The steam from the steam chest leaked into the cylinder drips and alternately from end to end of the cylinder. The engineer claimed that it was necessary to operate with the drips open, as water sometimes came over from the boilers. It was true that the boilers were dirty and foamed at times, but he ran more chance of wrecking his engine by leaving all the drips open while running, connected as they were, than by closing them. Upon examination the boilers were found to be coated with scale from $\frac{1}{32}$ to ⅛ inch thick.

The exhausts from two feed pumps and one large house pump, in continuous operation, were piped to the atmosphere, and the hot-water supply was heated by live steam. The low-pressure drips were trapped and led with the returns from the house-heating system into an open heater, from which the water was drawn to feed the boilers. The fact that the hospital was free from water tax gave the engineer the impression that it did not matter how much water was used. But all water in the building was taken from the large house tanks on the roof, to which it was first pumped by the house pump. The low-pressure drips which entered the open heater with the heating returns were found to be bypassed by the traps and created enough pressure in the heater to cause all the water to siphon out into the sewer; consequently the cold water from the mains poured into the heater almost continuously, to supply the makeup to the boilers. This necessitated burning more coal in order to get up steam; but the worst feature of the arrangement was that the house pump had to be in continuous operation to keep the tanks full, and at times this pump could not supply all the water needed.

The passenger elevator was in bad condition, having poor contacts in the controlling box and on the magnets; the counterweight cables were too long and some contact springs were broken. Also, the freight elevator was shut down because many of the push buttons were out of order.

The fire service, which is so important in a hospital, was not in operation at all. The standpipes had no water in them, as the valves connecting them to the house tanks were closed. The hose had never been tested, the porters had never been drilled for fire service, and when the fire gongs were tried the wiring was so defective that they would not ring.

The engineer had been in charge of the plant for four years, having taken charge when it was new, and had not inquired into a single feature of operation tending toward its betterment. When anything broke down he was accustomed to send for outside help, and had allowed the plant to become a menace to the safety of the occupants of the building.

The board of directors finally called in outside aid, and when these defects were pointed out to the engineer he declared they could not be helped, and that he was operating as well as anyone could under the circumstances.

The first changes that were made were to stop all leaks past traps and to connect all pump exhausts to the heating coils in the hot-water tanks. This saved the use of live steam for heating water, and, by saving all of the drip returns from the heating system, it cut off entirely the use of cold water for boiler feed, while at the same time, the house pump was not required to operate more than one-third the time.

All these changes to effect economy and give uninterrupted service on the elevator and lighting service required about two months, but in the first month the coal bill was cut from $710 to $590 on the same output, and during the second month so much saving in steam consumption had been effected that only one boiler was required, whereas two had formerly been in constant service. This boiler steamed so easily after having been overhauled that a low grade of coal was used, with the result that the second month's bill was $280; at which figure it kept during all the winter months.

A Lack of Ordinary Judgment

An instance where the man in charge did not use ordinary judgment in locating a simple cause of trouble is shown in the following.

At a certain summer resort a hotel stands on piling out over the bay. The lighting is furnished by a small isolated plant located in a separate building, and the equipment consists of a locomotive boiler, a small high-speed engine and a dynamo. The engine has combined relief and drip valves, with a star wheel having a rising stem. When the stem extended through the wheel, the operator knew that the drips were open, and when the wheel was loose on the stem he could tell that they were closed.

The drips from the cylinder led through these valves and in this instance were piped together into a tee, as shown in Fig. 1. From the tee the drips led outside the building and discharged into the bay. The water supply to the hotel and the feed water for the boiler were taken from one tank.

The complaint was made that the engine ran badly, that the exhaust made so much noise as to annoy guests and cause them to leave; furthermore, that the engine used so much steam that it had to be shut down by 9 or 10 o'clock in the evening, leaving the place in darkness as the hotel was not piped for gas.

An expert was called in and discovered the cause of the trouble immediately upon entering the engine room. It all lay in the engineer's misconception of how the drip valves looked when open. When the expert looked at the engine he casually remarked that the drips were open, as was not unusual, for the engine was standing idle. The engineer said that they were all right, as he had set them that way when he first took the job and they had remained so all the time.

Questioning confirmed the fact that the engine had been running with the drips wide open all the time. The cylinder was 7 inches in diameter, with 1/2-inch drips, which were wide open for steam to flow from end to end of the cylinder, the surplus exhausting in a steady roar

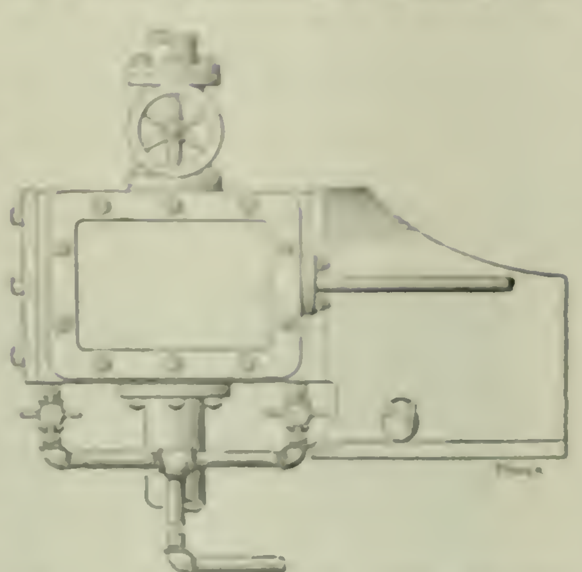


Fig. 1. Showing Drip Pipes Together

out of the drip line. Here was the cause of all the trouble and the engineer did not understand enough about running an engine to know that steam should not come in a steady stream from the drip pipe from the cylinder.

Trouble Could Have Been Prevented

Another instance where a little observation and thought would have prevented trouble is shown in the following incident. The engine in a factory plant was giving trouble and the engineer, acknowledging himself to be at a loss to account for the cause of the difficulty, allowed the proprietor to send for outside aid. When the expert arrived, he was told that the engine not only would not govern, but used so much steam that the boiler could not keep up the required pressure to run longer than half an hour at a time. The engine had been shut down for two weeks' repairs and after being started behaved in this way. The cylinder and valves on this engine are illustrated in Fig. 2, which shows the steam and exhaust valve on the crank end, the head-end valves being cut away to show the steam passages.

The engine was started to observe its action and the first thing noticed was that steam was steadily blowing through somewhere. The trouble was located at once on the crank end of the cylinder. After shutting down, the steam-chest cover on the crank end was taken off, and while turning the engine one complete revolution, it was observed that the steam valve did not seat by 1/8 inch at any time. The steam was blowing through on that end all the time, but why this valve should not seat was puzzling, for the stems appeared, as shown in Fig. 3, with the lower end turned to a small shoulder. This small end enters the yoke up to this shoulder and is secured in place by a set screw, as can be seen in Fig. 2.

The valve stem in this instance was apparently down on this shoulder and the valve should have seated.

When the valve and stem were taken out, the cause of the trouble was apparent. The valve stem had worn small in the packing box; to remedy it, it had been turned off up to the [illegible] the size of the small end of the stem, and a bushing had been put over the stem, making it the original size, with the lower end of the bushing forming the shoulder in fitting up on the valve yoke. It was assumed that at some time the valve stem

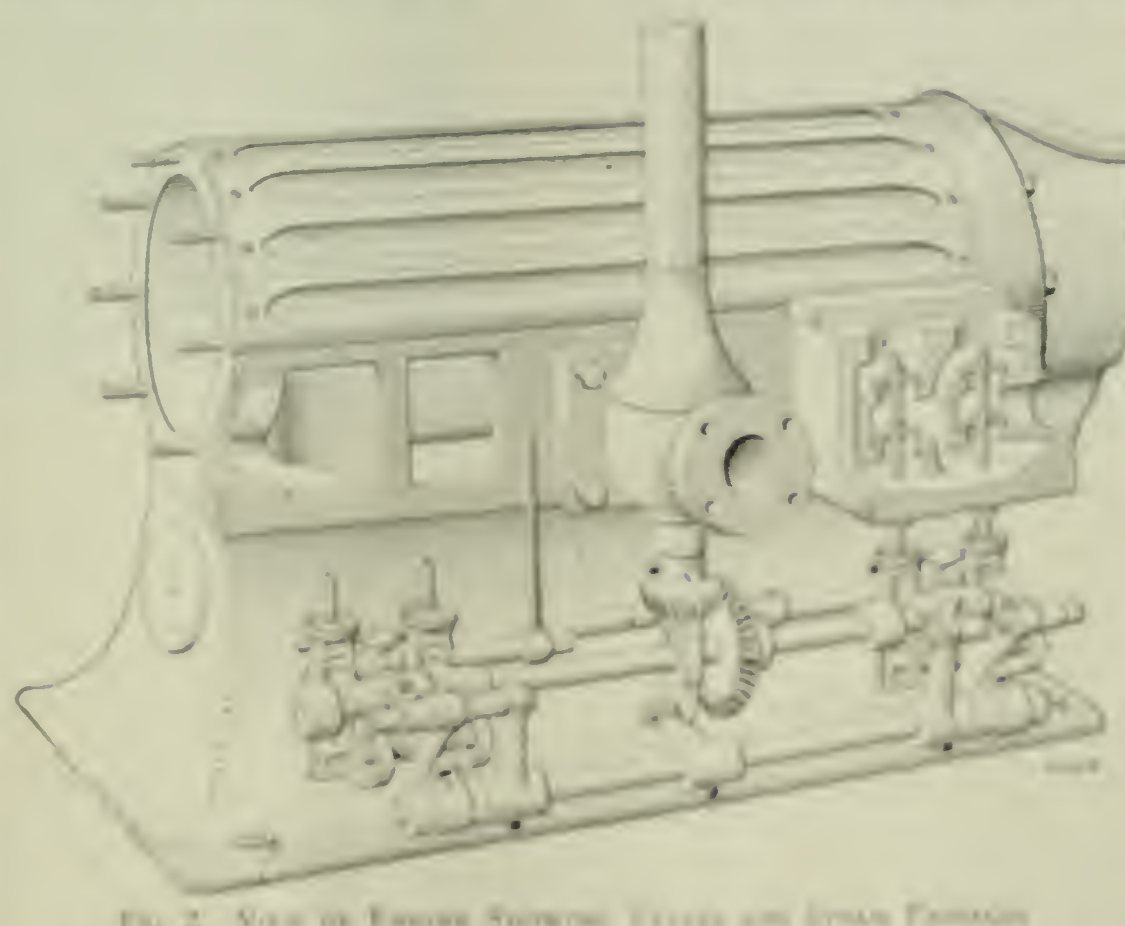


Fig. 2. View of Engine Showing Valves and Steam Passages

had become loose in the yoke and slipped up through the bushing until it was flush with the end of the valve stem, so that whoever took it out thought the small end was broken off, not noting the gap on the stem between the bushing and disk.

At any rate, the bushing on the stem had slipped down to the end of the old stem and a hole had been drilled and tapped into this, with a stud screwed into it, making the whole stem length longer by as much as the bushing had slipped down, in this instance ⅝ inch. This is shown by Fig. 4, where *A* is the gap between the bushing and disk on the stem. The amount added to the length is apparent. The stem had been put back with this added length which did not allow the valve to seat.

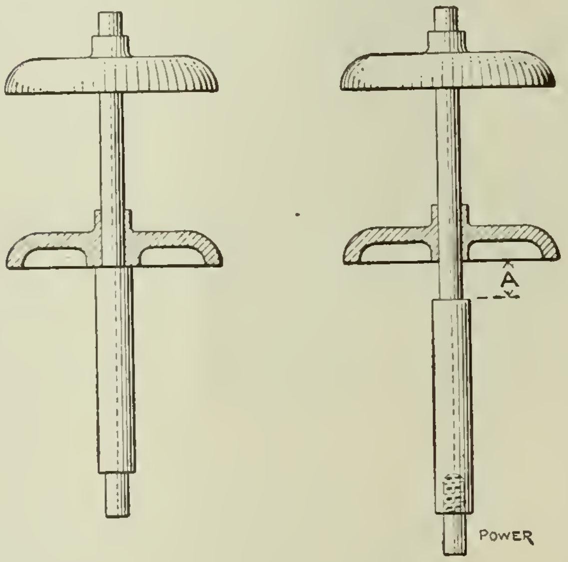
A striking feature of it all was that the valve stem was of steel and the bushing of brass; so that it attracted the expert's attention to the trouble at once. Neither the machinist nor the engineer had noted this, but had deliberately gone ahead and added to the length of stem and thus caused the trouble.

Pump Cylinders Out of Line

In a department store there is a large three-cylinder compound steam pump, the valves of which had been reset after a complete overhauling by an outside firm. The pump would have been accepted if the diagrams had not shown that with 120 pounds initial pressure in the high-pressure cylinder there was from 36 to 41 pounds back pressure in the high- and only 29 pounds initial pressure in the two low-pressure cylinders. This showed too much back pressure in the high-pressure cylinder and too great a loss in the receiver. The cutoff in the high-pressure cylinder was about 60 per cent. of the stroke, and this was changed to about 45 per cent. of the stroke, with the result that the receiver pressure was brought down to 30 or 31 pounds and the initial pressure in the two low-pressure cylinders remained at 29 pounds. This economized in the use of steam and by reducing the back pressure in the high-pressure cylinder, the same amount of mean effective pressure was obtained with less steam and the two low-presusre cylinders received enough steam to do their work. It proved that before the change was made there was too great a volume of steam admitted to the receiver for the low-pressure cylinders to take care of. After this slight change in valve setting, the work was accepted.

This pump has three steam and water cylinders, side by side, and the center line of the steam cylinder and guides is also the center line of the pump cylinder.

When the pump was first stripped for repairs, the repairmen were told to run lines through the cylinders and report if they were out of line. They reported to the chief engineer that the water ends were from $\frac{3}{16}$ to ½ inch low and would need raising. This would have necessitated the breaking of eight large joints on the water end, the use of tackle and jacks to raise the water cylinders and the resetting of the frames on the foundations, which meant an indefinite shutdown and the expenditure of several hundred dollars. They were ready to proceed with the work when the chief called on the outside man to go over the lines and verify the supposed conditions. This is what was found: In the first place, the lines of twisted cord, about 3/16 inch in diameter, had been put through the cylinders. These lines were too heavy for such work and one end was fastened outside the open end of the steam cylinder and, passing through the stuffing box, guides and water cylinder, was fastened outside the latter in such a manner that the line could not be stretched very taut.



Figs. 3 and 4. Valve Spindle Before and After Being Altered

Even with the most rigid attachment, this line could not have been stretched enough to prevent a serious sag. This attracted the attention of the investigator at once and, after observing the conditions, he took the calipers and proceeded to find the truth of the setting. He found the line set true in the steam-cylinder counterbore and in the stuffing box of the same cylinder, but along the guides and in the water cylinder the line was high, or the guide and water cylinder were low, getting worse toward the end of the latter. Each of the three water cylinders were low, according to the setting of these lines, but the investigator contended that there was a sag in the lines so that in order to set the line true at the steam-cylinder end the opposite end would have to be raised, and the water cylinders were low in varying degrees, according to the tautness of the individual lines.

He had these lines taken down and new, fine lines of woven sea grass substituted. Then they were stretched taut and set true at the steam end, after which it was found that all three of the guides and two water cylinders were in line with the steam cylinders, and one water cylinder was 1/16 inch low. This cylinder was lined up by shimming. The job took only two days, as against the weeks of work that it would have taken to make the other cylinders so much out of line that the pump could not have run, in the first place, and the work would have had to be gone over again before it was right.

High Gas Velocity in Boilers

Of late much attention has been directed to the increased heat-transmitting power of boiler plates by making the hot gases travel at a high velocity. C. E. Stromeyer, chief engineer of the Manchester Steam Users' Association, has the following to say on the subject: High velocity means that the resistance in narrow and restricted passages is so much increased that it exceeds the resistance in the bed of fuel, and has to be seriously taken into account, and the question arises whether the extra cost for producing this necessarily powerful draft is balanced by the advantage of being able to use a small boiler. The question is perhaps deserving of attention by marine engineers, but with them the tendency is at present toward water-tube boilers, which, as is well known, offer very little resistance to the flow of gases. In any case trouble is almost certain to arise if the principle is carried to excess, for the effects associated with what may reasonably be called a blowpipe flame acting on a very small surface is that this surface tends to warp itself on account of very great differences of temperature on either side. If the water is sedimentary all the scale will be deposited locally and result in overheating, and in addition there will be difficulty in providing locally the necessary supply of water, without which, of course, no evaporation takes place, and overheating and bulging result. The locomotive boiler, the Lancashire multitubular and, in fact, most smoke-tube boilers, do cause the gases to move quickly, but further reductions of the tube section can only be made if artificial draft is resorted to, and artificial draft, although it is likely to be efficient in ordinary cases, where the natural draft is inefficient, does sometimes aggravate the evils which it is called in to remedy. The Admiralty had no end of trouble with leakages of the tube plates of its Scotch boilers because of the intense heat transmission at these parts.

Artificial draft has to be paid for in steam consumption, and when certain limits are reached no further gain is possible. In a recent case it was found that in spite of using 25 per cent. of the steam generated for jets, they added less than 20 per cent. to the steaming power of the boiler, which was therefore being more heavily worked than before, and yet supplying less steam.

Automatic Shaking Grates

By A. R. Maujer

Boiler grates originally designed to be shaken by hand were fitted with automatic shaking mechanism which resulted in improved operating conditions and economy.

With hand-fired furnaces and shaking grates a very common trouble is that the fires receive first a feast and then a famine of shaking, so to speak. Even though the fireman has had plenty of experience, he will neglect to shake the grates as long as he dares, in order to avoid as much work as possible and because it is slightly easier, probably, to operate the fires. As a consequence, the fires get dirty, the draft poor and the combustion becomes proportionately bad. When the grates finally are shaken, the fires are so broken up and the fuel bed so thinned that the temperature drops abnormally when green fuel is added.

FIG. 1. MECHANISM FOR AUTOMATICALLY SHAKING THE GRATES

To eliminate this variable element in the operation of the fires, George Schautz, consulting engineer for the Jacob Dold Packing Company, at Buffalo, N. Y., has designed and installed in the Buffalo plant of this company an automatic shaking mechanism, using the same grates that were installed with the boilers.

As happens in the power plant of practically every growing industrial concern, a time came when the boilers as well as the engines and other apparatus were so heavily overloaded that extension became imperatively necessary. The original boiler equipment consisted of ten return-tube boilers, each rated at 100 horsepower. The boiler room was so located between other buildings that no additional floor area was available unless some other location was selected and an entirely new boiler house erected.

The original amount of head room in the boiler house was only 21 feet. By increasing this to 34 feet it was possible to install water-tube boilers in the place of the old fire-tube boilers and, without increasing the floor space occupied, secure a great increase in boiler capacity.

The first change to be made was the removal of five of the 100-horsepower fire-tube boilers and the installation in their stead of four Fitzgibbons boilers, each of 275 horsepower capacity. Later, the five remaining fire-tube boilers were replaced by four Keeler water-tube boilers of a combined rated capacity of 2140 horsepower. Both the Fitzgibbons and the Keeler boilers were fitted with Ajax shaking grates for burning run-of-mine bituminous coal which comes from the Shawmut, Penn., district.

After the new installation had been in operation for a few months, Mr. Schautz decided that conditions in the boiler room could be improved if some means were found to obviate the irregularity which the shaking of the grates by hand produced. After some study and considerable experimenting, the arrangement shown in the accompanying figures for automatically shaking the grates was installed in connection with the Keeler boilers. Later, it was extended to operate the grates under the Fitzgibbons boilers also.

The chief difficulty was to secure a low enough rate of rotation for the eccentric shaft. This was finally overcome in the manner shown. A small high-speed engine was mounted in the alley between two batteries of boilers. A small sprocket on the engine shaft drives a lay shaft by means of a chain and large sprocket on the latter. A small sprocket on the

FIG. 2. MECHANICAL DETAILS OF SHAKING MECHANISM

lay shaft drives the chain which runs over the large wheel keyed to the eccentric shaft. In this manner the speed of the eccentric shaft is reduced to about two revolutions per minute.

The system has the greatest flexibility. Fig. 2 serves to illustrate the manner in which this flexibility is secured. The tappets *A* and *B* can be adjusted so as to give the grate either slight or considerable motion as may be desired; or, the eccentric rod may be completely disconnected when it is desired to shake the grates by hand or so allow them to remain entirely undisturbed for a period of time.

This automatic shaking arrangement has given complete satisfaction. It makes the firemen's work easier; the fires are maintained in a more even condition, and an appreciable gain in economy has been effected. The fires are carried at a uniform thickness of about 6 inches. The quantity of smoke emitted from the stack has been greatly reduced.

Recent Steam Engine Failures

By H. S. Knowlton

The description of a number of accidents taken from the reports of an insurance company, and the deductions arrived at by their investigators.

The following is an account of a number of recent accidents to steam engines, the facts being drawn from the investigations and reports of a large accident-insurance company:

The first case noted was that of a horizontal noncondensing engine fitted with a single slide valve driven by an eccentric keyed upon the crank shaft. The engine operated wood-working machinery, and was left without attention, as a rule, from the time the plant started in the morning until it was shut down at night. While the engine was in service it stopped suddenly, and it was found that the wooden wedge between the front end of the crank pedestal and the lug on the bedplate had come out of place and left the pedestal free except for the restraint of the holding-down bolts. The holes for the latter were long enough to allow considerable movement and the pedestal was forced forward sufficiently to bring one of the nuts which secured the slide valve upon its spindle into collision with the front end of the valve chest. The shock broke the eccentric strap, and at the same time the connection between the eccentric rod and the crank shaft thus leaving the slide valve stationary.

Another accident was caused by a stray bolt and nut. The trouble occurred in connection with a vertical, single-acting air pump, driven by links from the low-pressure piston-rod crosshead. The bucket was hollow, flat on top and conical on the under side, being divided internally by six radial ribs into compartments to which access was obtained by holes in the upper surface of the bucket; these had been filled by screwed plugs after the cores had been removed. The bottom of the pump was also conical, with a central hole 16 inches in diameter to facilitate boring. This hole was closed by a flanged and spigoted cover 7/8 inch thick, whose upper surface was turned to form the apex of the conical surface of the air-pump bottom. The cover was secured by fourteen 3/4-inch studs.

While in regular operation one morning, the cover was broken and driven off. Upon examination a crushed and battered T-head bolt was found below the pump, and on drawing the bucket the nut belonging to the same bolt was found jammed tightly into a hole in one of the compartments. It appeared that the bolt, possibly with the nut screwed upon it, had become lodged in the bucket after the cores had been removed, and had been left there when the core holes were plugged. Here it had rolled about till the nut had come off, and the bolt or nut, or both, had worn a hole in the bottom of the bucket. The bolt, having a head smaller than the nut, had dropped through the hole, rolled to the bottom of the pump, and been driven through the cover by the next downward stroke of the bucket.

The next case was that of a 42x60-inch vertical condensing engine, running compounded with a 19x60-inch horizontal noncondensing engine, the two being coupled to the same shaft. The speed was 42 revolutions per minute and a boiler pressure of 110 pounds per square inch was carried. Each cylinder had a short slide valve, the valve chest of the horizontal engine being on the top of the cylinder and that of the other engine being on the side facing the crank shaft. The valves of the latter were driven by an eccentric keyed to the crank shaft through a light eccentric rod, rocker shaft and links below the engine-room floor. The cylinder was a plain tube, with a port at each end, to which the valve chest was bolted. Its cover and bottom were spigoted, so that the vertical distance between them measured on the inside was less than the distance between the extreme edges of the ports; therefore, water could not lie on the bottom of the cylinder without running into the port. The valve chest was a large rectangular casting with flanged openings half way up the right and left sides, to which the steam pipe from the horizontal cylinder and the exhaust pipe to the condenser were bolted. These openings were about 16 feet above the water surface of the pond from which the condenser was supplied. The air pump, driven in the usual manner, was 25 inches in diameter by 30 inches stroke. The condensing water was supplied through about 40 feet of 5-inch pipe, and there were two injection cocks, one 3 inches in diameter and the other 4 inches.

During the temporary absence of the engineer the fireman noted a change in the speed of the engines. He found the engine room full of steam, but was able to reach and close the stop valve of the horizontal engine. He then found the piston rod of the vertical engine disconnected from the crosshead, and the cylinder fractured nearly all around, close to the bottom flange. Further examination showed that the piston-rod cotter, which was 3½x¾ inches, had been sheared through, the crank forced about 1½ inches around the shaft, the rocker shaft which worked the valves being twisted and the cylinder bottom and piston broken. As no mark could be found on the piston or cylinder cover it was evident that the damage to the piston-rod cotter and the cylinder and the shearing of the keyway on the crank shaft had been caused by water in the top end of the cylinder, and that it had happened just before the crank reached the bottom center and the piston the end of its up stroke. It was also clear that the cylinder bottom had been fractured by the impact of the piston, driven down upon it by the steam pressure, when liberated from the crosshead. At first it was not evident where the water had come from, why there was no dangerous accumulation in the bottom of the cylinder, or how the twisting of the rocker shaft was related to the other damage. The following conclusions were arrived at by the insurance company's engineer:

First, a comparison of the volume of water supplied to the condenser per stroke, calculated from the temperatures of the injection and discharge, with the displacement of the air-pump bucket, proved that the water could not have come from the condenser. At the normal speed the displacement of the bucket was five and three-tenths times the volume of the water and condensed steam entering the condenser; consequently, the air pump would clear the condenser as ng as the speed of the engines exceeded or 7.9 revolutions per minute. The eman who stopped the engines was cern that the speed was not as low as s. Therefore, the water came from her the pipe connecting the two cylders, or from the boilers. The pipe as bolted to a nozzle on the left side the valve chest of the high-pressure linder, and carried horizontally for a ngth of 10 feet toward the vertical enne, and then upward for 4 feet, enterg the right side of the valve chest of e latter. It appeared that the water me from the boiler. The fireman had n the water nearly up to a full column, eparatory to shutting down for the ght, and the boiler had begun to prime. ne water carried over had passed rough the high-pressure cylinder withit accumulating enough to cause damge, and had been carried on to the valve est of the other engine, where the me and scum carried over interfered ith the lubrication, causing the valves stick and the rocker shaft to twist. ne effect of this was to lower the valves bout [illegible] inch, and to put nearly this nount of lap on the exhaust edge of the p valve, while giving the exhaust edge f the bottom valve about the same nount of lead. The port at the bottom nd of the cylinder then remained open ir exhaust almost to the end of the own stroke, but that at the top was osed while the piston was yet some 9 iches from the top of the cylinder. hus, small quantities of water entering e bottom of the cylinder could run back ito the port and be blown into the conenser during the down stroke, but enring the top could not escape, owing the port being closed before the pisn reached its level. The water entering ie top port, therefore, remained upon e piston and accumulated until its olume became greater than the clearice; then the break occurred. When ie low-pressure valve chest was opened was found that the valves and faces ere covered with a white deposit which roved that there had been priming, and ie rocker shaft had also been twisted nce before and at about the same time f day, apparently from the same cause. here was no relief valve on the top end f the cylinder of the vertical engine.

Another breakdown was caused by ater entering the upper end of the lowressure cylinder of a 10 and 1[illegible] by -inch vertical engine. The exhaust pipe ed from the valve chest of the low-presure cylinder in a horizontal direction, hen turned vertically upward for 2 feet, hen ran horizontally for 7 feet and fielly downward to the top of the conlenser, a conical receptacle of small caacity. The higher of the two horizontal engths of the exhaust pipe was about 0 feet above the surface of the pond rom which the injection supply was drawn. The air pump was of the horizontal type, with a 12x10-inch cylinder, and was steam driven. The frame which inclosed the cylinder and the moving parts fractured circumferentially close to the flange by which it was bolted to the bedplate. It appeared probable that the accident had been caused by the air pump failing to discharge the water forced into the condenser by the atmospheric pressure on the surface of the pond. This might have occurred in two ways: first, owing to the steam pressure being reduced previous to stopping, the air pump might have been running at a speed just sufficient to keep the condenser clear while the normal supply of water was passing through the injection cock, but not sufficient to discharge the larger supply which would enter the condenser when the vacuum improved owing to the governor's cutting down the steam supply when the machinery was being shut down; second, the engineer may have slowed down or stopped the air pump before destroying the vacuum in the cylinder. The condenser was equipped with a float designed to operate a small atmospheric valve in the event of the water rising above the normal level, but as the engineer had never seen the inside of this mechanism it was probably out of order; or, if it did lift the valve, the air entering was unable to destroy the vacuum before the water reached the cylinder. The insurance company's engineer called attention to the fact that water entering a condenser under a vacuum of 12 pounds had a theoretical velocity of about 42.5 feet per second, and an actual velocity of about 25 feet per second, which is sufficient to carry a considerable quantity of water into the condenser, even after the vacuum has been destroyed if the injection pipe is long. The best practice is to stop the engine before shutting down the air pump, in independent condensing plants.

A case of piston-rod breakage occurred in a triple-expansion engine running at 62 revolutions per minute, where the high- and low-pressure pistons were carried tandem on one rod, and the intermediate piston on the other. The rod carrying the two pistons was 10 feet long by 3[illegible] inches in diameter where it entered the crosshead, to which it was secured by a [illegible]-inch cotter, with rounded edges and a taper of [illegible] inch per inch. The cotter hole in the rod was 1[illegible] inches broad and [illegible] inches long, and the inside diameter of the socket in the crosshead in which the rod was cottered was [illegible] inch larger than the diameter of the rod. Two steel disks or shims, each [illegible] inch thick, were inserted between the end of the rod and the bottom of the socket, probably to compensate for reductions in the effective length of the connecting rod by the wearing of the brasses.

The piston rod gave way inside the crosshead socket at the cotter hole. The two pistons which it carried were projected backward, driving out both cylinder covers, cracking the larger cylinder back of the flange and breaking some of the studs connecting the front end of the high-pressure cylinder to the engine bedplate. From the appearance of the rod it was evident that the failure had been gradual. It appeared probable that if the rod end had been carefully examined when it was taken out of the crosshead to put in a new packing piece, the crack would have been discovered and the failure averted. The cause of the initial fracture could not be determined, but there was little doubt that it was concentration of stress upon a small part of the cross-section of the rod by the pressure of an imperfectly fitting cotter. The load upon the pistons, divided by the cross-sectional area of the rod, was 6788 pounds per square inch.

Neglect of proper foundations in erecting new engines upon an old site led to the breaking of a bedplate in connection with a 1700-horsepower horizontal tandem-compound engine. The foundations for the original engines had been built of good ashlar blocks, but during many years of service the stones became saturated with oil, the cement softened and squeezed out of the joints, and settling took place, especially under the crank-shaft bearings, until finally the bedplate broke. When the replacement of the engines was under consideration the casualty company's engineers advised the rebuilding and strengthening of the foundations, but on account of a lack of time this advice was disregarded, and the new engines were erected upon the old dilapidated seats. As soon as they were put in operation, movements were observed, and, although the joints between the stones were wedged open, cleaned out and pointed, and the engine bedplates wedged up and screwed down, neither the engines nor their foundations could be made firm. A week was spent in cleaning oil from the joints of the stones and the bottom of the foundations, the joints were again run with cement, and the movement was much reduced, but the flywheel and shaft were not lifted to take their weight off the bearing, neither were the nuts of the holding-down bolts slackened, to allow the bedplate to come to its natural position so that it might be packed and properly supported. The result was that the bedplate cracked near the holding-down bolt next to the crank-shaft bearing. This accident illustrated the great importance of keeping oil off the foundations, particularly in cases where engines are erected on masonry foundation structures.

In this connection the insurance company's report pointed out that when using masonry foundations, bedplates cannot be placed on their under sides and bedded by running against the foundation. They are usually leveled up on small iron wedges and grouted with cement or fine concrete. The bearing surfaces on the under sides are often not more than 3½ or 4 inches wide, and even when kept dry are insufficient to hold a heavy engine absolutely steady for any length of time. As soon as motion begins, the cement is ground away and the wedges become loose. To stop the motion the foundation bolts are tightened, and so the process goes on till the bedplate breaks. When oil reaches the grouting, destruction is far more rapid. It is good practice, if wedges are to be used, to have them machined and of substantial thickness and large area, bedded to machined surfaces on the under side of the bedplate at each foundation bolt. The lower wedges should be set at the right level in cement, and the upper lightly driven between them and the bedplate, when the latter is in position, on temporary supports. At the crank end, projections may be cast on the under side of the bedplate to engage in recesses in the concrete, to prevent end motion. If wedges are not relied upon, the bearing surfaces on the under side of the bedplate must be broad, so that if the oil softens the edges of the grouting there may still be sufficient hard cement between. Footings at least 8 or 9 inches wide are desirable with large engines. The foundation bolts should also be increased in number to make the bedplate grip the grouting at as many points as possible. The most substantial plan, however, is to cover the concrete where the engine is to rest upon it with strong cast-iron plates with raised facings to receive the planed feet of the engine bed and raised edges to return oil and water.

Corrosion and the accumulation of scaly deposit in a 100-kilowatt steam turbine caused serious damage to the machine only five months after a complete overhauling. The turbine had fifty-four rows of blades, increasing in diameter from 6½ to 12½ inches, and its speed was 3000 revolutions per minute with a boiler pressure of 160 pounds per square inch. All the blades of the first thirteen rows at the high-pressure end and the corresponding blades in the casing were broken off at the roots and crushed into one mass, which stopped the turbine. In addition half the blades in the next eleven rows were found to have been in contact with the casing, but it was not possible to determine whether this had happened before or after the first thirteen rows had been stripped. The blades of the high-pressure end were of copper, brass being used at the low-pressure end.

Can and Plate Systems of Making Ice

By F. E. Matthews

What is meant by "can ice" and by "plate ice" and a description of the processes involved in their manufacture. The economic phase of ice making is also touched upon.

Next in importance to the direct utilization of refrigeration, such as for the cooling of perishable products, etc., is that of artifical ice making. While there are a number of systems which may in the future modify present methods, practically all the ice produced today is made by either the can or the plate system.

The Can System

In general, the process of manufacturing can ice consists of immersing cans of water in brine tanks not unlike those employed for cooling brine for brine-circulating systems. First, the specific heat, then the latent heat of the water is given up to the brine which, in turn, passes it on to the liquid refrigerant, most commonly ammonia.

Distilling Apparatus

Since any impurities in solution or suspension in the water fed to the cans are eventually frozen into the ice, it becomes necessary to use water as nearly pure as possible. The purity of ice, however, is somewhat erroneously judged by its transparency. Impure ice may be almost entirely transparent while, on the other hand, pure ice, except for the presence of air which produces whiteness, may be unsalable because of its opaque appearance. To remove air as well as both organic and inorganic impurities from the water, distilling systems are usually employed in can ice-making plants. As large quantities of water must be evaporated to make the steam necessary for driving the ammonia compressors and other machinery of an ice-making plant, it follows that the boilers and engine should constitute a part of the water-distilling system.

Fig. 1 illustrates diagrammatically the simple or high-pressure system commonly employed in making can ice. As a steam boiler is virtually a thermal filter which separates out, in the form of incrustation and sludge, most of the impurities brought to it in the feed water, the water supply for an ice plant should be selected with particular care, especially as it often becomes necessary to supply raw "make-up" water to the storage tank when the supply of distilled water runs short.

As shown in the illustration, the exhaust steam from the engine driving the compressor passes first to the grease separator in which it is freed of a large part of the entrained lubricating oil by impinging upon baffle plates. From the grease separator it passes to the steam condenser from whence, after being condensed, it flows to the reboiler, skimmer and hot-water storage tank. From the latter the hot distilled water is allowed to flow as required into the water cooler; entering at the bottom and passing up through a series of pipes it is here cooled by water flowing down over the outside of the pipes. From the water cooler it passes to a charcoal filter or deodorizer and on through a hose to the can filler. When frozen the ice is removed from the cans by spraying with hot water and then gravitates down an incline into the ice-storage room.

In traversing that part of the system between the steam condenser and the ice cans the distilled water, after having been freed from air and other gases in the reboiler, is not again allowed to come in contact with the air; the reason for this is twofold: First, any air entering into solution in the distilled water will separate out in the form of minute bubbles during the freezing process and give the ice an opaque appearance; second, distilled water in the presence of air is very corrosive to iron and should they be allowed to come in contact with any part of the system not thoroughly protected by galvanizing, a sufficient amount of iron would be dissolved to discolor the ice.

Freezing Time Required for Can Ice

With brine at 14 degrees the average time of freezing different-sized blocks of can ice is as shown in the following table:

TIME REQUIRED FOR FREEZING CAN ICE.

Size of Can, Inches.	Weight of Ice, Pounds.	Freezing Time, Hours.
6x12x26	50	15—25
8x16x32	100	30—50
8x16x42	150	30—50
11x22x32	200	50—72
11x22x44	300	50—72
11x22x57	400	50—72

While no exact rule can be formulated for expressing the freezing time in terms of difference in temperature between the brine and the freezing water in the can, because of the fact that the heat-transmitting surface of the freezing water is decreasing and the insulating effect of the ice forming is increasing; it, nevertheless, has been claimed by some that the time required for freezing can ice with brine at the usual temperature varies directly as the square of the thickness of the cake of ice. On this basis the relative time of freezing 6-inch and 11-inch blocks would be as 36 is to 121, or allowing 50 hours for the latter, the former should freeze in 14.9 hours.

The Plate Ice System

Where pure water is available the can system with its distilling apparatus is often replaced by the plate-ice system. The important requisite of any ice-making system from a commercial standpoint is its ability to produce marketable ice, which, unfortunately, often depends more upon the appearance than upon the purity of the product. In the can system practically all solid impurities are left behind in the process of distillation, air and foreign gases being expelled by violent boiling in the reboiler. In the plate system the keeping of the product free from both solid and gaseous impurities is almost wholly dependent upon the agitation of the freezing water. Snow may be pure but it is white because of the presence of a large number of minute air spaces between the crystals of ice. Gases, in general, are soluble in liquids, the degree of solubility varying widely with the temperature and pressure; the higher the pressure and the lower the temperature, the greater the amount of gas a liquid will absorb. In the case of freezing water, however, the air is driven out of solution and collects in the form of little bubbles on the freezing surface. These bubbles will finally be frozen into the ice if not forcibly dislodged.

In the manufacture of plate ice the principal inorganic impurities to be guarded against are the salts of iron which give a reddish discoloration, and the carbonates and sulphates of lime and magnesia which produce a slight cloudiness. Unless large quantities of magnesium carbonate or carbonate of iron are present the effects of these impurities, as well as that of air, can be overcome by increased agitation. In the case of carbonates of either magnesia or iron, increased air agitation may tend to increase the discoloration through the hydrating of the former and the oxidizing of the latter. This difficulty may be overcome, however, by the substitution of mechanical for air agitation.

Mechanically, a plate plant is so constructed that the raw undistilled water to be frozen is brought in contact with plates of sheet metal bolted to either brine or direct expansion coils in which a sufficiently low temperature is maintained to bring about the necessary heat transfer from the water at 32 degrees. These plates, which are not usually less than 14 feet long by 10 feet deep, are submerged in the plate tanks. The refrigerating agent, whether brine or ammonia, is allowed to flow through the coils until ice has accumulated to a thickness of 12 to 14 inches on the plate. The cold brine or ammonia is then shut off and hot brine or ammonia is circulated through the coils until the ice is loosened from the plate and floats free in the water. Chains are then fished around the cake and it is hoisted from the tank by a traveling crane and carried to a tilting table where it is carefully deposited to avoid breaking. Here it is sawed into cakes of the required size, by two gages of traveling circular saws, one traveling lengthwise and the other crosswise of the table. Because of being frozen from water at 32 degrees Fahrenheit with which it is always in contact, the actual temperature of plate ice is not as low as that of can ice, the temperature of which is limited only by the temperature of the brine. On account of this fact, plate ice is less likely to be brittle, has less tendency to freeze together and, therefore, can be stored more readily than can ice.

The factor which limits the application of the plate system is the time required for freezing, the absorption of heat having to take place in this case wholly from one side while that in a can is from five sides. This disadvantage has been overcome to some extent in the "Center-freeze" system in which the plate of ice is frozen on a comb-formed series of vertical brine pipes attached at the top to suitable feed and return headers. In this system heat is absorbed radially from all directions to each pipe and, being located in the center of the plate of ice, the total thickness of ice frozen through need never be over half that of the usual plate system producing a plate of the same thickness. The center pipes are loosened from the ice as in the preceding case.

Evaporators and Vacuum Distilling Apparatus

In can ice-making plants of over 100 tons daily capacity and employing engines of the Corliss type, there is seldom sufficient excess of distilled water from the exhaust-steam condensers to supply the freezing tanks. This defeats maximum steam economy where the usual high-pressure distilling apparatus is employed. For instance, assuming a 100-ton ice plant requiring 2.75 horsepower per ton and operated by a four-valve engine using 30 pounds of steam per horsepower per hour, the steam required for the engine would be about 100 tons per 24 hours. The auxiliaries and reboiler, together with the usual condensation and leakage past the valves of the engine and auxiliaries would probably amount to 25 tons, making in all about 125 tons of steam. This amount of steam would supply sweet water for the 100-ton can plant and allow for a loss of 20 per cent. between the exhaust pipe and the cans. If, however, the loss were as much as 25 per cent., which might readily happen, the make-up water required would amount to about 8000 pounds per 24 hours. This amount of steam at a cost of 20 cents per thousand pounds would be worth $1.60 per day.

If the engine employed were of the Corliss type, simple noncondensing, and having a steam consumption of 28 pounds per horsepower-hour, the steam required to drive the compressor would be about 92.4 tons. Hence, the amount of make-up water, even on the basis of 20 per cent. waste, would be 52,100 pounds, which at 20 cents per thousand pounds would cost $10.42 per day.

From the foregoing it is evident that

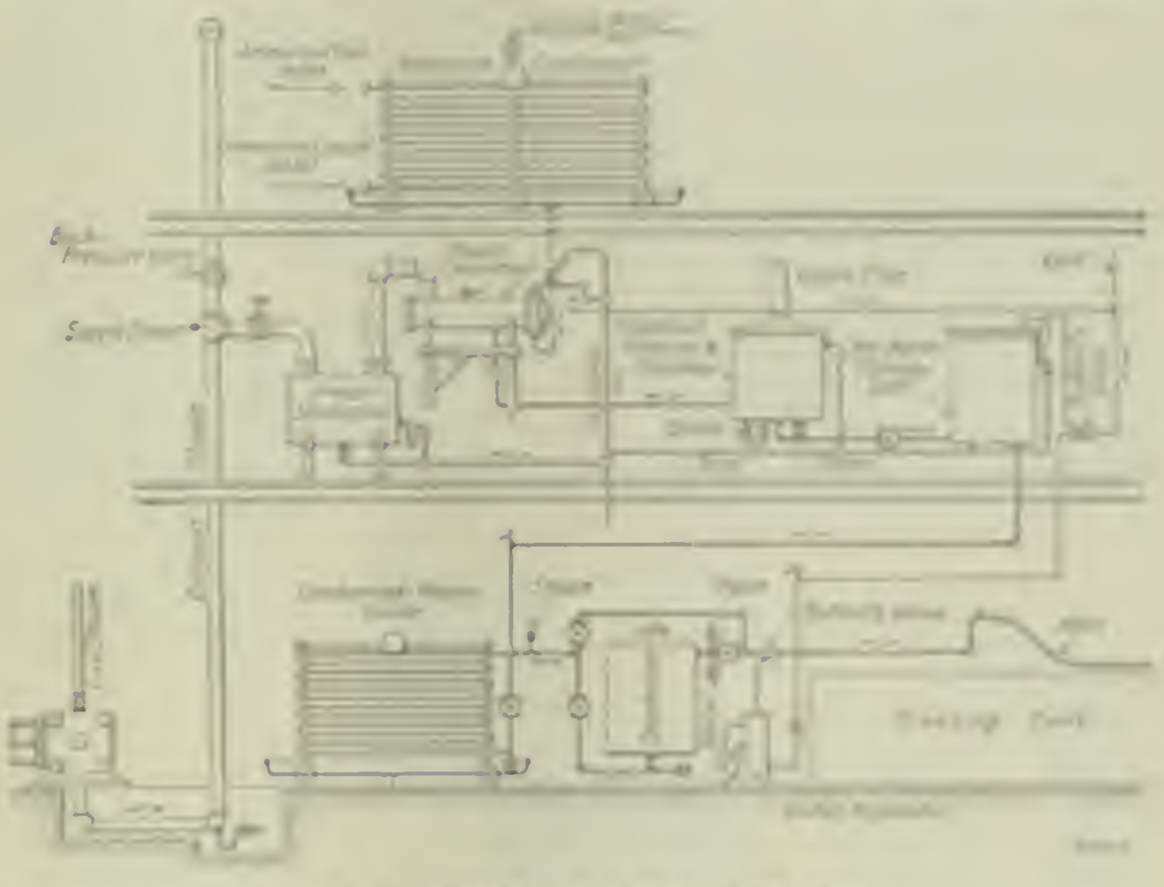


Fig. 1. System for Making Can Ice

to employ engines of lower steam consumption results in developing an ice-making capacity in excess of the amount of sweet water available. This excess capacity over that required to freeze the available distilled water, may be employed to freeze ice in a plate tank, or the deficit in sweet water necessary to supply the can plant may be made up by means of evaporators.

A combination can and plate plant, designed to satisfy the first of these conditions is illustrated diagrammatically in Fig. 2. Leaving the ammonia compressor the gas is first discharged into the two pressure tanks where any entrained oil is deposited. From there it passes through pipe B to the condensers and after liquefying it flows through pipe D to the liquid receiver. The line from the bottom of the liquid receiver branches off, line F supplying the can plant and ice-storage room and E supplying the plate plant. The water forecooler is fed in series with the plate plant, after passing through which, the ammonia gas returns to the compressor.

The circuit traversed by the sweet water is as follows: The exhaust from the engine, encountering the back-pressure valve on the main exhaust pipe from the engine, is diverted through a grease separator into a steam condenser. The condensed water then passes through the vacuum reboiler and enters the suction of pump P which discharges it into the hot-water storage tank; from here it flows through a regulating valve through the water cooler and into the cold-water storage tank from whence it is drawn to fill the ice cans as required. The water for the plate plant passes first through the water filter in the engine room, through the water forecooler and into the plate tank. Similarly the air used for agitation in the plate-ice tank is discharged by the air compressor through an air-storage tank in the engine room, through the water forecooler and into the plate-ice tank.

Fig. 3 represents a vacuum-distilling system, having an evaporator which provides the second means of maintaining the full capacity of the ice plant when the available sweet water is insufficient. For simplicity only the distilling part of the ice-making plant is shown in this illustration.

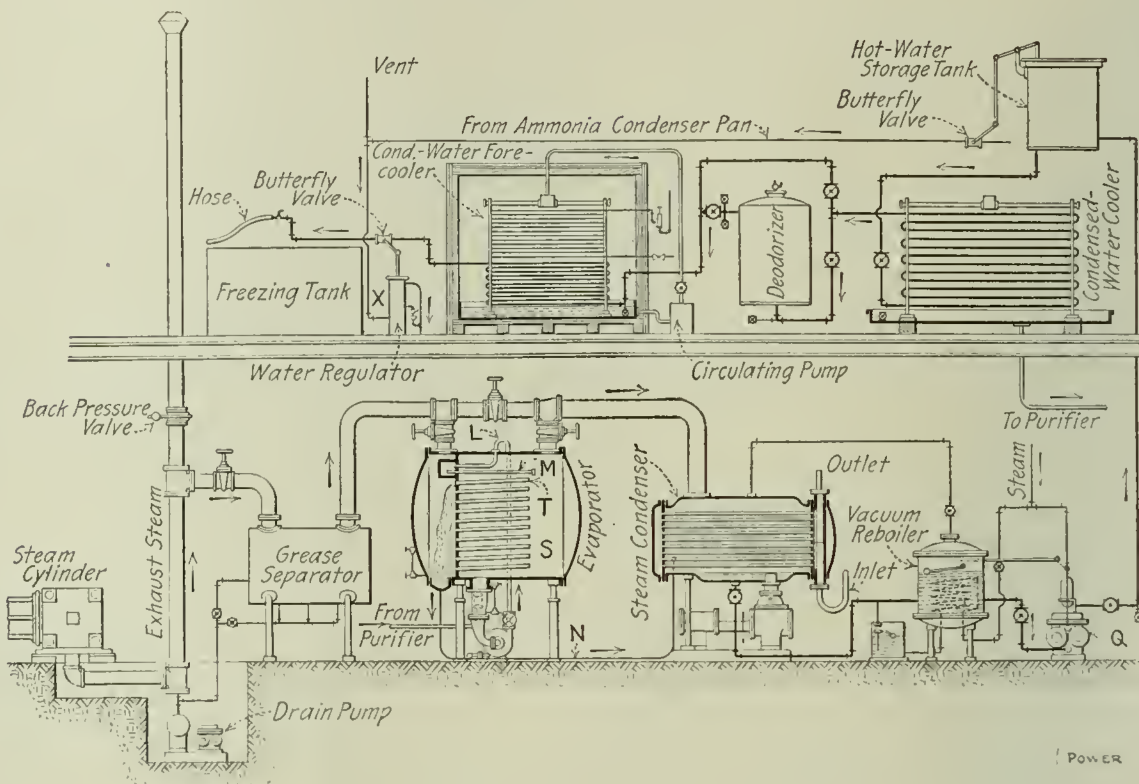


FIG. 3. VACUUM DISTILLING SYSTEM

The exhaust steam, as before, passes first through a grease separator, but in this case it also passes into an evaporator where the steam must stop, the heat being carried over by the vapor to the steam condenser. Assuming that the engine is running under 18 inches of vacuum, the exhaust from the low-pressure cylinder will enter the evaporator at about 168 degrees Fahrenheit. The steam enters the dead-ended copper tubes T which extend upward at a slight angle through the tube sheet into compartment S. Here it is condensed by cooling water circulated from the bottom of the evaporator, through the centrifugal pump, distributing pipe L and discharge line M. On the condenser side of the tube sheet a vacuum of from 24 to 26 inches is maintained by the condenser and this higher vacuum enables the heat liberated by the condensation

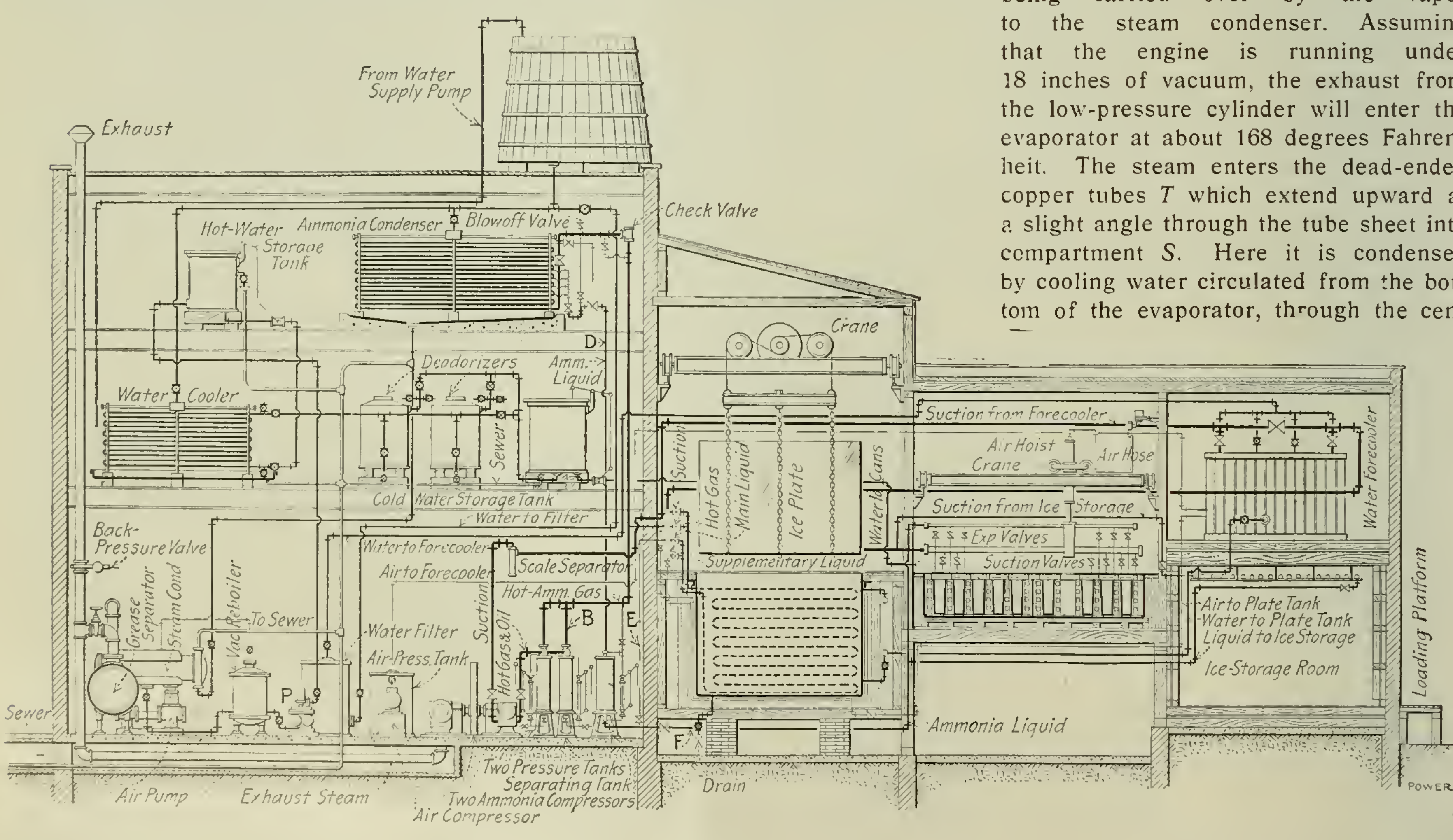


FIG. 2. COMBINED CAN AND PLATE-ICE PLANT

of every 1.15 pounds of exhaust steam to evaporate about one pound of cooling water. The cooling-water vapors are liquified in the steam condenser. Here they are joined by the condensed exhaust steam from the evaporator which is drawn through pipe N by the higher vacuum in the condenser, and also by a small amount of vapor drawn through the vent pipe from the top of the vacuum reboiler; condensed water from both the evaporator and steam condenser being drawn into the reboiler by the vacuum maintained in the steam condenser. The water from the steam condensed in the coils of the reboiler drains into a trap provided with a float, which as soon as the water has collected to a certain level, admits it into the suction line leading to the sweet-water pump Q. This pump discharges the sweet water into a hot-water storage tank, from whence it flows through the condensed-water cooler, deodorizer and condensed-water forecooler to the ice cans. In the reboiler a float valve controls the operation of the condensed-water pump, allowing it to draw water from the reboiler only when it has accumulated to a predetermined hight. In the trap from which the water condensed in the coils of the reboiler is drawn, there is a similar float valve opening only when there is a certain amount of water present. A float valve in the hot-water storage tank controls the position of another valve through which water from the ammonia condenser pan flows into a regulating device X which operates a butterfly valve in the sweet-water supply line leading to the ice cans and prevents the drawing of water from the storage tank below a certain level. These precautionary measures are all taken to prevent the possibility of air entering the pipes of the distilling system.

The deodorizer into which the sweet water is introduced through a strainer to insure uniform distribution through the filter bed, consists of a vertical cylindrical shell filled with charcoal covered with a second strainer which prevents any of the material from floating and entering the discharge pipe at the top. By means of a simple bypass the deodorizer can be cut out of the system for cleaning, and the sweet water fed direct from the cooler to the cans. In some instances the presence of iron salts in the water makes it advisable to supplement the deodorizer with a sponge filter.

The forecooler shown in the illustration consists of an insulated compartment in which a direct-expansion coil is installed over the distilled-water coil. Water is circulated from the pan beneath these coils and passes over the expansion coil where it is cooled to practically 32 degrees; it then gravitates down over the water coil and absorbs heat from the sweet water. As the circulating liquid is water, it is impossible to freeze up the sweet-water coils and since this circulating liquid can be chilled to the freezing point the condensed water can also be cooled to within a very few degrees of the freezing point, resulting in a great saving in freezing time, which is equivalent to increasing the capacity of the ice-freezing tanks. The reboiling of the sweet water under a vacuum at a temperature of from 200 to 204 degrees not only reduces the amount of steam required to effect the reboiling but also the amount of cooling necessary to reduce its temperature to that of the freezing tank.

The Ratchetless Wrench

By John E. Sweet

The history of this wrench is this—I was engaged as draftsman at the Patent Nut and Bolt Company in Birmingham, Eng., and we had commenced the manufacture of finished nuts before the case-hardened ones were in vogue. On these the spanners (the English word for the American wrench) would mar them unless a mechanical fit—and this led to the design given in the illustration. As at that time I had commenced writing for *Engineering* this appeared in that paper on page 112, July 31, 1868, as follows:

"In the use of the ordinary spanner on finished nuts either one or the other of two objections has to be endured. If the spanner is a perfect fit it must be brought to the exact angle at which the nut stands before it can be entered on, and then the least dirt or bruise will make it stick or prevent it from going on altogether. If the spanner is a loose fit all the strain is thrown on the corners of the nut and perfection in workmanship in this case only aggravates the evil.

"The spanner shown above may be a perfect fit, takes a bearing on three sides of either a square or hexagon nut and will enter on freely when brought to any angle within ten degrees of the angle at which the nut may stand. Although the jaws are thick and strong, a nut

"Ratchetless Ratchet Wrench"

standing against a flange can be turned even when there is only room for the corners of the nut to pass. This principle may be carried out in different ways, and even introduced into shifting spanners; but the form here shown has the merit of extreme simplicity and yet should be used for the work for which it is designed—finished nuts—and only by men who, it is hoped, will appreciate its advantages, 'finished workmen.'"

Crosshead Buckled

An item comes to us from a New England daily newspaper. It contains a mine of information which is not procurable from any other source of which we know.

Anxious to have the good work go on, we reproduce it herewith verbatim, omitting only the identifying name:

"A defective cylinder in the engine which operates the machinery of —— mills 6 and 7 caused the mills to close yesterday afternoon and men were compelled to work late into the night in adjusting the machinery.

"The accident occurred at 2:30 p.m. yesterday. The crosshead is a short bar which acts as a sort of a hinge between the piston of the engine and the shaft of the wheel. When the crosshead 'buckles' it moves so far toward the cylinder on its backward journey that it becomes caught and cannot make its next forward movement.

"The buckling was caused yesterday by some water getting into the cylinder. A vacuum was created which allowed the crosshead to move so far back that it became wedged too tightly for it to return.

"It is fortunate that no accident of a very serious nature occurred, for if the steam had not been turned off very quickly an explosion of the cylinder might have occurred.

"As it was, mills 6 and 7 had to suspend operations for the rest of the day, and the machinists had to work on the engine late into the night. The necessary repairs have been made and the mills are running today."

Investigations to discover the causes of rusting in galvanized wire have been undertaken by the agricultural-engineering department of the University of Iowa, Ames, Ia. It has been well known that the lower wires of the fence, down among the moist grasses and weeds, where rusting action would be expected to be most active, invariably last longer than the upper wires in the dry air. M. L. King, experimentalist for the department, says he has found that these lower wires in fences of any length ordinarily carry small currents of electricity, reaching in some cases a value as high as 0.001 ampere, and sometimes showing a difference of potential of as much as one volt above ground. Such currents are absent in the upper wires, and it has been suggested, but not proved, that the greater preservative action of the lower strands is due to the suppression of local electric couples by the through currents flowing in the lower wires.—*Ex.*

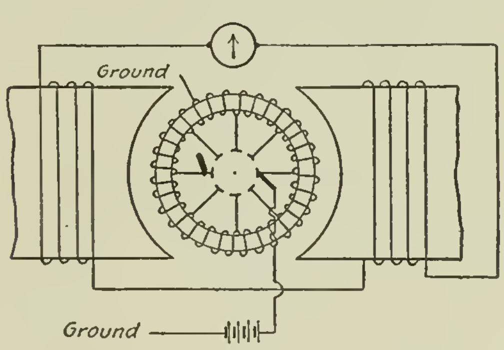
Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Locating a Grounded Armature Coil

By Francis H. Davies

The location of a grounded coil in the armature of a direct-current dynamo or motor may be very simply done by the following method: The connections should be made as per the diagram, from which it will be evident that the field circuit is entirely disconnected from the armature and its terminals are connected to a galvanometer; this should be of a fairly sensitive type—the ordinary lineman's instrument will do very well. After making this connection the brushes should be shifted to the position shown. One of them should be raised clear of the commutator and the other connected through a switch to three or four storage-battery cells; the other terminal of the battery is grounded on the frame of the



Connections for Testing

machine. When the switch is closed, current will flow through the armature winding to the core at the grounded point and the magnetic field generated in the armature core will give rise to a momentary induced current in the field winding, which will produce a kick by the galvanometer. The armature should be rotated step by step and the operation repeated as each commutator segment comes under the brush; when the segment connected to the grounded coil is reached, the galvanometer will show no indication upon closing the switch, or, at the most, a very slight one. The reason is, of course, that the current from the cells then flows through little or none of the winding, and therefore produces little or no inductive effect upon the field winding.

It is important that the brushes should be rocked into such a position that the coil connected to the commutator bar under the brush will be situated right in the center of the field-magnet pole face, in order to enhance the inductive effect. It must, however, be borne in mind that the brush position is not necessarily that shown in the diagram, which only applies to the type of armature represented. Generally speaking, it will be so, but some machines are built with the commutator displaced at an angle of about 90 degrees ahead of the winding in order to make the brushes easier of access, and in such cases the correct position will be *between* the poles and not opposite the pole-face center.

A ground will sometimes make itself apparent upon the surface of the armature by signs of burning; but if this is not the case it may be possible to locate it by applying a current of the full voltage of the machine between the commutator and the frame. If the fault is a bad one, arcing will be either seen or heard.

The Excitation of Alternators Working in Parallel

By G. E. Miles

While much has been written on the subject of the parallel operation of alternators the feature of the adjustment of excitation does not seem to have received much attention. This may be because the subject is considered so simple that it deserves little comment. However that may be, both practical and theoretical men have fallen down on this point.

I do not wish to be understood as posing as an authority on the subject but think perhaps some of my experiences and observations along this line may be of help to others.

A certain company operated two hydraulic plants situated about two miles apart, either of which was capable, during the season of high water, of carrying the load alone during the morning "shift." At station No. 1 the voltage was regulated by hand, but at No. 2, where I was located, the voltage was controlled by an automatic regulator. By visiting back and forth I soon observed that when the plants were operating in parallel, with the voltage controlled by the regulator at No. 2, the voltage at No. 1 was higher than I had been instructed to carry it by the man on the opposite shift at that plant. I also observed that the power factor was better at station No. 1.

After a few more weeks the water fell off so that both plants had to be run in order to carry the load, so another man was put on at No. 1. No. 2 was run with a waterwheel governor and automatic voltage regulator and took care of all changes in load and voltage, while No. 1 was run with a constant load and with constant excitation. The new man at No. 1 adjusted the excitation as instructed by the man on the opposite shift but I found the power factor very low at No. 2. By comparing notes over the telephone, the power factor at No. 1 was found to be high, so I asked that the excitation there be adjusted until the power factors were the same at both stations.

After a few weeks more I was transferred to station No. 1, when a discussion at once arose between the man on the opposite shift and myself, the other man insisting that I was using more excitation than was necessary when the plant had the entire load.

To make sure of my position, I submitted the question to an authority in whom I had the greatest confidence, and was advised that when two machines are operated in parallel and one of them takes care of the changes in load and voltage, the excitation of the other machine should be such as to make its current the minimum, which would be true when the machine took no wattless current from the system and delivered none to it. A trial was unnecessary to convince me that these instructions were wrong; nevertheless, I resolved on a trial. As I expected, the power factor on my machine rose to about 100 while that at the other plant went below 50.

A short time after making this trial an occasion arose for carrying the entire load on station No. 1 for a few hours. This gave an opportunity for observing the exciting current required when the load was all on one machine (the load was low enough part of the time for one machine to carry it all) and also the effect of varying the excitation when it was necessary to run two machines. I promptly found that in order to carry the same load at the same voltage and power factor it made no difference, as to the exciting current required, whether a machine was running alone or in parallel with another.

From this experience I would lay it down as a safe rule that when alternators are running in parallel the ratio of amperes to kilowatts should be the same on both machines, which, of course, gives both machines the same power factor.

LETTERS

Mr. Greer's Rotary Converters

I note that Mr. Greer in the January 31 issue takes exception to my analysis of his converter trouble, claiming that it is largely in error; also that he takes the same view as Mr. Farwell, who claims that No. 1 converter actually "hogged" the load from Nos. 2 and 3 converters.

Mr. Greer further states in his letter that "it was not simply an exchange of current between No. 1 and the others, but No. 1 actually was carrying the load of both feeders." He undoubtedly comes to this conclusion on account of the ammeters of Nos. 2 and 3 having reversed or dropped back against the zero stops. The fact that these ammeters reversed is not proof that No. 1 took all the load.

The diagram by Mr. Harvey in the January 31 issue (Fig. 1 herein) shows quite clearly the path taken by the negative current; as stated by Mr. Harvey, the negative current of the east and west feeders passed through the negative lead and armature of No. 1 converter, and in addition to this there was the excess of cross current from the negative leads of Nos. 2 and 3. As stated in my previous article and by Mr. Harvey, if ammeters had been connected in the positive leads of Nos. 2 and 3 converters they would have shown the load current of the west feeder passing through the positive leads of Nos. 2 and 3 and of necessity through the armatures of Nos. 2 and 3.

To those familiar with the principle of rotary-converter operation it will be evident that the current which passes into the armature at the negative brushes passes out on the alternating-current leads nearest to the point of negative commutation or at nearly ground potential, where the negative is the grounded side of the direct-current system. The negative current of the west feeder would therefore pass through the armature of converter No. 1, along the alternating-current leads nearest to ground potential to the alternating-current busbars, through the armatures of the generators or the windings of the transformers supplying the busbars, thence back through the alternating-current leads nearest to the point of positive commutation in the armatures of converters Nos. 2 and 3; this current would then pass through the armatures of Nos. 2 and 3 and appear at the positive brushes at the working potential of the machines above ground.

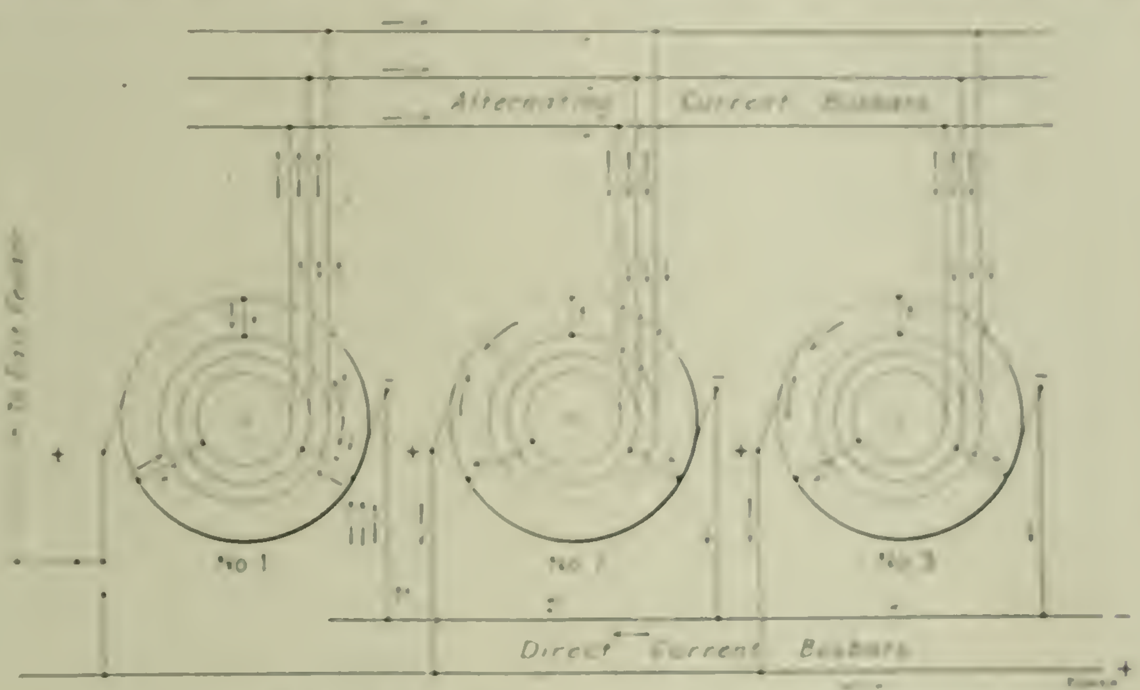


FIG. 1. MR. HARVEY'S DIAGRAM OF CIRCUITS

Bearing in mind that the alternating-current generators supply all the power it will be evident from the foregoing that No. 1 converter rectifies the positive current of the east feeder and the negative current of both the east and west feeders, and that Nos. 2 and 3 rectify the positive current of the west feeder. Nos. 1, 2 and 3 all rectify the current in the local circuit. It, therefore, cannot be properly said that No. 1 took all the load of the west feeder.

The current flowing in the local circuit between No. 1 and Nos. 2 and 3 was due to a very small difference of potential between the negative brushes of No. 1 and those of Nos. 2 and 3, and, therefore, represented only a small amount of power, although the current flowing was probably of a very high value.

I agree with Mr. Harvey that the wave form of the current in the alternating-current leads between No. 1 and Nos. 2 and 3 was very much distorted and I should very much like to see an oscillogram taken under these conditions.

Referring to Mr. Farwell's December 20 article, I would say that I can hardly agree with his statement that "all necessary conditions for parallel operation existed." Suppose, for instance, that Nos. 1 and 2 were of the same size and we should attempt to operate them in parallel with the connections as shown in Mr. Greer's original diagram, reproduced here as Fig. 2. Assume that No. 1 has been properly adjusted so that trouble with local currents will not be experienced; if a load be put on the west feeder equal to the combined normal capacity of the two machines and carried for any great length of time, the armature of No. 1 will be burnt out, as it is evident that the

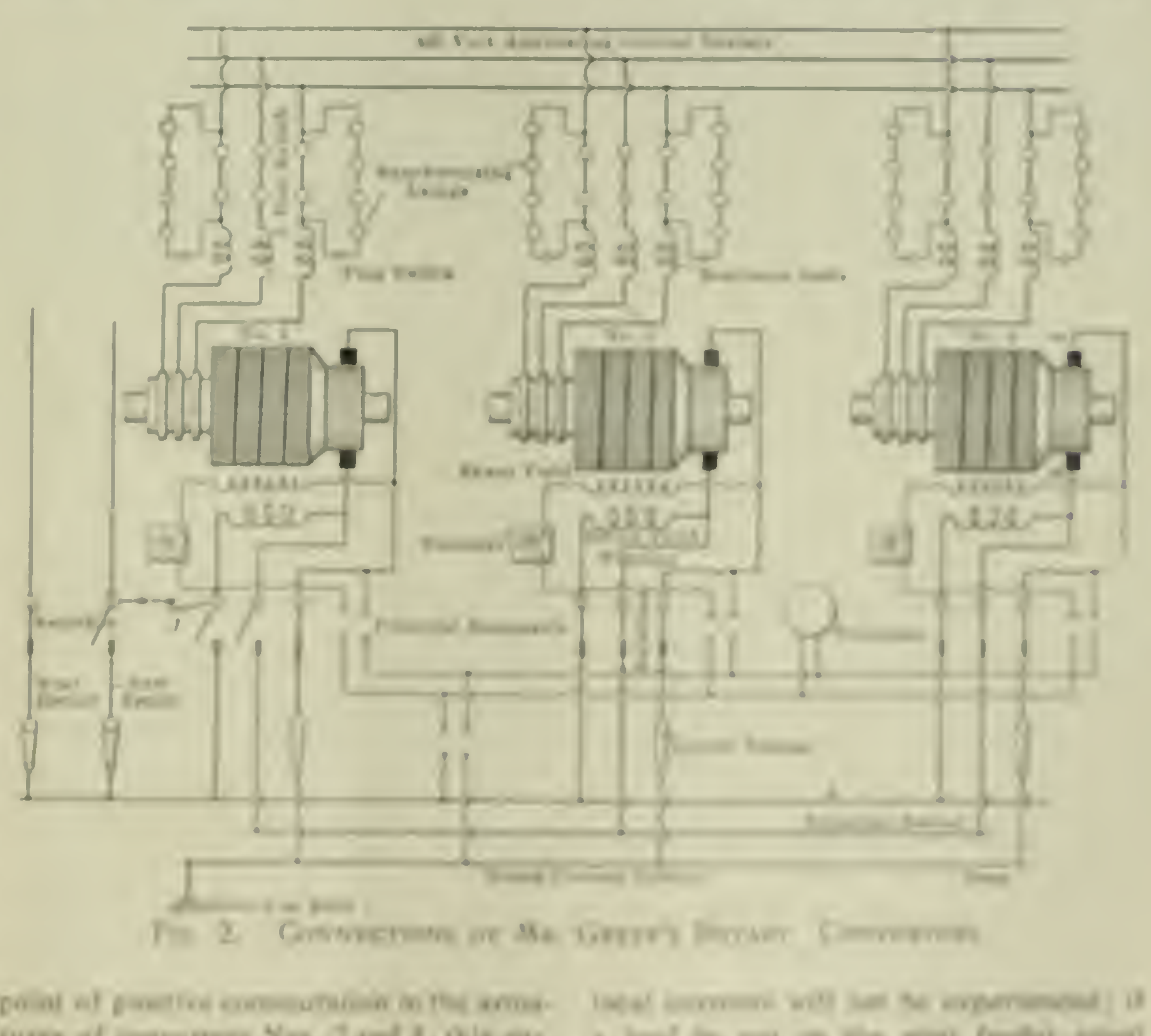


FIG. 2. CONNECTIONS OF MR. GREER'S ROTARY CONVERTERS

connections that all the positive current must pass through the armature of No. 2. This is certainly not an ideal condition for parallel operation.

If Mr. Greer still believes that No. 1 took all the load perhaps he will kindly explain how the positive current gets from No. 1 to the west feeder.

If it were possible to operate these machines in parallel with only the negative terminal of No. 1 connected on the direct-current side, using the alternating-current leads to carry the positive current, why would it not be well to go a step further and leave off the negative lead, using the alternating-current leads for both positive and negative current?

LESTER MCKENNEY.

Wappingers Falls, N. Y.

[Mr. McKenney's analysis of the occurrence is the only plausible one unless there were other conditions which escaped Mr. Greer's notice and were therefore not stated. Rotary converters cannot be paralleled in the accepted sense through their armature windings, because of the opposing electromotive forces generated therein.—EDITOR.]

Dynamo Burned Out Due to Misplaced Steam Drains

Several years ago I took charge of a small central station which ran only during the night and furnished light for an enterprising little borough. The equipment of the plant consisted of a compound-wound single-phase generator, belt driven by a waterwheel. The flume, a 40-inch steel tube, passed through part of the plant to the turbine, which had a draft tube extending down to the tail race. An auxiliary steam engine and boiler were housed in a building alongside of the main power plant; this equipment was used only in cases of emergency, and these would usually happen in the dead of winter.

I had been warned that I could expect trouble from this auxiliary equipment but never had occasion to use it until one day, a few days before Christmas, when something went amiss with the turbine. The engineer, a man on the job about three years previous, started the fire and got everything in good shape. The boiler was connected to the engine by an overhead 5-inch pipe passing through the partition between the boiler house and the dynamo room; this pipe had never been protected by a covering and naturally there was much condensation. The cylinder, valve-chamber, exhaust-pipe and water-separator drains were arranged to discharge into a terra-cotta pipe laid underground and emptying into the draft-tube pit of the waterwheel.

Toward evening the engineer got ready for the night's run, and, as it was a bitter cold day, he started to "warm up" the engine. During this process the steam escaping through the drains into the draft-tube pit was forced back into the engine room by an up draft from the tail race, and this cold air condensed the steam, which settled on the dynamo and turbine; drops of moisture settled even upon the commutator, field winding and armature. The generator was wiped as dry as possible and the engine was started slowly. As we were obliged to leave the exhaust-pipe drain open on account of the condensation caused by its passing under ground into the boiler house to the feed-water heater, steam was drawn from the draft-tube pit up to the generator and kept it pretty damp. The engine was very gradually brought up to speed, but we had to cut down the exciting voltage on account of excessive sparking at the rectifying commutator, due to the condensation on it. We finally had everything working in good order, apparently, and brought the generator up to its full voltage slowly; while looking after the brushes, however, the armature suddenly became ablaze. We shut down as quickly as possible, but found that the whole armature was damaged; where it was not burned it was punctured.

All this was caused by placing the drain pipe wrong, principally to save in the cost of installation.

The trouble was subsequently abolished by changing the position of the drain outlet.

A. J. ALTHOUSE.

Birdsboro, Penn.

Exciting an Alternator from an Arc Dynamo

An electric-lighting and pumping station where I was employed a few years ago was equipped with a 250-horsepower Corliss engine, a 2000-volt direct-current arc-light machine and a 100-kilowatt 1100-volt alternator, both dynamos belt driven from a line shaft. A shutdown would cause the city to be thrown completely in darkness and stop several small motor-driven factories, which were entirely dependent on the plant for power.

Early one morning the lights in the plant went out, and the trouble was finally located in the exciter which supplied current to the field winding of the alternator. There was a broken wire in the armature winding and it was so far in the coil that I could not splice it; bridging across the commutator bars was not feasible because the winding was grounded on the core.

As a last resort, I tried the following expedient, which worked very well temporarily: After rocking the brushes on the arc machine as far forward as possible and blocking them in that position, I ran two wires from the direct-current switchboard panel to the exciter terminals on the alternating-current panel, after disconnecting the exciter leads, and excited the alternator from the arc-light machine. The object in blocking the arc dynamo brushes forward was to prevent excessive voltage at the terminals of the alternator field winding.

M. V. MILLER.

Fort Snelling, Minn.

Mounting Trolley Wire Hangers in Mines

I have had a good deal of trouble with trolley-wire hangers in mines. Expansion bolts set in the ordinary way will not "stay put" because the rock soon becomes soft and the hanger is then easily pulled down. Finally I set the bolts in a mixture of cement and sand, half and half, enlarging the bolt hole and nearly filling it with the mixture, then pushing the bolt up in the hole, tightening the wedge and cementing it around the bottom. The result is a neat, inexpensive and permanent job; the hanger bolts do not pull out any more.

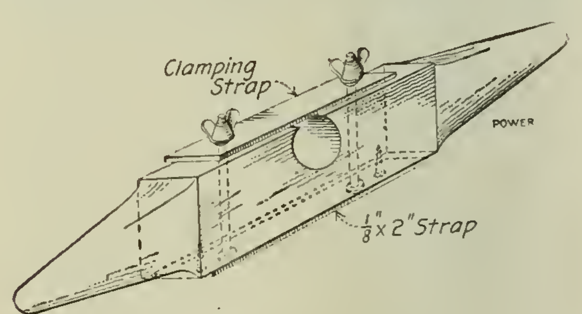
JOHN CULLOM.

Collinsville, Ill.

Another Armature "Stretcher"

Some time ago I saw a description in POWER of a frame made up of pipe fittings and used for carrying armatures. I had tried such an arrangement but had to give it up because I could not use it to advantage on account of narrow doorways and short turns and short flights of steps in the office building where our plant is.

I then made a pair of stretcher beams like the accompanying sketch, which I find to be more convenient. They are easily and cheaply made, do not take up much room and can be juggled around



A "STRETCHER" BAR

short turns. I made my pair out of the pine cross arm of a telegraph pole, which I sawed into two lengths, making each beam 28x5x2⅞ inches.

I shaved each end down to make a good hand hold, cut a circular "notch" across the center of the top edge and reinforced the bottom edge with a piece of ⅛x2-inch strap iron. The two ⅜-inch bolts which pass through the beam serve to hold the armature shaft in the circular opening, a clamping strap being forced down on the shaft by the thumb nuts on the through bolts.

I have six armatures, all of the same size, weighing nearly 400 pounds each, and with two men and one of the beams ahead and the same behind we can carry an armature very comfortably.

T. F. MCFADDEN.

Columbus, O.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Elementary Lectures on the Gas Producer

By Cecil P. Poole

Usefulness of the Economizer

In one of the early lectures it was explained in a general way that the air which is admitted to the fuel bed is first passed through an "economizer," which heats it. The study of specific heat has

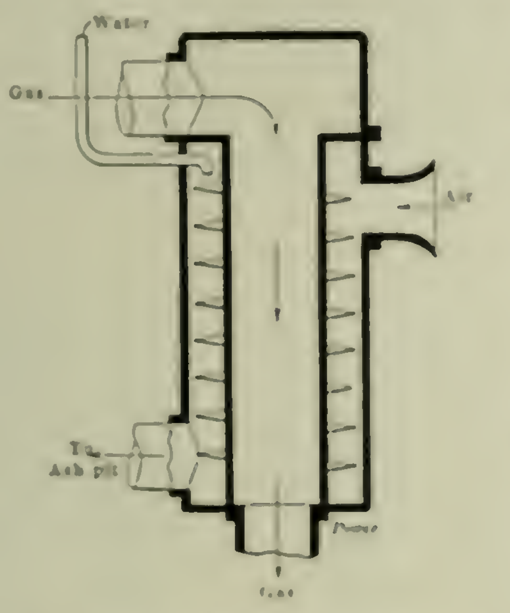


Fig. 2. Combined Economizer and Vaporizer

since put the student in position to understand more definitely the advantages gained by this process.

When the gas leaves the top of the fuel bed it is at a rather high temperature—somewhere around 700 to 800 degrees ordinarily. This is too high for use in a gas engine for reasons that will be discussed at some future time; for the present it is enough to say that the gas supplied to an engine should be as cool as possible.

If the gas should be cooled entirely by the water spray of the scrubber, a large part of the sensible heat in the gas would be simply carried off in the scrubber water and thrown away. Instead of doing this, some of the sensible heat is transferred from the gas to the air passing to the ashpit and carried back into the generator, thereby avoiding the taking of just that much heat from the fire zone to heat the air.

The saving effected by preheating the air with the outgoing gases will be made clear by considering the details of a practical case. Suppose a generator 3 feet 3 inches in diameter (across the fuel bed) gasifies 100 pounds of anthracite coal an hour; also, suppose that the coal contains 78 per cent. of fixed carbon, 1½ per cent. of hydrogen and 5 per cent. of moisture, the remainder being noncombustibles.

Further suppose that carbon monoxide is made with 66 of the 78 per cent. of carbon and carbon dioxide with the remaining 12 per cent., that one-fourth of the oxygen required for operation is obtained from steam and the remaining three-fourths from air. The operations will figure out as follows:*

Air supplied per hour, lb.	374
Steam supplied per hour, lb.	[illegible]
Steam units per hour, total	[illegible]
Gas made per hour, lb.	402
Refuse rejected per hour, lb.	15½
Heat energy in the gas, B.t.u.	980,100
Sensible heat per degree of temperature of the gas, B.t.u.	138½

The air contains

$$374 \times 0.77 = 288$$

pounds of nitrogen and argon, air being 23 per cent. oxygen, 76 per cent. nitrogen and 1 per cent. argon. For simplicity the argon is considered as nitrogen.

From the foregoing, the gas characteristics are as follows:

	Pounds		Cubic Feet at 700°		Per Cent. by Vol.	Sensible Heat per Degree	Heat Energy, B.t.u.
CO	[illegible]	=	[illegible]	=	[illegible]	[illegible] × 0.246 = [illegible]	[illegible]
H	[illegible]	=	[illegible]	=	[illegible]	[illegible] × 3.409 = [illegible]	[illegible]
CO_2	44	=	[illegible]	=	[illegible]	44 × 0.217 = [illegible]	0
N	288	=	[illegible]	=	[illegible]	288 × 0.243 = [illegible]	0
Totals	402	=	17,[illegible]	=	100	[illegible]	980,100

Specific heat = [illegible] ÷ 402 = 0.2815

The gas will leave the fuel bed at a temperature of about 785 degrees, Fahrenheit. Suppose that the air takes out of it only enough sensible heat to reduce its temperature 300 degrees. That will amount to

$$300 \times 138\tfrac{1}{2} = 41{,}550$$

B.t.u. per hour, because there are 402 pounds of gas delivered per hour and the specific heat is 0.2815, making the sensible heat per degree, for the entire quantity,

$$402 \times 0.2815 = 138\tfrac{1}{2}$$

B.t.u. (See details in the footnote.)

As the heat energy in the gas delivered to the engine is 980,100 B.t.u. per hour, it is evident that the heat saved by the economizer (41,550 B.t.u.) amounts to about 4 per cent. of that used in the engine. That it is a clean saving is undeniable; if the air were not partly heated by the outgoing gases it would have to be entirely heated by the fire in the generator and the heat in the gas would be thrown away in the scrubber water.

The 41,550 heat units taken out of the gas by the air will raise the temperature of the latter 468 degrees, because the specific heat of air is 0.2375 and there are 374 pounds affected by the 41,550 heat units;

$$0.2375 \times 374 = 88.825$$

B.t.u. required to raise the temperature of the 374 pounds one degree and

$$\frac{41{,}550 \text{ B.t.u.}}{88.825 \text{ B.t.u. per degree}} = 467.77$$

degrees, or practically 468.

Effect of the Vaporizer

The vaporizer also effects an important saving when it is arranged to use the heat of the outgoing gases to make the steam, as in the types illustrated by Figs. 2, 3 and 4. In all three of these the steam is made by the heat from the generated gas. Figs. 2 and 3 show combined vaporizers and economizers; in the type represented by Fig. 4 the air is preheated in an economizer before entering the vaporizer and picking up the steam.

Consider the case previously assumed. The generator was supplied with [illegible] pounds of steam per hour, and in order to make steam at this rate from water

*The figures given are derived in this way:

Oxygen required to burn 66 pounds of carbon to carbon monoxide, 66 × 1⅓ = [illegible] lb.

Oxygen required to burn 12 pounds of carbon to carbon dioxide, 12 × 2⅔ = 32 lb.

Total oxygen required, [illegible] + 32 = [illegible] lb.

Oxygen supplied by steam = [illegible] lb.

Remainder supplied by air = [illegible] lb.

Air required to supply [illegible] lb. of oxygen, [illegible] ÷ 0.23 = 374 lb.

Steam required to supply [illegible] lb. of oxygen, [illegible]	[illegible] lb.
Water in the coal	5 lb.
Steam brought in with air	[illegible] lb.
Hydrogen in 100 lb. of coal	1½ lb.
Hydrogen in the total of steam [illegible]	[illegible] lb.
Hydrogen in delivered gas	[illegible] lb.

of, say, 62 degrees temperature, 37.240 B.t.u. must be supplied per hour, because it takes 1120 B.t.u. to heat one pound of water from 62 to 212 degrees and evaporate it into steam at atmospheric pressure.

If these 37,240 heat units were not supplied from the sensible heat of the gas, they would have to be supplied from some other source; if they were so supplied, it would cost something to supply them, whereas they are there in the gas, ready for use, and would be thrown away if carried into the scrubber.

Adding this saving of 37,240 heat units

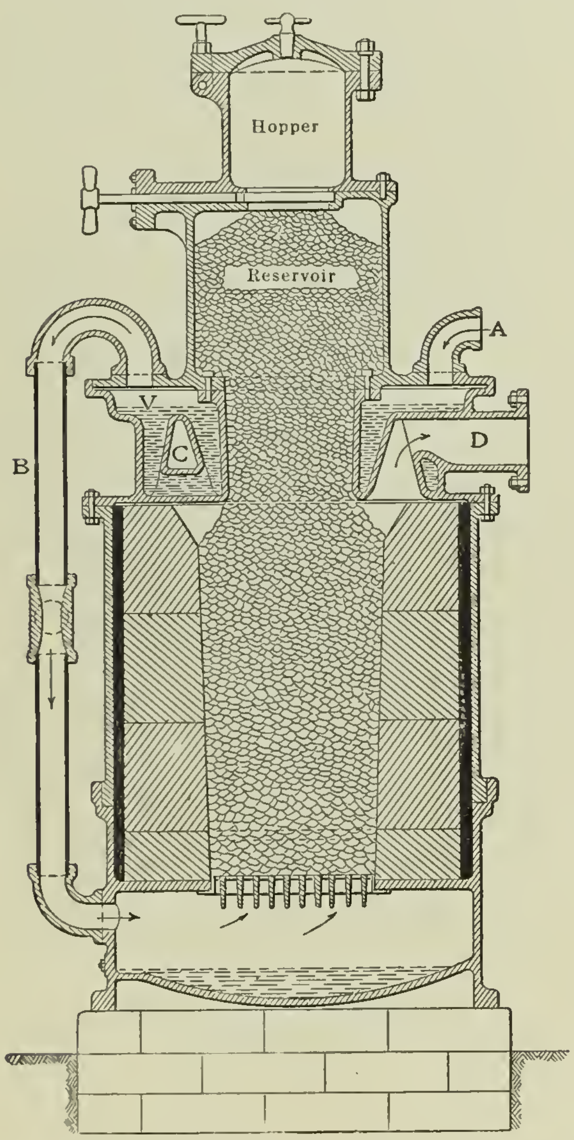


Fig. 3. Vaporizer Built in Top of Generator

by making steam to the 41,550 units of sensible heat utilized in heating the air makes 78,790 heat units per hour "rescued" from the gas on its way to the scrubber. This is the equivalent of

$$\frac{78,790}{2545} = 31$$

horsepower, theoretically, or nearly 8 actual brake horsepower at the engine.

The Scrubber's Share

When the gas finally reaches the scrubber its temperature will be much below 485 degrees, because of the use of sensible heat in making steam. As just shown, the total sensible heat used in heating the air and making the steam amounts (in the assumed example) to 78,790 B.t.u. an hour. The temperature of the gas will be reduced, therefore, by

$$\frac{78,790}{138\frac{1}{2}} = 568.9$$

degrees, instead of 300 degrees, and if we consider the effect of radiation it will be safe to assume a reduction of 570 degrees by the time the gas enters the scrubber. Its temperature then will be 215 degrees.

Suppose it is desired to cool the gas to 85 degrees in the scrubber. That is a temperature reduction of

$$215 - 85 = 130$$

degrees and it means that the scrubber water must take 18,005 heat units out of the gas per hour, because the sensible heat of the gas per degree* is 138½ B.t.u. and the temperature change is 130 degrees;

$$138\frac{1}{2} \times 130 = 18,005.$$

As the gas is to be cooled to 85 degrees, the temperature of the water cannot rise above that point; say it rises to 82 degrees and is at 62 when it enters. With this rise each pound of water will absorb 20 heat units and as there are 18,000 heat units to be absorbed per hour, there must be

$$18,000 \div 20 = 900$$

pounds of water passed through the scrubber per hour. In practice, a good deal more than this would be needed because it is impossible to make each drop of the water come into contact with its share of the gas.

Now, 900 pounds of water is not such a tremendous lot; at 62 degrees temperature it is 108 gallons. But suppose for a moment that the gas had not been cooled in the economizer and the vaporizer before reaching the scrubber. Instead of taking out 18,000 heat units an hour the scrubber would have to take out that much plus 78,790, or 96,790 heat units an hour. This would require about 580 gallons of scrubber water per hour instead of 108 gallons.

It would also be necessary to use a large scrubber, because efficient contact could not be obtained between the gas and five times the normal quantity of water in the same sized scrubber.

However, this final consideration is of minor importance, not only because it is indefinite but because the saving of heat makes it advisable to preheat the air and make the required steam with the waste heat that is in the gas when it leaves the fuel bed.

Vaporizing in the Ashpit

The figures just given show very clearly that the practice of making steam in the ashpit, which is necessary with some forms of generator, is rather uneconomical. A gas-producer attendant once told me, with the air of having discovered an important labor-saving feature in producer operation, that he had found the vaporizer unnecessary; all he had to do was to throw a couple of pailfuls of water in the ashpit the first thing in the morning and another one just before the factory started up after the noon hour. The heat radiated downward from the fire zone vaporized the water as the generator needed steam and he did not have to bother with regulating a flow of water to the vaporizer.

*Sensible heat per degree is the number of heat units that must be added to a given quantity of gas to raise its temperature one degree, or taken from it to lower its temperature one degree.

This plan of working has only one merit—it is a little easier to dump bucketfuls of water in the ashpit than to adjust the small drip in the water supply to the vaporizer. It entails two serious disadvantages: waste of heat and irregularity of gas quality.

It might seem that there is no waste of heat because the "heat is already in the ashpit," as my operator friend expressed it. The answer to that is that it is largely untrue. There is some heat in the ashpit, of course; it is warmer there than in the outside atmosphere, but the heat normally there is not enough to make the steam required by the generator.

In order to allow enough heat to pass down from the fire zone to water on the

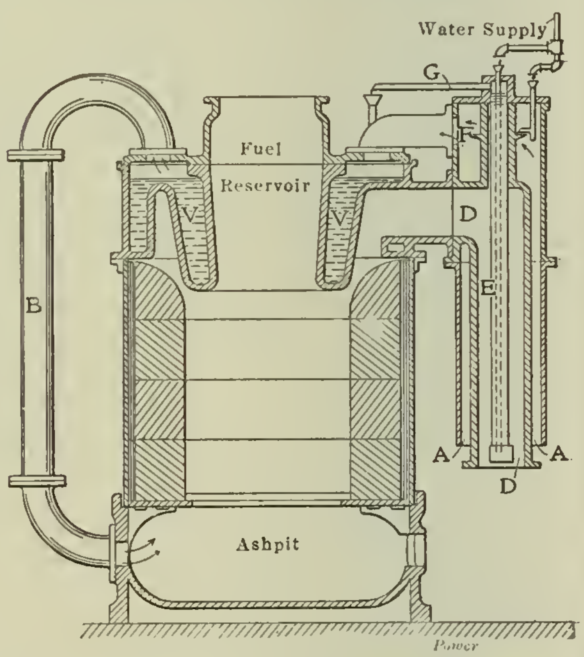


Fig. 4. Built-in Vaporizer and External Economizer

floor of the ashpit and vaporize as much as the generator needs, the bed of ashes beneath the incandescent coal must be kept thinner than it would otherwise be; this will permit more heat to escape from the fire than would get out under proper conditions. Moreover, with water in the ashpit the temperature there will be lower and, consequently, the flow of heat from the fire into the pit will be greater than if no water were there. Every heat unit taken from the fire *unnecessarily* is wasted, no matter what you do with it.

The quality of the gas is made irregular by this practice because more heat will flow from the fire to the ashpit immediately after ashes are shaken or poked out of the generator into the pit than immediately before; consequently, more hydrogen will be put into the delivered gas. As the ash bed beneath the fire zone increases in thickness, due to the combustion of coal, the heat passing from the fire to the water each minute or hour will gradually decrease, causing a decrease in the water evaporated and a resulting decrease in the proportion of hydrogen in the delivered gas.

In short, when the fuel bed is poked down or the grate shaken, the proportion of hydrogen in the delivered gas suddenly increases; then it gradually decreases until the next poking or shaking is done. And an increase in the proportion of hydrogen usually means an increase in the proportion of carbon dioxide and a corresponding *decrease* in carbon monoxide.

The reason for this is that increasing the proportion of hydrogen can be done only by increasing the proportion of steam passed through the fire; this reduces the temperatures of both the fire and the decomposition zones, and the reduction of temperature almost always reduces the percentage of carbon monoxide and increases that of carbon dioxide, as explained in the last lecture (January 10, 1911).

An Engine that Generates Its Own Gas from Coal

Another stride toward ultimate simplicity has been made. A. M. Low, an English engineer, has devised an engine which generates from coal the gas by which it is driven. The accompanying sketches illustrate the more important constructional features of a small experimental engine that has been in operation some time.

Fig. 1. Rear End of Engine with Generating Attachment

Fig. 1 is a view of the "breech" end of the engine, which is of the single-cylinder single-acting type with a horizontal cylinder. Several tubes pass horizontally through the combustion space of the cylinder, from the coal box at the right to the water-sealed gas box at the left; these tubes, where they lead from the cylinder to the gas box are indicated by the letter *A* and at other points by dotted lines. The tubes pass also through a distillation box *B*, where they are subjected to the heat of the exhaust gases as the latter leave the cylinder.

The coal box is filled with crushed coal and this is forced into the tubes just mentioned; when it reaches those parts of the tubes inclosed in the distillation box, the heat of the exhaust gases distils out the lighter volatiles in the coal and these are immediately taken out by the small branch pipes *C* and carried to the gas box. When the heavier constituents in the coal enter the tube sections which are located in the combustion chamber, they are heated to a very high temperature, of course. At this point, steam and air blown in by fans supplied with steam from the water jacket of the cylinder (this connection is shown semi-diagrammatically in the horizontal section, Fig. 2) act upon the carbon exactly as in a gas generator, forming hydrogen, carbon monoxide and carbon dioxide.

These final gases pass on to the gas box, which is really a small holder, where they mix with the volatiles previously distilled out of the coal. From the holder the gases pass to the inlet-valve chamber of the engine, where they are mixed with air, in the usual way, before entering the cylinder.

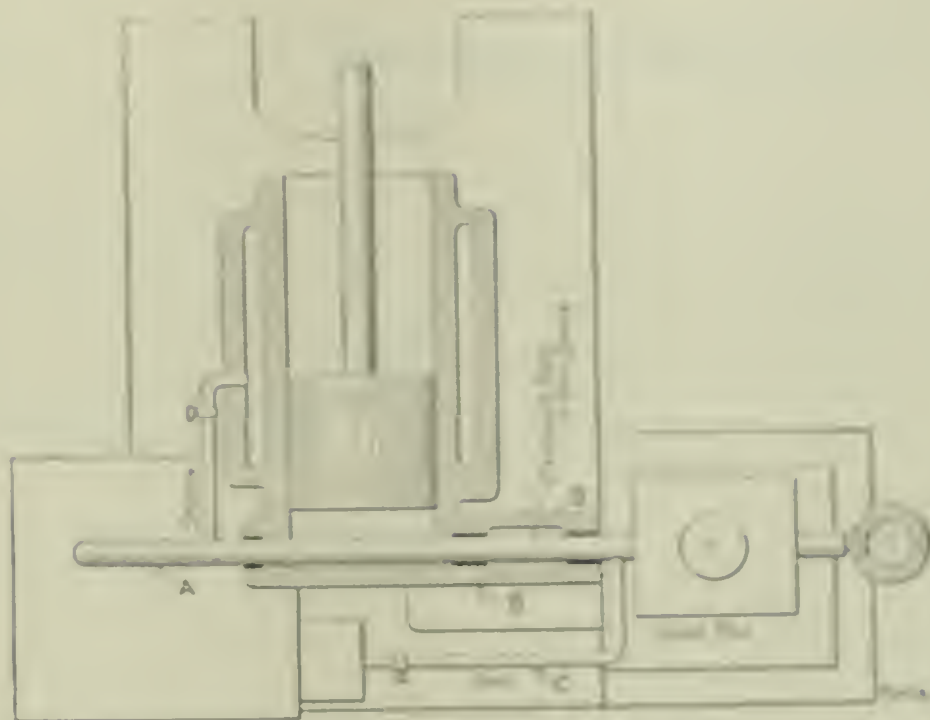


Fig. 2. Horizontal Section through Cylinder

The mechanism for feeding the crushed coal into the gas-making tubes consists of a number of archimedean screws, each arranged as represented in Fig. 3. In the engine illustrated by Fig. 1 there are four gas-making tubes; coal is forced into each of these by an individual screw and the four screws are gear-driven from a single vertical shaft. This shaft is driven through an adjustable clutch by a belt from some part of the engine mechanism and the governor controls the clutch so as to vary the supply of coal according to the load conditions.

Fig. 3. Coal Feed

The inventor claims that his experimental engine has shown a fuel consumption of ¾ of a pound of coal per brake horsepower-hour; also that the coal is "cracked" so quickly by the high temperature that all hydrocarbons can be passed through the engine and discharged without any difficulty. Several weeks of running, he states, have failed to show any tar or lampblack. The producer part of the outfit works on practically the "Dowson" system, the coal being fed in minute quantities as needed and immediately gasified.

We are indebted to Gas and Oil Power for the general information and the illustrative material utilized in the preparation of this article.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Pumping Water by Air

A State institution has a well that is 135 feet to the water, and it is 57 feet to the top of a tank into which the water is to be delivered. They wished to do the work by means of air, and had a 15-horsepower gasolene engine and an 8 and 4 by 8-inch two-stage air compressor set up, the latter to run 265 feet piston travel per minute. The engine had a 34-inch pulley and the air compressor had a 42-inch pulley.

The air line extended down 285 feet below the water level.

As the engine would not do the work, I decided, after a night's sleep, to make it do it. The intake was bushed from 3 to 2 inches and a close nipple and a globe valve were screwed in the 2-inch opening. The valve was partly closed and the trick was done. By opening the valve, all the air that the engine could pull could be admitted and all the water that the 15-horsepower engine could supply air for was obtained. I think that if the pulley on the engine were reduced to 24 inches in diameter, so the intake could be opened to its full size, better results might be obtained. Would this be the means of producing any more water, the engine running at the same speed? I would like to hear from those who have had a similar experience.

H. T. Fryant.

Mobile, Ala.

Distant Control Valves and Oil Indicating Scheme

During a recent visit to a large pumping station I was much interested in the arrangement made use of for operating the service gates and heavy valves in the neighborhood of the station. Many of them were of several tons weight and all were operated by hydraulic pressure from the engine room.

The water used in the operation of the gates was pumped to an ordinary pressure tank where a pressure of 160 pounds per square inch was maintained. It was admitted to the cylinder at the top or bottom as desired, by a four-way valve, which also serves the double purpose of admitting pressure upon the side of the piston necessary to operate the gate, and that of opening a means of escape for the water already contained in the cylinder to the return tank.

The operator can control the gates with perfect ease by means of a small hand lever upon the control board. The opposite end of this lever is extended beyond the valve stem a few inches and serves as a pointer indicating upon a quadrant which way the four-way valve is open.

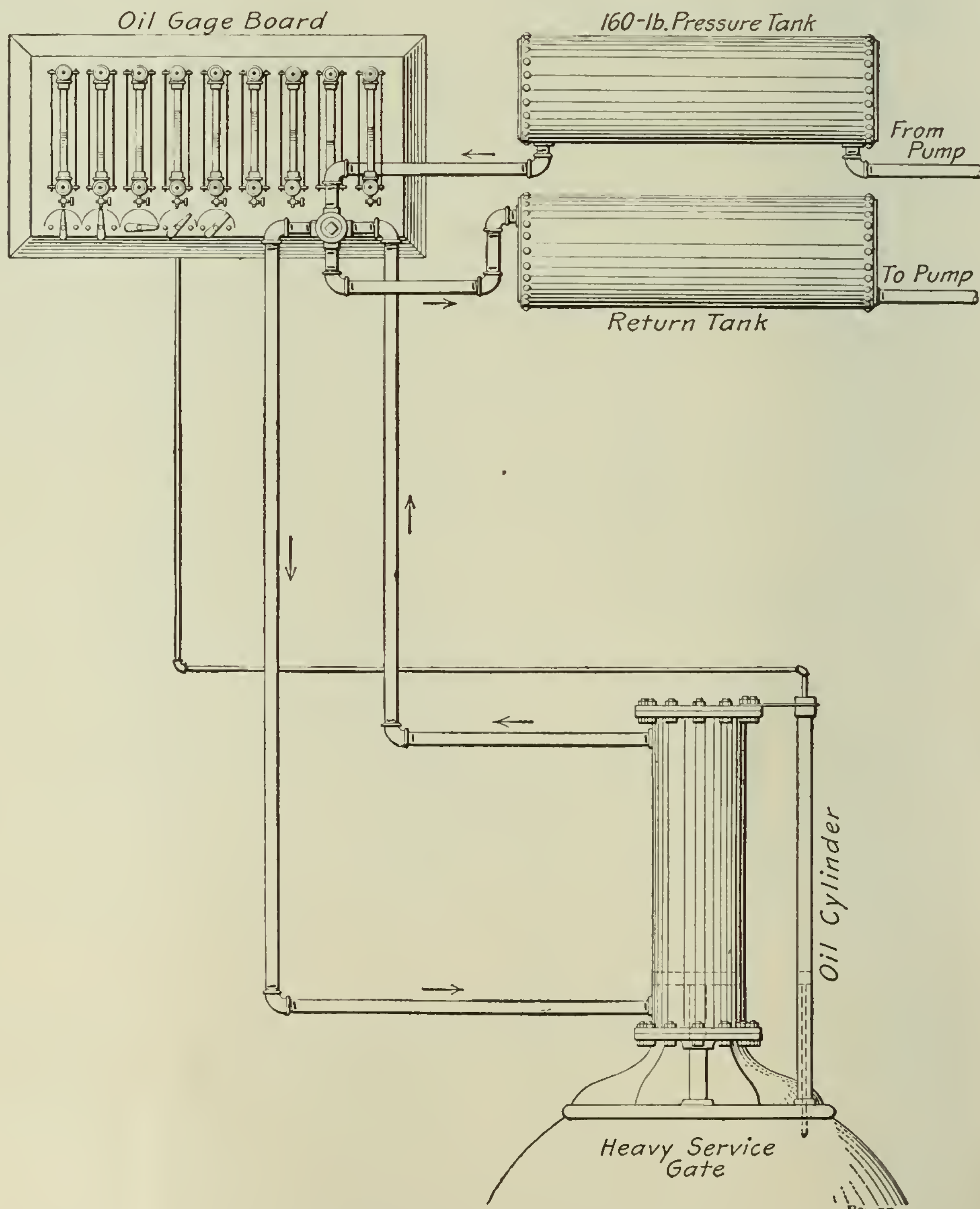
An interesting oil-indicator scheme has also been worked out. A tail rod is attached to the valve disks in the conduits, which plays up and down with them.

This rod operates a piston in a small cylinder of the same length as the large ones.

This cylinder is filled with oil, also the pipes which run to the control and gageboard. There is a gage glass for each valve where its position is plainly indicated by the hight of the oil.

When a gate is open, the corresponding oil gage glass will be nearly full. The tail rod forces the oil up out of the small piston and when it is closed the conditions are reversed.

A little difficulty was encountered when



Showing Piping of Indicating Device

the system was first installed, due to air bubbles in the oil, which would give an incorrect reading, and some experimenting also had to be done before the proper oil displacement could be gotten at to keep the range of altitude right for the glasses. The first difficulty gradually adjusted itself after the system of piping was opened at the highest point. The second trouble was overcome by the establishment of a common reservoir for all the lines at the top of the gageboard. It serves as a sort of an overflow tank and replenisher. The accompanying sketch gives an idea of the scheme. One pump, pressure tank, return tank, etc., are used in common for handling all heavy gates about the station. Only the four-way valve and piping for one are shown.

EDWARD T. BINNS.

Philadelphia, Penn.

Reduced Discharge Pipe Increased Motor Load

In the plant where I am employed, there is an 8 and 7 by 10-inch steam pump and a 5½x8 triple-plunger power pump, driven by a 10-horsepower motor. This outfit furnishes the town with water, but the former pump is used only in case of emergency.

Upon taking charge of this plant I looked over the pump-piping layout and found the suction and discharge pipes to be 4 inches in diameter. The discharge pipe from the power pump had been reduced to 3 inches by putting a bushing in the pump flange and one in the main discharge pipe with a nipple between.

The old pipe was removed and a new 4-inch pipe was put in its place, and it was found that the motor load was reduced from 6.2 to 5.2 kilowatts per hour. This was partly accounted for by the fact that the old pipe was badly scaled.

T. K. LEE.

Benson, Minn.

Temporary Pipe Repair

A 2-inch supply pipe to an overhead tank was allowed to freeze and when thawed out was found split open for about 30 inches. The tank was situated at the top of a steel tower some 70 feet in hight.

This 2-inch supply pipe, a 3-inch discharge pipe and two 1½-inch steam-heating pipes ran up the center of the tower inside a wooden casing. The leak was about 50 feet from the ground.

Owing to the close proximity of the other pipes it was not possible to use the pipe cutters, and it seemed that the only alternative was to remove the casing and pull down a long run of pipes.

However, it was decided to put a patch on the pipe until the weather should become milder. A piece of 2½-inch pipe, 36 inches long, was procured and cut lengthwise into two equal parts.

One-half was retained and lined with sheet rubber. This was placed over the leak and drawn firmly up to the pipe by means of four clamps placed about 10 inches apart.

This effectually stopped the leak.

WILLIAM WATT.

Lambton Mills, Canada.

A Condenser Accident

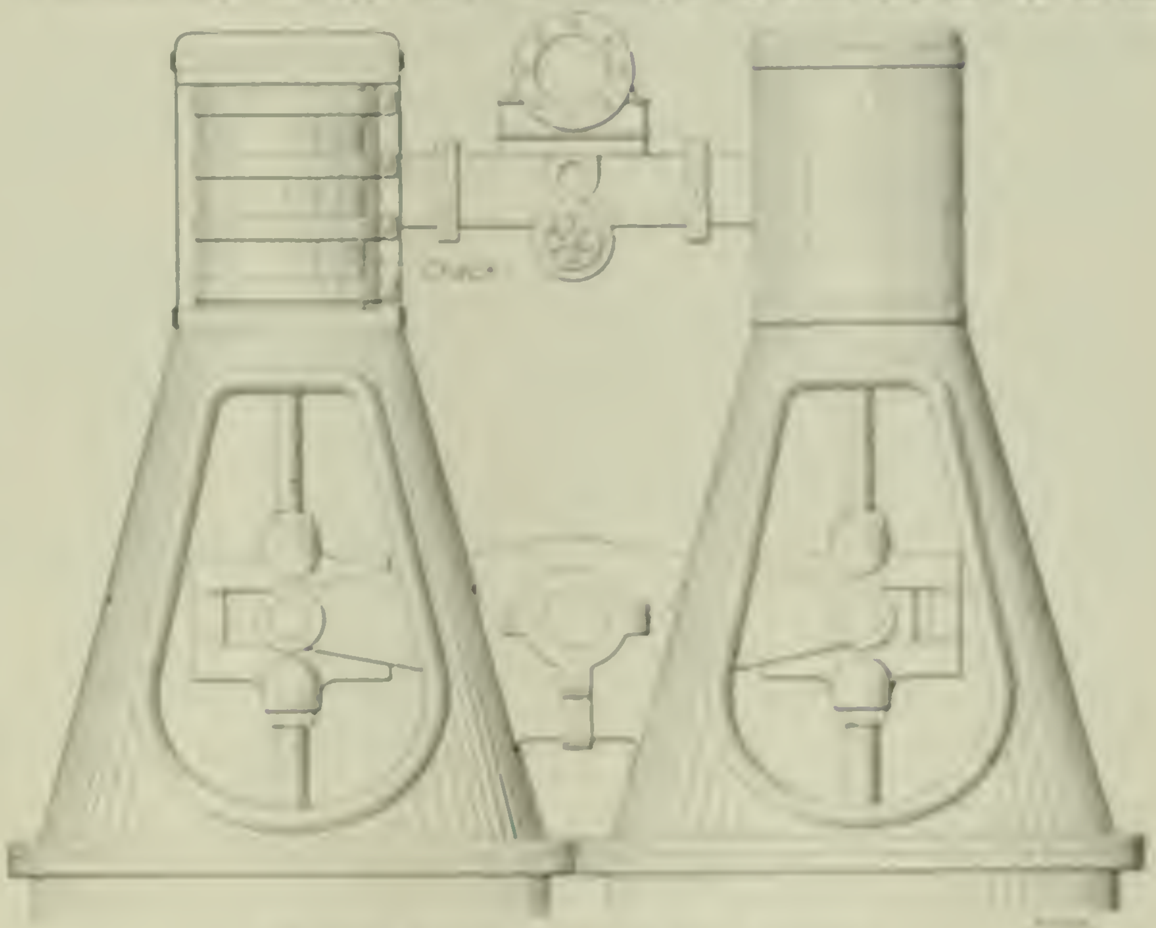
A large compound jet condenser had been used in a power station for about five years. The high- and low-pressure piston rods were connected by means of crossheads and wristpins on the end of a rocker beam that was pivoted in the center.

The valve gear was automatic and often caused the pump to hang up whenever the valve stuck, which reduced the vacuum. Requests had been made to have a valve rod connected to the beam, but without success.

A cylinder head had been blown out of the high-pressure cylinder soon after it had been installed. Some time later a new cylinder was put on because a thin wall had been discovered when drilling a hole to allow a quicker flow of steam to aid in operating the main valve. Everything went as usual after the new cylinder had been put on and the men predicted the pump would always be a hoodoo in the plant, owing to its design.

Last winter it refused to work and an examination revealed that the low-pressure cylinder had cracked on one side the length of the cylinder.

Temporary repairs had to be made and as the low-pressure cylinder worked under a low steam pressure, it was decided to put a strip of gasket rubber over the crack and a flat strip of iron over the gasket to hold it tight. Bands fitted with draw bolts were made of such a length as to go around the cylinder over the strap. They were then bolted tight, as shown in the illustration, and made the crack tight enough for service, although there was some leakage at the flanges.



HOW THE CRACKED CYLINDER WAS REPAIRED

The condenser was run this way for nearly six months when two new high-pressure cylinders were put on, also, a new valve and steam chest, the valve having a rod connected to the beam, which made the action of the valve more regular and positive with each stroke.

Just what caused the cylinder to crack is not known, but when the piston, which was of the solid type, was taken out, the lower packing ring was found broken and a piece had worked over into the other slot where the ends of the ring were found to have worn thin. The thin end of the broken ring extending over the edge of the slot had become wedged between the piston and the wall of the cylinder. When the piston was on the downward stroke the force from the high-pressure cylinder transmitted through the beam, together with the weight of the descending bucket, probably caused the fracture. But how the piece of ring got over from the bottom slot into the top one, is most mysterious, as it could not have overridden the intervening 8 inches, the thickness of the piston, or swing enough to allow the top ring to spring out, or it would also have been broken.

R. A. COLLINS.

Cambridge, Mass.

Manhole Gaskets

Perhaps my method of putting manhole gaskets on manhole plates will be of interest. I take any good make of ⅝-inch round gaskets for the manhole, but, before using, the plate is cleaned with a sharp tool, and a mixture of either red or white lead and boiled linseed oil with a consistency of a thick paint is applied to cleaned surface. The gasket is cut to the proper length and the lead tube inserted in both ends and the joint taped.

Then a coating of graphite and cylinder oil is applied on the exposed side of the gasket and the plate is then placed in position in the manhole.

Before removing the plate again, I take a sharp tool and mark it so as to always replace it in the same position.

When removing the plate the gasket will stick to it, and it is only necessary to trim off the overhanging parts of the gaskets and apply a coating of graphite and cylinder oil before replacing it.

I have used this method for many years with success and have used the same gasket twenty times or more, without leakage, before replacing with a new gasket.

E. L. Morris.

Salem, Va.

Boiler Setting

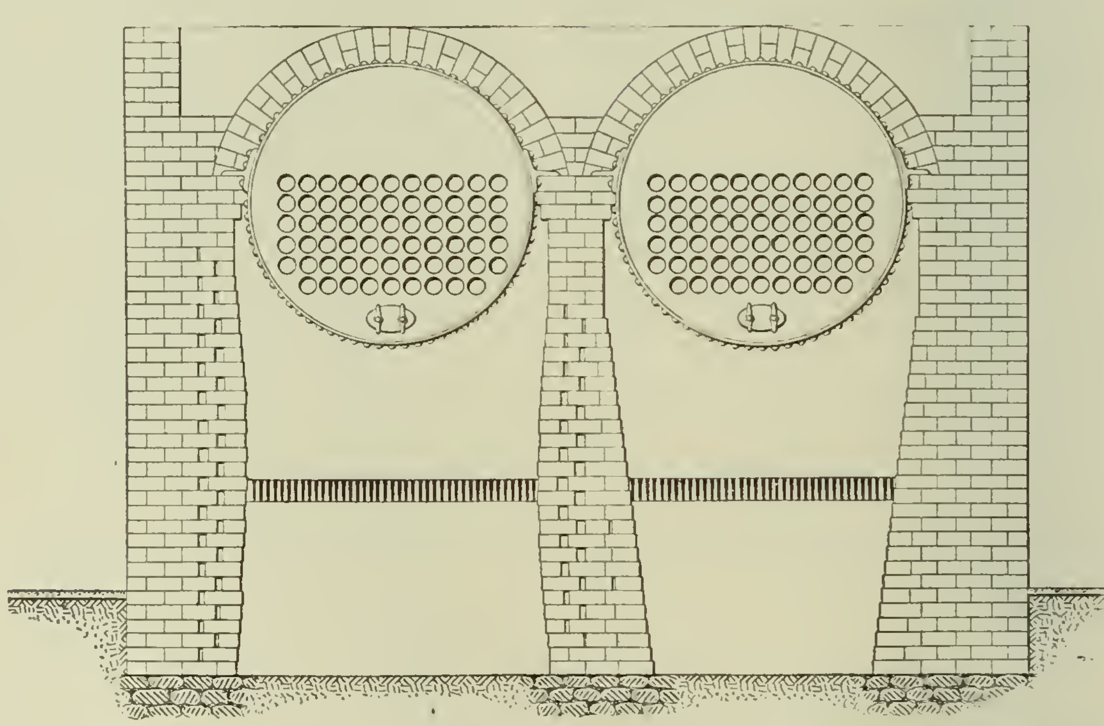
Perhaps a job of repair work which was recently done on the brick settings of some horizontal tubular boilers may be of interest. There were four 5x18-foot horizontal return-tubular boilers, set in batteries of two, each boiler supported by lugs resting on wall plates in the usual way.

For some reason the walls were never properly built, the furnaces having been made with thirteen courses of firebricks on the side walls before any headers were reached, and the bridgewalls had been faced with bricks laid flatwise to the grate surface. The side walls of the combustion chambers were laid up with common red brick, the joints being from ⅜ to ¾ inch thick, and considerable lime had been used in the mortar. Further, from twelve to fourteen courses of bricks had been laid up before any headers were tied into the wall. As a result the mortar worked out of the walls and the heat caused the walls to bulge in about 6 or 7 inches, and one side wall fell into the combustion chamber before the boiler could be laid off for repairs.

The furnaces were first repaired by taking down the wall and rebuilding the lining, cutting in a course of headers at the sixth course above the grates and using a good grade of firebrick, and fire clay so thin that it could be put on very thin, which allowed the bricks to come practically brick to brick, only clay enough being used to fill in the unevenness of the bricks.

The rear wall was quite another proposition, as it was not advisable to tear down the whole of the wall if it could be avoided, although that was what I recommended be done and an entire firebrick wall be built in its place.

The combustion chamber of these boilers had been carried down to within about eight inches of the ashpit level as there were many reasons for not entirely rebuilding the wall. As much of the face of the wall as was deemed safe was removed, after the boiler had been blocked up to prevent accident, and at the bottom of the combustion chamber the wall was brought out 14 inches and then built up to a hight nearly to the lugs and under a course of headers, above which the wall was sound. This wall was stepped in about one-quarter inch for each course and was all of firebrick, laid close together and headers every fifth course. The old red bricks were used as backing to the firebricks. These walls were carried from the bridgewall back to the rear wall on all four boilers.



Condition of the Old Furnace How the New Furnace was Bricked

The bridgewalls were taken down far enough to allow firebricks to be set in edgewise and was lowered 4 inches, so that it is now 13 inches from the boiler shell, whereas, before it was but 9 inches. The changes can perhaps be better understood by referring to the right-hand view, which shows the side walls as they are at present.

These boilers steam much easier than before and lowering the bridgewall has increased the draft considerably. As the center wall has a batter on both sides, built entirely of firebrick, it is expected that these repairs to the combustion-chamber walls are good for the life of the boilers, and so far the results have been better than was expected.

Return-tubular boilers are set too low in most cases for soft coal. From my observation a 72-inch boiler should be set at least 40 inches if not 48 inches above the grate bars, and plenty of room left for the combustion of the gases.

One experience I had some few years ago, on some large boilers which were set high, has convinced me that any engineer having the matter of setting new boilers in hand can do no better than by setting them high above the grates for soft coal, with good, thick walls and headers every fifth or sixth course, thin joints on the outside walls, all firebrick surfaces practically rubbed together, a low bridgewall and plenty of room between the rear wall and the rear head of the boiler. The first cost may be a little more, but it will be found a first-class investment.

William S. Trofatter.

Boston, Mass.

Starting a Plunger

An old, rusty steamboat doctor had been idle for over a year, and the plungers were stuck tight.

Every available suggestion was tried but it would not "break loose" even with a heavy leverage upon the flywheel, and even coal oil had not touched every part of the surfaces in contact, though a large quantity had disappeared.

Someone tucked some oily waste around the top of the plunger and then set fire to it, which was followed by an explosion. No damage was done and the plunger was loosened.

The same scheme was carried out on the other plunger, but less oil was used and the waste was put in and set on fire before much oil had time to soak down.

This method of loosening a pump plunger is not to be recommended, and is more or less dangerous.

Lloyd V. Beets.

Nashville, Tenn.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Expansion Valve

Of late several letters have appeared in POWER under the above head. Some of the writers seem to be under the impression that engineers apply the term "expansion valve" to the feed valve through ignorance of the principles of refrigeration, but that is not the case. We get the term from the builders of ammonia valves and fittings, and the use of it is no more incorrect than the use of such terms as "expansion coil" or "flooded system."

R. E. HENSLEY.

Hico, Tex.

Blowoff Piping

In the December 20 issue, Edward Hamilton described the blowoff arrangement for his boiler. O. B. Critchlow in the January 24 issue criticizes it, claiming that it is in no way satisfactory to him. He thinks that all of the circulation would be due to the condensation in the small riser, which would be of no practical value. I think that he is in error, for in my experience the device works satisfactorily. Further, it is recommended by boiler inspectors.

W. STEINDORFF.

Brooklyn, N. Y.

The Benefit of Organization

I have been following the items in POWER on engineers' wages. Strive as we may our wages will never go up, unless we all join and form an organization of some kind, and "stick together." Nowadays if an engineer demands more pay, no matter how good a man he is, the employer will say "Well, if you can't work for the wages you are getting, we can get someone that will work for even a little less." He will not stop to think, "Is my next engineer going to be capable of handling my expensive machinery?"

I have been in the employ of one company for the last eleven years and have been engineer for six years in charge of one 150-horsepower Corliss engine, one 75-kilowatt generator, seven motors, ranging in capacity from ½ to 12 horsepower, and one 200-horsepower water-tube boiler. I have all of the repair work to look after, and still can not convince my employer that I am worth more than some of the men working in the factory, running one machine for ten hours a day.

But, then, whose fault is it? Surely we cannot blame the employer. In a way, it is the engineers' fault. As I said before, why not stick together and form an organization. Then we can demand higher wages, and not until then.

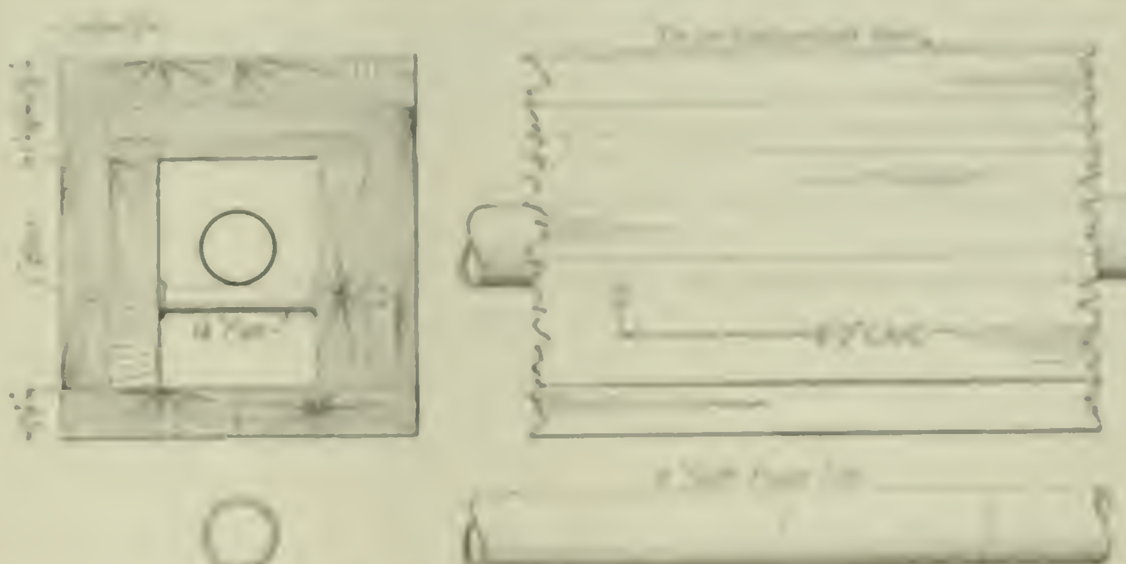
CHARLES GOTSTEIN.

Algoma, Wis.

Underground Pipe Protection

Having seen several articles in POWER on underground steam-pipe protection, I submit the accompanying sketch showing the construction we have used with good results.

Opinion may differ as to the proper size of the space for the pipe. For a 4-inch pipe the inside width should be about 8 inches, the inside depth about 12 inches and the rollers about 4 inches above the bottom. The 1½-inch insulation space at the sides may be filled with shavings to good advantage. If desired, the top of the box can be covered with old tin or galvanized iron so that the water cannot soak through the top of the box. The rollers are made of old 1½-inch pipe and 1-inch bolts or rods so that when expansion occurs the pipes will be free to roll.



BOXING FOR UNDERGROUND STEAM PIPES

In case the soil is very wet, a 3- or 4-inch field tile should be laid about 3 inches under the box to drain the water away. If several hundred feet of pipe are laid in a direct line in the box and a leak occurs the pipe can be disconnected at both ends and then easily drawn out and repaired; a rope should be secured to the one end so when the pipe is repaired it can easily be drawn back in place again. In this case the cost of digging and searching for the leak, and the time lost in replacing the dirt can be saved, which is quite an item.

W. H. WOLFGANG.

Toledo, O.

Reliability of Test Figures

The editorial in the February 7 number under the above title is quite true. I firmly believe that one of the greatest hindrances to engineering progress today is the overconfidence which the average man has in his own work and the readings and results obtained by himself.

Erroneous results of gas analyses made with the Orsat apparatus have undoubtedly occurred hundreds of times. In the majority of cases the operator is not as inquisitive as the one referred to was, and fails to learn the cause of the inaccurate results; in fact, many are unable to tell when the results are right and when not.

The trouble described can easily be avoided by having the tubes in the front leg of the pipette supported on a spiral wire so that none of them will drop in to the small U-tube connection through which the liquid passes back and forth between the two legs of the pipette.

F. G. BAILEY.

Boston, Mass.

I was interested in the editorial headed "Reliability of Test Figures" in the issue of February 7, especially that part relating to the Orsat apparatus, as we had the same trouble recently in analyzing producer gas. In all previous tests we had obtained only a trace of oxygen, generally none. All at once we began to get anywhere from 4 to 11 per cent. The action described in the editorial was all there. We thought that the new reagent was at fault and emptied it out of the oxygen pipette at which time we found that one of the little glass tubes had slipped down into the neck of the pipette. We got all of the tubes up into the body of the pipette, put the reagent back, made an analysis and the percentages ran about as they should.

J. O. Benefiel.

Anderson, Ind.

Capacity of Refrigerating Plant

The article under the above in the February 21 issue contains errors.

The total heat transmission,

$3.43 \times 484 \times 55 = 91{,}307$ *B.t.u., not* 91,770.

After having ascertained the number of B.t.u. to be abstracted it is useless, and not customary, to convert this quantity into "pounds" (ice-melting effect), because in dividing B.t.u. by 288,000 the capacity of the compressor in tons refrigeration per 24 hours is obtained directly. For 12 hours' run simply use 144,000 as the divisor.

The temperature of ammonia evaporating under a back pressure of 27 pounds gage is 14 degrees Fahrenheit. As the room temperature is to be 35 degrees, the difference will average 21 degrees. A lineal foot of 1¼-inch direct-expansion pipe will abstract between 9.6 and 13.7, say on the average 12, B.t.u. per 12 hours for each degree difference; hence, in our case 252 B.t.u. For 12 hours' run we, therefore, require only

$91{,}770 \div 252 = 364$ *lineal feet of pipe,*

not 3500 or 4000 feet as was given. With 3500 feet of piping properly distributed there would be absolutely no storage space left in the size of refrigerator under consideration.

To operate for only 6 hours continuously is bad practice, because of the incidental fluctuating temperatures which are injurious to the goods stored, their temperature having to be reduced to below 35 degrees in order to counteract excessive temperature rise during the 18-hour period of shutdown. The proper way then is to use brine-storage tanks which continue to refrigerate after the machine is stopped. When, however, expansion pipes only are employed, the machine should be run mornings and evenings. With but 6 hours' continuous operation, provided the goods can be cooled down in so short a time, we require not only twice the amount of piping needed with 12 hours' run but rather more, say 800 feet (as against 6400 feet) because toward the end the temperature difference will be small. Rather than crowd in the 800 feet of pipe, the machine should be proportioned to do its work with ammonia gas at some temperature lower than 14 degrees.

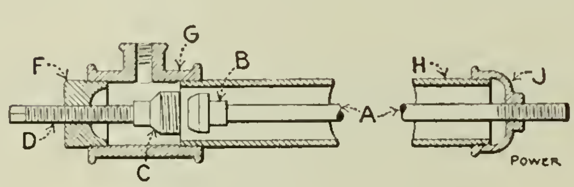
One receives the impression from the article that for 6 hours' run *less* than double the amount of piping needed for 12 hours is sufficient, while, as shown above, *more* than the double amount is required, at the same back pressure.

Charles H. Herter.

New York City.

Homemade Trap

I saw in the January 31 issue of Power a description of a homemade steam trap, by George J. Little. I have had a good deal of experience with traps of the same general type, and find that they give excellent service. They can be so constructed that there is practically no loss of steam. The outlets from all of our traps of this kind are exposed; in operation there is a flow of water, then a barely perceptible puff of steam which instantly stops. Good satisfaction may be secured by making the brass pipe from 18 to 24 inches long. This allows a sufficient movement for satisfactory operation.



A Homemade Trap

The construction of the traps which we make is shown in the accompanying figure. The pipe *A* is of brass, the size depending on the amount of water to be handled. This pipe is threaded on both ends. One end screws into the half *B* of a ground brass union, the other into the reducing coupling *J*. Enough thread is cut on this end to allow for a connection to the system to be drained. The coupling, in turn, goes onto the piece of iron pipe *H* which is large enough to contain the two parts of the union. On the other end of the iron pipe is a tee *G*, with its side outlet connected to the discharge for the water. Screwed into this tee is a reducing bushing *F*, through which passes the solid rod *D*, with a squared outer end, connected to the other half *C* of the union. This rod affords a very easy method of adjusting the relative positions of the two parts of the union.

The advantages of this trap are its uniform reliability, ease of adjustment to prevent loss of steam, and the simplicity of its construction.

J. F. Mowat.

Joliet, Ill.

Vacuum for Reciprocating Engines

I cannot but feel a little sorry for the young engineer who learned some facts about steam distribution in engines and then lost confidence in his knowledge when confronted with the arguments of John H. Ryan, as presented in Power for January 31. It seems hardly possible that the young man was considering the change of the low-pressure cylinder to permit of expansion clear down to 28 inches vacuum—producing a sharp point on the indicator diagram. The 36-inch low-pressure cylinder of the engine (an 18 and 36 by 48) would probably be operated with a terminal pressure of from seven to ten pounds absolute, according to load. An improvement in the vacuum would not imply an increase in cylinder dimensions, but only a little greater drop at the end of the diagram.

I am ready to credit the young man's next statement, that a well designed new engine in the same town was being operated with 28 inches of vacuum. His instructor's bet—that indicator diagrams from that engine would show the exhaust valves opening early in the stroke, with the cylinder pressure falling to the exhaust back pressure (28 inches of vacuum) by the end of the stroke—was safe. What well designed engine would be operated otherwise than with the exhaust valves opening early enough so that the forward-pressure line would fall to the back-pressure line at the end of the stroke, or very shortly after? A later opening of the exhaust valves would cause what every engineer knows as a "toe" on the end of the diagram.

The fact is, the young student was right in principle, but perhaps failed to make sufficient drawback allowances when estimating the saving to be realized by the proposed condenser improvements. He was right in believing that a pound pressure removed from the front of the piston is equal to a pound applied to the back. He was also right in suggesting a larger air pump for a higher vacuum as a means of increasing the economy of the plant. The larger pump would have to handle twice the quantity of entrained air and noncondensable gases, not twice the volume of vapor or steam, when the vacuum increases from 26 to 28 inches, and the volume of the air would, of course, be much less than the total volume of the vapor exhausted from the engine into the condenser, therefore, much less than 60 additional cubic feet volume per pound of steam, upon increasing the vacuum from 26 to 28 inches. Air-pump operation costs the same, whether the steam comes from cylinders or turbines; why use 28 inches vacuum on a turbine, if the cost to produce the higher vacuum is as much as the gain?

In regard to cylinder cooling and the consequent initial condensation, the terminal pressure due to the expansion of the steam in the cylinder has more effect than has any subsequent terminal "drop" or free expansion of the exhaust into the condenser. If the compound engine of this argument were operating with a mean effective pressure, referred to the low-pressure cylinder, of 40 pounds, the removal of 2 pounds back pressure, by increasing the vacuum from 24 to 28 inches, would make it necessary to cut off enough earlier to reduce the average forward pressure by 2 pounds in order to keep the same area in the indicator diagram. This indicates, roughly, a saving of 2/40 or 1/20 of the steam, against which there would be some increased losses, so that the full 5 per cent. saving would not be realized; but as large compound engines often operate on lower mean effective pressure than 40 pounds, I am not convinced that the ambitious young engineer was all wrong in expecting to save enough coal to justify a better vacuum than 24 inches.

S. H. BUNNELL.

New York City.

It looks to me, after reading J. H. Ryan's article in the January 31 issue, that he tried hard to throw dust in the young refrigerating engineer's eyes concerning this low-vacuum theory for reciprocating engines. I believe that the young fellow knew better but had not the argumentative tact necessary to pin Mr. Ryan.

Of course, I do not believe that 28 inches of vacuum makes for economy in this size of engine, but neither do I believe it would prove economical were the cylinder twice as large. What has the size of the low-pressure cylinder to do with the degree of vacuum attainable or maintainable by the condenser? I always thought that consideration of the power required to drive the air pump and the amount of heat to be supplied to the feed water by the primary heater determined the economical degree of vacuum, provided there was sufficient cooling water to be had. During my experience with a number of compound engines of different cylinder ratios, I never yet was able to take a diagram where the low-pressure steam expanded to the temperature of the vacuum, before the exhaust valve opened. Therefore, did Mr. Ryan expect to overawe the engineer by all that talk about the expansion laws of gases, and did he think the young fellow swallowed such statements that he would require a 60-inch low pressure cylinder and 500 degrees of superheat to obtain 28 inches of vacuum? What did all these engineers who operate a compound engine, having a low-pressure cylinder of 30x48 inches think on reading the statement that 21 inches of vacuum is all they should carry if they would run their engine to the best advantage?

In one paragraph Mr. Ryan allows something sensible when he states, "I admit that anyone could get 28 or more inches of vacuum if he had water enough." That is just what the young engineer was after, the very thing that Mr. Ryan was called to settle—the question of obtaining more and cooler water. It seems to me that he should proceed to show (if it were true) how the interest on the initial expense would offset in dollars and cents whatever gain resulted from an increase of the vacuum. Instead of that, however, he wants to wager that the exhaust valves of the cotton-mill engine open for release before the piston reaches the end of the stroke. Of course, the young engineer did not take him up. Would you?

Further on he states, "There would probably be more than six pounds absolute pressure in the low-pressure cylinder when the exhaust valve opened and all this heat would be rejected into the condenser," when 28 inches of vacuum was carried on the cotton-mill engine. Now, would there be any less heat rejected if 21 inches was the rate of vacuum carried? Is it common sense to assume that the higher the vacuum the higher the terminal pressure? Toward the end of the article he states, "Reciprocating engines running with complete expansion to a high vacuum do not show as good results (as turbines) because the loss from the cylinder condensation is high," meaning thereby, from what can be gleaned from preceding paragraphs, that most of the condensation takes place in the low-pressure cylinder if a fair vacuum is maintained. Now, taking Mr. Ryan's example of 15 pounds receiver pressure, I would like to ask in which cylinder is the greater condensation in the following case: The high, assuming the common absolute pressure of 165 pounds and a back pressure of 30 pounds; or the low, which expands this 30 pounds absolute pressure to an absolute back pressure of 2 pounds? It is commonly asserted, and generally believed that cylinder condensation is due to the difference in temperatures between the initial and the exhaust steam in each cylinder. Presuming this to be correct, Mr. Ryan, when considering the question, may neglect the fact that usually, due to a "drop" in the receiver, the initial steam of the low-pressure cylinder is dryer than that of the high-pressure cylinder.

C. HOONAN.

Saxonville, Mass.

Engineer or Laborer

The editorial under the above caption in the January 31 issue is one of the best I have ever read. The employment of such men as the quoted advertisement would undoubtedly bring out, probably is responsible for more waste and accidents than any other single cause. I remember one plant in which low-grade men were employed on the night shifts, there always was enough repair work to keep one or two men busy all the time.

Besides the man who does not know, the man who "boozes" is one of the most dangerous that can be employed in a plant. I remember a case where three high-speed engines were put out of commission on account of a night engineer who would "booze." The next day was a busy one for all hands, getting those engines into shape again. This man had been in the habit of "hitting it up" and then depending upon an assistant to carry him through. Because he ill treated his assistant the man stayed in the boiler room at his post and away went the engines. After that the management hired a higher-priced and more reliable man.

C. R. McGAHEY.

Baltimore, Md.

Plant or Unit Efficiency

One is frequently startled by the news that someone is producing a kilowatt-hour on something like 2.25 pounds of coal. Hence, it was with much pleasure that I read the editorial under the above caption in the February 7 issue.

My idea of the way in which to get the coal consumption per kilowatt-hour is to divide the pounds of coal consumed each month by the electrical output minus the quantity of current used by the electrical auxiliaries.

For instance, if there are 5000 tons (2000 pounds per ton) of coal in the bunkers at the first of the month and 15,000 tons are received during the month and if 4000 tons are left over at the end of the month, it is evident that 16,000 tons, or 32,000,000 pounds, of coal have been consumed.

Now, if the output of all of the generators is 9,000,000 kilowatt-hours and the consumption for station lighting and for driving the electrical auxiliaries, such as motor-driven wet pumps, motor-driven circulating pumps and motor-driven exciters, is 1,000,000 kilowatt-hours, the net output to the line is, evidently, 8,000,000 kilowatt-hours, and the coal consumption, four pounds per kilowatt-hour.

Now, to figure in another way, suppose that two 5000-kilowatt machines make a kilowatt-hour on 15 pounds of steam, that another uses 16 pounds and that four engine-driven 3000-kilowatt units use 17 pounds. With an evaporation of seven pounds of water per pound of coal, in the case of the machines consuming 15 pounds of steam it is the idea of some that a kilowatt-hour is being generated on 2.14 pounds of coal, and so on down the line.

Although it may seem paradoxical, sometimes the machine making a kilowatt-hour on 16 pounds of steam is using more coal than the one requiring 17 pounds. If the machine with the lower rate is a turbine, it probably would use nearly twice as much circulating water as the reciprocating engine and, hence, considerably more power for condensing purposes. Also, as it is essential that a high vacuum be maintained for the turbine, the condenser temperature is usually as close as possible to 70 degrees. On the other hand, with the reciprocating unit no undue alarm is caused if the condenser temperature is as high as 95 degrees. Roughly, this means 25 B.t.u. per pound to the good when it comes to making a pound of steam from the condensate.

Although I have transposed a few of the sizes in the foregoing, the averages and rates are the same as those obtained in a plant with which I was connected. It may be interesting to learn how closely the monthly overall plant results compare with individual test results.

Suppose that two 5000-kilowatt machines put out 4,500,000 kilowatt-hours per month at the rate of 15 pounds of steam per kilowatt-hour. This, based on seven pounds evaporation per pound of coal, would seem to require 4815 tons of coal.

Let the 5000-kilowatt machine with a 16-pound rate put out 2,700,000 kilowatt-hours. This would indicate the consumption of 3037 tons of coal. Then, consider that the four units with a 17-pound rate have a total monthly output of 4,000,000 kilowatt-hours. These would apparently require, then, 4840 tons of coal and the total for all of the machines would appear to be 12,692 tons. As a matter of fact, in a plant containing machines of these sizes the coal consumed per month would amount to very nearly 20,000 tons.

If the current used by the auxiliaries equaled 200,000 kilowatt-hours, the actual coal consumed would amount to 3.63 pounds per kilowatt-hour delivered to the line.

One naturally asks what causes such a large discrepancy. Besides the steam-driven auxiliaries there are the peak loads, and peak loads are not money makers by a long shot.

In a plant of the size under discussion there would be needed about 40 boilers of 600 horsepower capacity each. The maximum load would have to be carried on about 38 boilers, two necessarily being down for cleaning. The peak would probably amount to about 33,000 kilowatts. The smallest load would probably be 4000 kilowatts and the morning load would run about 8000 kilowatts less than the evening load. The load during the middle of the day would probably average about 17,000 kilowatts. At the usual rating of 700 kilowatts per boiler, there would be required 33 or 34 boilers in the morning and about 24 during the day. Thus, some of the boilers are banked twice each 24 hours and this necessarily entails quite a loss.

To sum up, the editorial states that unit tests are more common than plant tests. This is true to a certain extent, but if every engineer keeps a monthly report, as he should do, he has virtually a plant test each month and it is the only true test, for the fact remains that the only true way to figure plant economy is to find out what it will do month after month and not during few hours of frenzied effort to lower the world's record for steam consumption. A plant is not run under those conditions day after day. If the right sort of a record is kept, one can tell at the end of each month wherein the efficiency has dropped, whether it be waste, oil, machine supplies, low feed temperature or any other item used day after day.

L. H. Edwards.

Kittanning, Penn.

Compound Engine Proportions

Referring to Mr. Cassidy's criticism in the January 31 issue of my article on "Compound Engine Proportions," which appeared in the issue of November 29 last, the first point of misunderstanding is due to a typographical error. Where an engine operates against back pressure, the mean effective pressure, of course, will be reduced and not increased.

Relative to the next point, which pertains to terminal pressure, this may be made somewhat clearer as follows:

Assuming that an engine is cutting off at one-quarter stroke in the high-pressure cylinder with a 4-to-1 ratio, the number of expansions will then be 16, neglecting cylinder clearance. Now, the terminal pressure obtained in the low-pressure cylinder is dependent upon this ratio of expansion and the initial pressure in the high-pressure cylinder; that is, with 16 expansions and a known steam pressure a certain terminal pressure will result; thus it is a comparatively easy matter to calculate, at least approximately. If, now, with this same engine the size of the high-pressure cylinder is reduced, the cylinder ratio is increased. If the number of expansions or the steam pressure is not changed, there will be no change in the terminal pressure. By changing the high-pressure cylinder only the cylinder ratio and the point of cutoff in the high-pressure cylinder are changed.

In connection with the example worked out in the article of an engine having a 5-to-1 ratio and a cutoff of 0.275, it is true that in the case of an engine proportioned with a high cylinder ratio there is some drop in pressure at the end of expansion in the high-pressure cylinder, or, in other words, there is expansion through the receiver as Mr. Cassidy points out. But, tests show without question that up to a certain point, high-cylinder ratio is conducive to economy; that is, the benefit obtained by additional expansion secured by increased cylinder ratio more than offsets any loss due to expansion through the receiver. Some may say that the drop at the end of expansion in the high-pressure cylinder can be reduced by shortening the low-pressure cutoff, but when this is done the condensation in the low-pressure cylinder is increased and matters are not helped. It is, therefore, found in the case of an engine designed with a high cylinder ratio that it is best to divide the load about equally between the two cylinders; when this is done some drop will be obtained at the end of expansion in the high-pressure cylinder.

Relative to the next point: With an engine with cylinders 20 and 40 inches in diameter, cutting off at 0.2 of the stroke in the high-pressure cylinder, I would say that in the case of the average engine working, say, with 150 pounds steam pressure, condensing, it would improve the economy slightly to reduce the high-pressure cylinder to 18 inches in diameter. Theoretically, of course, there should be no change in economy since no change has been made in the steam pressure or the number of expansions, but when the engine is cutting off at only 0.2 of the stroke there is excessive cylinder condensation because this cutoff is somewhat earlier than is best for producing the most economical results. Therefore, the condensation losses would be reduced by reducing the diameter of the high-pressure cylinder.

I would like to add that in the article under discussion it was not my intention to give the student of engineering a complete treatise on compound engines and the rules for proportioning them, but to bring out certain points which it has been found are not always understood by engineers. The article and the diagrams were rather intended for those who have had some experience in designing engines—the diagrams having been found useful in making determinations of cutoffs, cylinder ratios and mean effective pressures rapidly without any calculations whatsoever. The results given in the diagrams have been checked up with a large number of indicator diagrams taken from a variety of engines and found to be very close to the results actually secured.

Alwin Hofmann.

New York City.

Consul Albert Halstead, of Birmingham, learns that there are now 80 plants in the United Kingdom for the conversion of garbage of cities into electric power, and that they are increasing at the rate of 20 a year. An English mechanical engineer calculates that there is a long ton of refuse for every 1000 inhabitants, equal to about 300 pounds of steam per hour for nine hours per day, if destroyed in the properly designed destructor.

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Contents

Mayor Gaynor's Attitude—?

Last May, the New York Engineers' Protective Society, said to be the oldest engineers' organization in New York, addressed a set of resolutions to Mayor Gaynor calling for an investigation into the shutting down of several city plants and the substitution of central-station service. Although nine months have elapsed, there have been no visible signs of activity in the matter emanating from the city hall, nor has the communication been acknowledged. We do not believe the mayor has wilfully sidetracked the resolutions but rather are of the opinion that, in the rush of official business, their importance has been overlooked; or perhaps they have been relegated to the care of some subordinate who lacks both the interest and the authority to take action.

However, the Bureau of Municipal Research, a private organization devoted to investigating and remedying the abuses and mismanagement of city affairs, has gone into the subject very carefully and is about to make a report upon its findings. It would seem to be good form, at least, for the mayor to officially recognize the agitation now being carried on and to show that he has an interest in a subject so important to the city's welfare.

Scientific Management in Education

Just now, popular interest and the space in the ten-cent magazines is about evenly divided between aviation and scientific management. Both are useful and interesting, but perhaps slightly overdone at present.

Scientific management, as first developed by Mr. Taylor and Mr. Gantt and afterward by Messrs. Emerson, Day, Cooke and others, has undoubtedly come to stay and will find wider fields of usefulness as time goes on. It is not a universal panacea and will not cure all evils or suit all conditions.

One of the most interesting applications of the principles involved has recently appeared in a bulletin published by the Carnegie Foundation for the Advancement of Teaching, written by Morris L. Cooke, of Philadelphia.

As stated by President Pritchett in the preface to the report, Mr. Cooke was chosen to conduct this investigation as an outside expert, not an educator, who would view the conditions from the standpoint of a business man.

Both President Pritchett and Mr. Cooke appreciate the fact that there is much in college work which cannot come under the ordinary rules of business, much less under the strict rules of modern management.

It was certainly rather a bold experiment to apply business standards to the more or less psychological problems of the college and university. Some still bolder spirit may next apply the same standards to the work of an episcopal diocese or a presbyterian synod.

Considering the inherent difficulties of the experiment, it would seem that Mr. Cooke has done pretty well. For the most part, he has confined himself to the material side of college work, such as the purchase of supplies, the care of grounds and buildings and the use of rooms and apparatus, and here he is on safe ground.

When he steps over the line into the field of research, of instruction and of educational efficiency, he treads rather gingerly and occasionally breaks through. The use of the student hour is not original with him, since it has been used many years as a unit of comparison. It is not and never can be a gage of efficiency. Let us suppose, for example, that a teacher has a class of twenty students for five hours a week, making one hundred student-hours.

Let us further suppose that the exigencies of the time require an increase of the number of men in a section to thirty. According to business standards, the instructor is turning out fifty per cent. more product per week for the same cost in dollars, and is therefore that much more efficient. From an educational standpoint, he is probably less efficient than before.

The employment of functional superintendents for the material or concrete things of the college is desirable, but that a business manager should have anything to do with the administration of the teaching or the control of teaching ... is extremely undesirable. The efficiency of one man's teaching or the inefficiency of another man's teaching can no more be measured by hours or by dollars than the preaching of a clergyman or the work of a statesman.

On the whole, Mr. Cooke's report is instructive and interesting and is destined to have a decided influence in the administration of colleges and universities. He should be met and welcomed in the same spirit in which he writes. Such sarcastic and ill-tempered comment as comes from some educators is childish and out of place.

As long as educational institutions look to the taxpayers and to private benevolence for support, they are open to the inspection and criticism of the layman. The methods employed in educating the youth of the land are of interest to all, outside as well as in, and are no more exempt from investigation than other public utilities. Publicity is wholesome for colleges as for municipalities or corporations, and the surest way to meet and to disarm unfavorable criticism is to throw all debatable subjects open to frank and free discussion.

Our educational institutions, like our religious ones, cannot afford to take an attitude of superiority to the rest of mankind but must be prepared to defend themselves against any accusations of neglect or inefficiency.

Neglecting Opportunities

A certain class of engineers are seemingly imbued with the idea that if a piece of apparatus will operate something after the manner intended, there is no necessity of giving it further attention.

Getting after a repair job "as soon as there is time" is what some engineers say that they are going to do, but they directly proceed to waste more time than would have been necessary to put the defective apparatus into proper condition.

"I am going to fix it next Sunday when the plant is shut down" is what another says. "Then I can take all the time necessary and do a good job." But he does nothing of the kind.

"It is working, so what is the use of meddling with it and perhaps make matters worse," says another.

But the makers of such statements know that they are offered merely as excuses for failing to do duties that should be performed.

Any piece of apparatus that requires repairs should be attended to at once. Never mind whether it is convenient and agreeable or not. The main thing is to eliminate the defect so that the device will operate as it was intended to, when built.

How "penny wise and pound foolish" for an engineer to allow two or more tubes to leak in the rear head of a boiler, when they could be made tight in a short time with the boiler cold and the water run out.

How wasteful for an engineer to allow the valves of an engine to continue to operate when improperly adjusted, just because he thinks he does not have time to attend to them. Many times one is led to believe that failure to adjust valves properly is due to a lack of knowledge of how to do the work, rather than because of lack of time.

Putting sundry repair jobs off until Sunday is bad practice, not only because a man gets into the habit of putting off things, but because it makes him spend a day doing the same kind of work seven days a week when he should spend one of these days in an altogether different manner. A day of leisure, devoid of the nerve-racking occurrences of the daily grind prepares a man for better service on Monday morning, and more efficient work throughout the week.

Nothing can be good enough unless it is the best. Engineers make a great mistake when they neglect to improve the operating condition of their plants. Because so many have taken the ground that conditions are good enough, the central station has expanded. Its solicitors have been able to show the isolated-plant owner that his operating conditions are not as good as they should be. A contract is signed by the owner and the central station has supplanted a man and his job just because he did not cut down expenses and put the plant on a sound operating basis.

Conditions Have Changed

In this age of progress nothing stands still. Men are constantly gaining experience and the march of progress is astonishing because of the rapidity and masterful manner in which the problems to be solved have been met.

Steam-power plants have received their quota of attention from the inventor and mechanical engineer and the improvement in power-plant equipment has been so great that the engineer has been obliged to advance in both mental and mechanical training.

When stepping into a modern power plant it is hard to realize that only a few years ago the direct-coupled unit was the exception. It would be difficult to imagine a belt-driven generator of the capacity found direct connected and in general use today.

Power-plant centralization has been largely furthered by the improvement in power-plant machinery, and engineers operating the small plant have spent uncomfortable hours wondering what will be the ultimate end. Small steam plants are facing a serious proposition and the men operating them must fight every moment of the day for their very existence.

But this fight is beneficial to the engineer. He knows now that it is possible to succeed only by applying his energies to solving problems that formerly were not considered of importance or necessary for him to know in order to make a success of his work.

What is the result? Just this, the men who have improved their opportunities and fitted themselves for assuming more responsible positions than they formerly held are today operating the large power plants.

What has been done will be done again and the engineer running in the small plant today may be the man selected to operate the large plant of tomorrow. The demand for engineers in large power plants is steadily increasing and the opportunities for rising to better positions will be as frequent in the future as they have been in the past.

Wise engineers will make ready for stepping into the larger plants. There may not be much glory or financial gain at first, during the preparatory stage, but higher wages will come to the man who has improved his opportunity and is standing at the line ready to lead when the starting gun is fired.

Congress recently passed a bill appropriating thirty-six thousand dollars for the installation of a refrigerating system in the Capitol. It is to be used for furnishing cool air to the House of Representatives and the various committee rooms. Judging from the debates that have been going on recently between the members of that body, the installation of a refrigerating system is timely.

How much water are you evaporating per square foot of surface per hour? How much over their rated capacity are you running your boilers? What draft do you use? What are the conditions of impingement of flame on spots of the tube surface, and what are the conditions of cleanliness of the tubes? We should like to have the subject discussed in the light of actual experience.

Is not the recent increase in boiler-tube troubles due more to increased work than to increased pressure, or poorer material? A tube is more than twice as liable to suffer when it is evaporating six pounds of water per square foot as when evaporating three.

The verdict of the coroner's jury which inquired into the cause of the recent dynamite explosion in Jersey City, to the effect that it had been caused by a lighted match or cigarette dropped by some careless individual, is in the same class as some boiler-explosion verdicts.

We believe there was an international exposition once which was substantially ready at the date of opening, and it was a success—San Francisco papers please copy.

And now Rhode Island is after a law providing for the licensing of engineers and the inspection of boilers. There is, as usual, a bill before the New Jersey legislature, several in fact.

Lap-seam boilers are unsuitable for some classes of work; likewise lap-seam engineers. Neither should ever be employed where the real thing is needed.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Replacing Mud Drum Nipples

If it were necessary to change nipples on a Babcock & Wilcox boiler, how should I go to work to replace them; the ones to be taken out are a foot away from the handholes in the mud drum, and what tools would be used?

C. N. T.

Use a bent diamond chisel to open the nipple, working through the handhole in the header. Then, with a blunt tool, drive in the side of the nipple between the header and mud drum, letting it drop into the drum. Hold the new nipple in place with wire and a wedge. Flare upper end slightly then expand it, being careful to see that each end projects ¼ inch beyond the tube hole. Change expander and expand lower end. After expanding the lower end, drop the expander to clear tube hole and expand slightly to flare the lower end. Use a Babcock & Wilcox special expander

Pressure on Projected Area

If the cylinder of an engine is 50 inches in diameter with 110 pounds pressure and 45 pounds receiver pressure, and if the crank pin is 12 inches in diameter and 14 inches long, what will the load be on the projected area of the pin?

P. O. P.

The total pressure on the piston is the product of the piston area multiplied by the difference in the pressure on its opposite sides. This divided by the projected area of the pin is the pressure per square inch. In this instance it is

$$\frac{1963.5 \times (110 - 45)}{12 \times 14} = 759.69 \text{ pounds}$$

Gravity and Vacuum Heating Systems

What are the essential points of difference between a gravity and a vacuum heating system?

G. H. S.

In a gravity system the condensation is returned to the boiler or led to a receiving tank by gravity. In a vacuum system the flow of steam is kept up by means of a pump or ejector connected to the radiators by which a partial vacuum is maintained in the system.

Change of Cutoff and Compression

How may cutoff and compression be changed in a simple slide-valve engine?

C. V. C.

Increase of outside lap shortens the cutoff. Increase of inside lap increases the compression and decrease of inside and outside lap lengthens the cutoff and decreases the compression.

Width of Belt

What should be the width of a double leather belt to transmit 500 horsepower, running on a 22-foot flywheel making 76 revolutions per minute?

J. A. L.

The rim speed of the wheel is 5250 feet per minute. Allowing 50 square feet of belt surface per minute for each horsepower, 25,000 square feet of belt will have to pass over the pulley each minute to transmit 500 horsepower, and the width will be

$$\frac{25,000}{5,250} = 4.76 \text{ feet}$$

Real and Apparent Clearance

What is the difference between the actual and apparent clearance in an air compressor?

A. R. C.

The apparent clearance is the space not swept through by the piston. The actual clearance is the space filled by the air compressed in the apparent clearance space after being expanded to the suction pressure. It shows on the indicator diagram at the point where the expansion line meets the intake-pressure line.

Power to Operate Elevator

Does it require the same power to operate a hydraulic elevator whether light or loaded?

O. L. P.

It is the same in both cases as it takes the same quantity of water to fill the cylinder and the water, whether from an accumulator or pressure tank, is under the same pressure.

Rewound Electric Motor

Suppose an electric motor rated at 15 horsepower running at 1200 revolutions per minute had its armature rewound to run at 800 revolutions per minute, would it then be able to withstand the throwing in of the switch without injury, and would its rating be 15 horsepower?

R. E. M.

If the work is properly done, yes.

Heat and Pressure Stresses

Which causes the greater stress to the sheets of a return-tubular boiler, heat or pressure?

H. P. S.

Heat, when it causes unequal expansion.

Equivalent Evaporation

If one pound of coal will evaporate ten pounds of water from and at 212 degrees, how many pounds will it evaporate from feed water at 80 degrees into steam at 100 pounds pressure?

F. O. E.

Water at 212 degrees contains 180 heat units above 32 degrees and steam at the same temperature 1150.4. It therefore requires 9704 heat units to change ten pounds of water at 212 degrees into steam at the same temperature. Water at 80 degrees contains 48.3 heat units per pound. Steam at 100 pounds gage pressure contains 1188.8, and it therefore takes

10 (1188.8 − 48.3) = 11,405 heat units

to change ten pounds of water at 80 degrees into steam at 338 degrees; and one pound of coal which will evaporate ten pounds of water from and at 212 degrees will evaporate

$$\frac{9704}{11,405} = 0.858$$

or 85.8 per cent. of ten pounds from water at 80 degrees into steam at 100 pounds gage pressure.

Patch on Boiler Sheet

In patching a boiler, should the patch be put on the inside or outside of the shell?

P. B. S.

It should be put on the inside, as otherwise it forms a pocket for the collection of sediment.

Hight and Capacity of Chimney

What is the relation of the hight of a chimney to its capacity?

H. C. C.

The capacity of a chimney varies as the square root of its hight. To double the capacity of a chimney its hight would have to be increased four times.

Boiler Explosion at Verona, Penn.

By Edward T. Binns

At about 4 p.m. on Monday, February 26, a vertical boiler, 36 inches in diameter by 6 feet high, exploded at the Ideal steam laundry in the town of Verona, Penn. A number of fatalities were narrowly averted. Two men were badly hurt; one of them, the engineer, in all probability will not recover. The boiler, which weighed about 1600 pounds, was shot vertically into the air about 300 feet, turning over several times and landing on top of a three-story building about two blocks away. It crashed through the roof, the third and second floors, and came to rest in the middle of a clothing store on the ground floor. As near as can be learned, the engineer, who was a new man and who came to the plant from the police force, had been doing some work in the main building and had just gone to the engine room to prepare for shutting down. On his way to the hospital he stated briefly that he had barely commenced these preparations when the explosion took place.

An examination of the ruptured plates plainly indicated that they had been red hot, the edges of the torn sections being curled and quite blue.

The firebox was 36 inches high and 30 inches in diameter, with a 9-inch flue leading to the smokestack. The feed water was delivered into the water leg. The city water pressure in Verona is about 150 pounds to the square inch, so that no pump or injector was needed to force water into the boiler, and in this case no heater was used.

Fig. 3. Interior of Firebox After Explosion

Fig. 1. The Boiler in the Clothing Store

Fig. 2. Damage to Engine Room

The boiler was only about three years old. About seven months ago it was inspected by the county boiler inspector who gave it a thorough hammer test. Also, at the owner's request, he gave it a hydrostatic test of 150 pounds. One hundred pounds steam pressure was allowed but the safety valve was set to blow at 80 pounds.

Some repairs to the steam gage, water column and safety valve had been ordered and made before the explosion.

The firebox, which was of 3/16-inch plate, was badly torn. The rupture commenced at one edge of the firing door and followed an irregular course for three-quarters of the way around. The tear was practically along the zone of the fire. The plate pulled loose from twenty-nine 3/4-inch, solid staybolts which were screwed into it, and doubled up against the crown sheet.

There is as yet no State engineers' license law in Pennsylvania, though a bill is now pending in the legislature.

The Industrial Safety Association

On Friday evening, March 1, D. T. Williams entertained at dinner at the Engineers Club, New York, a number of editors of technical and industrial papers for the purpose of acquainting them with the objects and activities of the Industrial Safety Association. After the host had effectually disproved his introductory declaration that he could not make a speech by setting forth most impressively the obligation of those in charge of industrial operations and others of the more fortunate class who are in a position so to do to minimize the hardships, dangers and chances for injury which surround the worker, he introduced Dr. F. R. Hutton, president of the new organization.

Doctor Hutton quickly demonstrated to his hearers that the association had a much wider field and loftier mission than the exploitation of mechanical devices for the guarding of life and limb, and impressed them with the economic importance of maintaining the efficiency of the working force of the community by establishing conditions conducive to health, comfort and security from bodily harm. His remarks were illustrated by a series of lantern slides, showing devices and methods employed toward that end.

The company then visited the American Museum of Safety, which is maintained in the Engineering Societies building, 29 West Thirty-ninth street, where many of the devices previously illustrated are upon exhibition, where statistics are available and methods exemplified. The museum is free to the public between the hours of 9 and 5 every day except Sundays and holidays.

Institute of Operating Engineers to Organize Branches

On Friday evening, March 17, at 8:30 there will be a meeting in the lecture room of the Modern Science Club, 125 South Elliot place, Brooklyn, for the purpose of organizing a branch of the Institute of Operating Engineers. Members and all interested are invited to be present.

On Saturday evening, March 18, at eight o'clock, there will be a meeting in the rooms of the Institute of all members and those interested, in New York City and the Bronx. This meeting is called for the purpose of organizing a branch of the Institute in New York City. At this meeting the officers of the branch will be elected, which will include the branch chairman, branch representative to the district council; lecturer on plant operation and chairman of the committee on apprenticeship training; lecturer on educational subjects and chairman of committee on educational subjects; a secretary-treasurer and three councilmen, each for one, two and three years' service. The naming of the branch will also be considered at this meeting and other matters of importance.

As this association will be looked upon as the leader and as all the meetings under the name of the Institute which are held in New York will have to be under its auspices, it is of the utmost importance for all interested to attend this meeting.

Organization of an N. E. L. A. Section at Pittsburg

A banquet to the employees of the Allegheny County Light Company was given by the officers at the Hotel Duquesne, Pittsburg, at 6:30 p.m., Tuesday, February 28. A section of the National Electric Light Association was formed, to be known as the County Light Section, and approximately 150 of the employees joined the section. Prior to this time about 35 of the employees were already Class B members and therefore the section started with 185. H. N. Muller, superintendent of distribution of the Allegheny County Light Company, acted as temporary chairman; W. H. Dunkin, general contracting agent of the same company, acted as temporary secretary, and James M. Graves as temporary treasurer.

H. H. Scott, chairman of the membership committee of the National Electric Light Association, gave a history of the organization, told of its growth and the objects for which the association was striving. A. R. Granger, of Chester, Penn., president of the Pennsylvania Electrical Association, followed Mr. Scott and told of the work the company sections were doing, particularly the Philadelphia section.

Erratum

The Heine Safety Boiler Company was organized by Col. E. D. Meier in 1884. Due to a typographical error on page 401 of the March 7 issue the year 1844 was given.

Prime Movers

The speaker for the regular weekly lecture on February 28 at the Modern Science Club, Brooklyn, was George A. Orrok, of the New York Edison Company. His topic was "Prime Movers." He briefly traced the development of the various types of engines from the time of the earliest waterwheels down to the present day.

It was shown that James Watt conceived practically all of the principles that underlie even the present-day reciprocating engine. Much of the increase in economy has been the result of the improvement in the machine tools upon which the manufacture of the engine parts depends.

To illustrate what progress had been made, Mr. Orrok stated that while some of the original pumping engines attained a duty of perhaps 60,000,000 foot-pounds, today a duty of very nearly 200,000,000 foot-pounds has been accomplished.

The lecture was attended by a representative gathering of members and friends.

"Game" to the Core

Frank V. Burlingame, age 30, was seriously injured at the Nickel Plate Railroad's Rocky River pumping plant, on February 24. He was caught by a key projecting from the end of the flywheel shaft and whirled around several times and thrown against the wall of the building. He was badly bruised and both legs were broken in several places. Notwithstanding these injuries he managed to crawl to the throttle when he recovered consciousness and shut down the engine.

Boiler Explosion Kills Four

On March 4, one man and three children were killed and six other persons injured when a boiler at the Blackburn-Gambill distillery on Howard's creek, Breathitt county, exploded. The children were playing about the distillery when the explosion occurred. The other victims were employees.

Flywheel Wrecks Building

On March 3 a portion of the Greensburgh Brush and Wire Factory was destroyed by a flywheel explosion. A defective governor allowed the engine to run away. Several employees were injured.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

Not long ago a great department store in New York City advertised a special sale of men's bath robes.

It was the intention to advertise them at a price of $5.00 each, but through some mistake in the copy the bath robes were advertised in all the morning papers for 50 cents apiece.

With the result that buyers were lined up before the counter three rows deep.

It was too late to do anything except to *stand by the advertising*. The clerks behind the bath-robe counter were instructed to politely explain the mistake, but to refuse no one a bath robe for 50 cents who insisted on having it at that price.

The result was interesting. The majority accepted the explanation and went away with no hard feelings. Some saw the value that lay in the bath robes at the intended price of $5.00, and purchased them at that figure. A few others, perhaps half a dozen, held their ground and refused to pay more than the advertised price—

And got them.

Back of this incident lies the great truth that nowadays *reliable concerns stand back of their advertising at all costs.*

And going into this a little deeper it is easy to see that when a reliable advertiser makes a statement in an ad. it is safe to assume that this concern has carefully sifted over what it has said in order that no misstatements may creep into the copy.

The concerns who advertise in POWER are *reliable* concerns.

They stand back of their advertising.

They claim certain things, secure in the knowledge that they can "make good."

What readers of advertised products need to cultivate more is a *belief* in the *truth* of what they read.

The power-plant man who thrusts aside the honest statement of a reliable concern with an "I don't believe it," isn't doing fair justice to the concern who makes the claim. Neither is he doing justice to himself.

The fact that an advertiser makes a statement which appears to you too big for him to fill does not affect the truth of that statement one way or the other.

Advertisers in POWER are not making claims that they cannot live up to.

They cannot afford it.

Thus, when the manufacturer of a lubricant, for example, tells you what his product will do, consider his word as his honest belief in the efficiency of what he is trying to sell. When the manufacturer of some new power-plant device claims certain advantages, consider his statement seriously and be willing to meet him half-way.

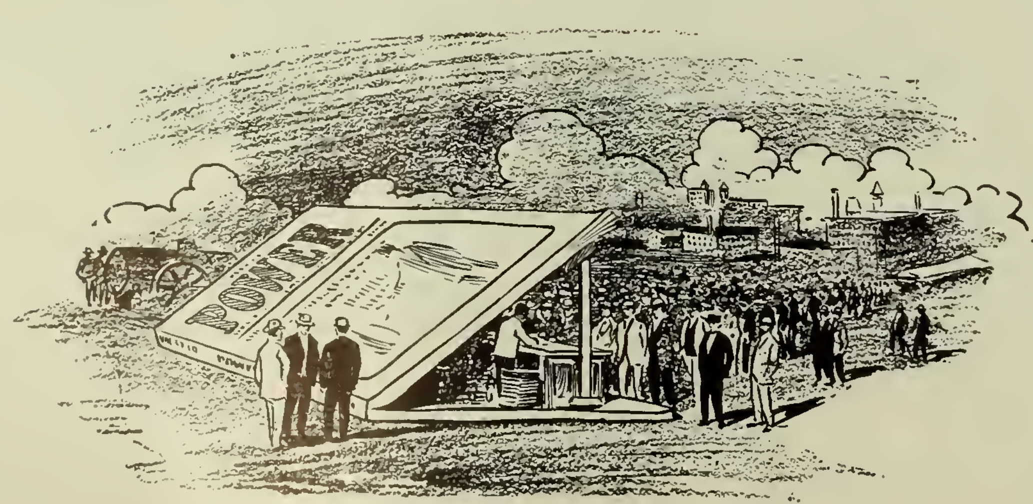
Naturally, the success of many advertised articles often depends upon conditions as they exist in your plant and advertised goods should be carefully studied with due regard to fitting them into existing conditions—

Which signifies that careful comparison and investigation are as necessary as a belief in the word of the advertiser.

The advertisers in POWER are in earnest. Every time they talk to you, through their ads., they put their reputation at stake.

Could they afford to say anything they knew they were unable to back?

Do more than merely *read* the ads.—



Read them with the knowledge that every statement made is an actual fact.

For, truly, the Selling Section is the very last place of all where an advertiser can afford to say anything except what is absolutely true.

POWER

NEW YORK, MARCH 21, 1911

HERE is an experiment that all may try: Select a straight joint in the sidewalk or floor and try to walk in a straight line, using the joint as a guide.

Observe the speed you make and the degree of success you have in following the line. Then, return to the starting point, pick out some distant object and with the eyes fixed on that object start the journey over again.

Your speed in the second case will be limited only by your ability as a "Marathoner" and, provided you are sober and in normal health, your course will be a true straight line between the starting and finishing points.

Consider the tight-rope artist; he does not concern himself particularly with the rope immediately under his feet—his eyes are focused on the end of the rope. And statistics tend to show that he is right, for casualties among professional tight-rope performers are less numerous than among even canal-boat cabin boys.

The lesson to be learned from the foregoing (there's always a lesson, you know) is that the safest and best progress is made when there is a definite objective point in view. The haphazard following of a line through life with the sight limited to but a few paces in advance never get anyone very far along—there are too many blank walls against which to run and too many blind trails upon which to get lost.

If your line is steam engineering, you are to be congratulated; you are "in right." There is plenty of room and glory ahead, perhaps more than in any other line today, for this is the mechanical age. Steam engineering and other branches of mechanical science are only just coming into their own. There never was such opportunity for intelligent, earnest endeavor. But don't take our bare word for this, look it up and prove to your own satisfaction that we are either right or wrong.

Pick out your goal, keep your eye on it and work to get there. If you are in earnest, not making believe, you will make good progress. Whether you ever actually arrive will depend on so many things that we cannot make an accurate prediction. But we repeat, you will make good progress.

Hustlers are needed badly. The busy man never complains of lack of opportunity; it is only the man who is too lazy to look for it who does the croaking.

There is some slight temporary gain to be secured by "pull" and "bluff," but the worth-while progress results only from "push" and merit.

Hydroelectric Plant in Italy

By J. B. Van Brussel

A low-head plant of 11,000-horsepower capacity supplying two transmission lines, one at 3750 volts and the other at 27,000 volts. The three-phase four-wire system of transmission is used on the line of lower voltage and the three-wire system on the one of higher voltage.

The Cervara hydroelectric plant, now in operation in the north of Italy, supplies electrical energy to the city of Terni, and to the electrochemical factories of the Societá Industriale Ellettrica della Valneria at Narni.

The water, which is supplied by the falls of the Marmore, passes into an open channel nearly 1300 feet long, 40 feet wide and 6 feet 5 inches deep with a fall of one foot in every hundred, and terminating in a clearing pond of about 25,000 square feet. Two parallel flumes, each 1640 feet in length and 13 feet in diameter, lead to an open reservoir from which intake pipes lead to 12 sluices. The original intention was to install 12 units of 1000 horsepower each, but this was later changed to six 2200-horsepower units. In order to utilize the existing sluices, each three intakes leading from the reservoir were combined jointly to feed two penstocks leading to the turbines. Nine intakes were thus combined with the six penstocks feeding the 2200-horsepower units; two more connections were used for two 1000-horsepower turbines which had been transferred from an old power house to the new generating plant, and the twelfth intake was arranged to feed two exciter turbines. In Fig. 1 only five of these penstocks are shown.

An expansion sleeve and a vertical air chamber, intended to compensate for fluctuations in pressure, are fitted to each penstock. The main locking gates of the turbines are hydraulically balanced and are controlled from the generator floor. The turbines are of the double-rim reaction type, and, according as the head varies between 65 and 79 feet, each utilizes from 2300 to 2700 gallons of water per second. Fig. 2 represents a cross-section through the turbine room and Fig. 3 is a view of the same room, showing the switch gallery at one end.

The general character of the electrical equipment was determined by the fact that two different kinds of service were required; current at 3750 volts for light and power at Terni, and at 27,000 volts for transmission to the electrochemical works at Narni. This necessitated two separate sets of busbars. At present there are installed five three-phase generators, each of 1900 kilovolt-amperes capacity coupled direct to a 2200-horsepower turbine, and space is provided for a sixth unit. Two generators of 865 kilovolt-amperes each, have been transferred from an old power house and are coupled to the 1000-horsepower turbines. Each of the larger generators can be connected to either of the busbar systems. When working on the 27,000-volt system, each of the generators is connected directly and only to a transformer of the same capacity, the high-tension side of the transformer being connected to the 27,000-volt busbars. When supplying the 3750-volt system, however, the generators are connected directly to the busbars. The two smaller generators serve the 3750-volt system exclusively. The Narni electrochemical works are fed by a duplicate three-wire transmission line and the Terni transmission line is of the three-phase four-wire type.

Fig 1. General View of Plant, Showing Penstocks and Reservoir

The basement of the switch house, which forms one end of the building, is occupied by the generator switches and the field rheostats. The transformers are on the first floor, the transformer switches and busbars on the second floor and the line switches and lightning arresters on the third floor.

The large machines generate three-phase currents at 42 cycles and a normal voltage of 3750, although this can be increased to 4150 volts. Two direct-current turbine-driven generators of 75 kilowatts each are used for excitation. Also, a motor-generator set, consisting of a 240-horsepower three-phase motor fed from the 3750-volt busbars and coupled to a direct-current shunt-wound generator of 120 to 150 volts, is provided for additional excitation.

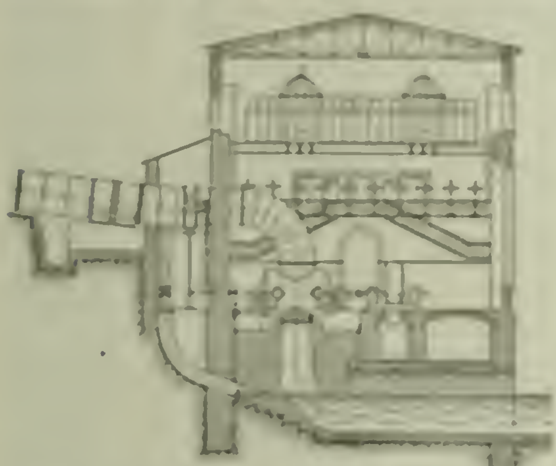


Fig. 2. Section through Turbine Room

The generator panels are separated by fireproof partitions and each contains a four-pole oil switch with a maximum and reverse-current relay, and the knife switches for connecting the generator to either the 3750-volt busbars or to its corresponding transformer. The oil switches are operated through hand ropes from the main switchboard.

In the compartment below the switch structure are located the series rheostats for the fields of the three-phase generators and the shunt regulators for the exciters. Provision has been made for six three-phase 3750- to 27,000-volt transformers, each of 1900 kilovolt-amperes capacity, although only five are installed at present. They are mounted on wheels, which permits them to be readily removed from their stalls. An air duct running under each of the stalls is supplied by two fans, either of which is capable of furnishing enough air to keep the transformer windings cool.

From the transformers the conductors lead to transformer switches provided with maximum-current relays, which are located on the second floor. These switches, which can be operated through hand ropes from the switchboard, are designed with the terminals at the bottom and all the operating mechanism at the top. From the switches the circuit passes through three current transformers, which actuate the maximum time relay, to a structure containing the busbars and section switches.

There are two sets of 27,000-volt busbars, one serving as a spare. Each transformer, as well as the outgoing line, can be connected to either set. The current and voltage transformers, used in connection with the ammeters and voltmeters, are inserted between the connections of the large transformers and those of the outgoing lines in the 27,000-volt and the 3750-volt busbars. Section switches permit any section of the busbars to be cut out in case of breakdown, thus cutting the disabled apparatus out of the circuit.

Fig. 3. Turbine Room with Switchboard Gallery at One End

Fig. 4. Transformer Mounted on Wheels

Fig. 5. Horn-gap Arrester

The outgoing 3750-volt line for the Terni plant, being of the four-wire system with neutral conductor, is controlled by a four-pole automatic oil switch having a time-element relay, and operated by a hand rope from the main switchboard platform. Horn gap arresters, each with a glass-tube water resistance and four-pole water jet, are used to handle excess voltage discharges. A 60-kilowatt transformer, reducing the voltage from 3750 to 500 volts, is connected to the 3750-volt busbars for station service.

The 27,000-volt line, which comprises two three-wire transmission lines, is controlled by an automatic remote-control oil switch operated from the main switchboard. Each outgoing wire is protected against atmospheric discharges and excess voltage by a horn gap arrester and a choke coil. Figs. 4 to 7 show the switching equipment, one of the transformers and the spark gaps.

The main switchboard is shown in Fig. 8. The instruments and operating levers for the generator sets are located on switch pedestals, while the switchboard is equipped for controlling the outgoing lines. Each of the pedestals for the 1900 kilovolt-ampere generators carries a hand lever for operating the generator oil switch, a hand lever for the transformer oil switch, and handwheels for the series rheostat in the exciter circuit and the carbon switchout of the exciter. The exciter switches are mechanically interlocked with the main switches of the generator, so that the latter can be closed only after excitation has taken place; on the other hand, the exciter switch can be opened only when the main switch is open.

The motor-generator set is also controlled from a pedestal, as are the two small turbine-driven exciters. One-half of the switchboard, shown in Fig. 8, is set apart for controlling the Narni line, and the other for controlling the Terni line.

Pierre and His CO_2 Recorder

Old Pierre, the French fireman, said that if he had that new CO_2 recorder he would fire it to the bottom of the lake where nobody would ever find it. He soon became thoroughly acquainted with the new recorder and was told that he could have it to take home when he raised the marks to 20 per cent. After receiving instructions on the theory of combustion and the principles of the CO_2 machine he was able at times to obtain about 15 per cent., which was much nearer 20 than the highest records he was able to get when the recorder was first installed. Still something strange would happen nearly every night which worried Pierre. The CO_2 would take an abrupt drop too great to be caused by any change in firing. This he could not account for. Every surmise was investigated, but the cause was not found, until finally one night Pierre rushed in—his face beamed with delight, and exclaimed, "Me finds zie troub', zie coal pass' go 'sleep in zie car, an' no coal in zie chute, zie cold air go down over zie fire an' zie machine mark a' no good."

Sure enough Pierre had located the trouble, which was soon overcome.

He decided not to throw the machine in the lake, even if he could get 20 per cent. CO_2.

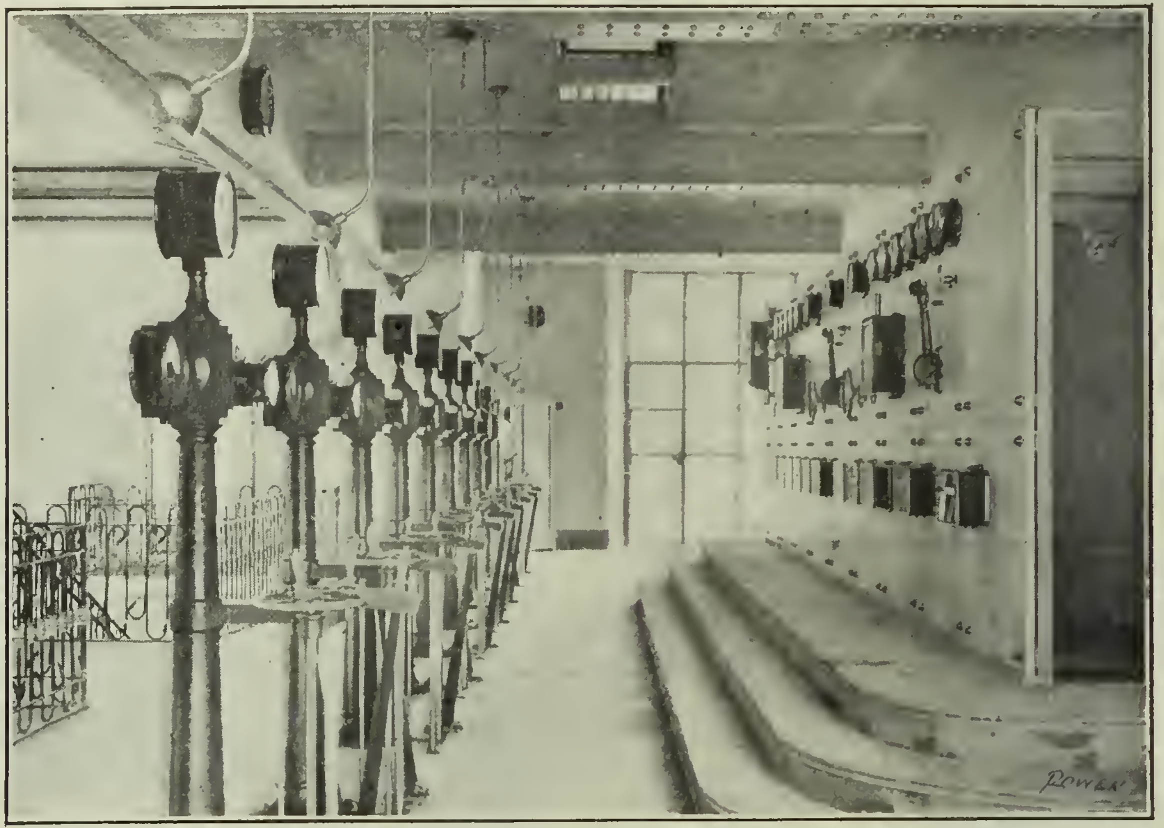


Fig. 8. Main Switchboard

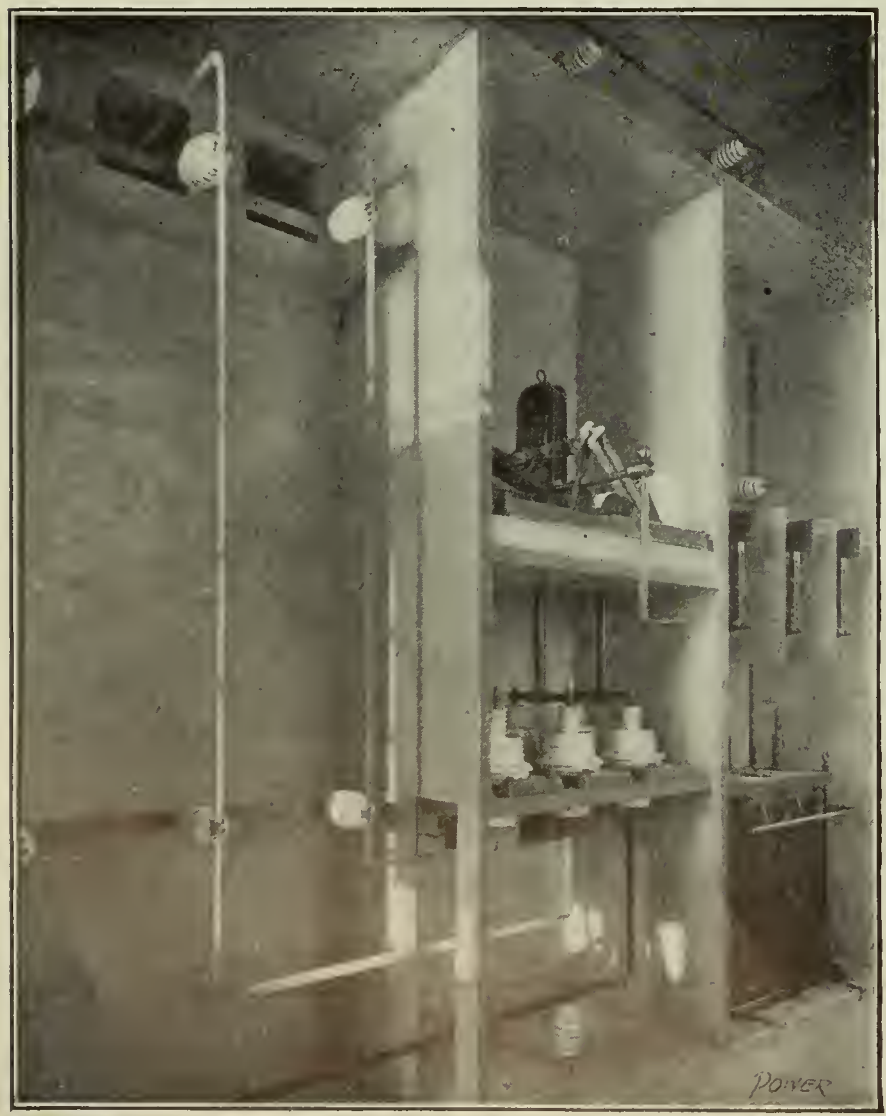


Fig. 6. Main-line Switches

Fig. 7. Passageway between Transformer Stalls and Switch Structure

Jet versus Surface Condensers

Some interesting data and cost figures which should aid materially in making a choice between jet or surface condensers for high- or low-pressure steam turbines.

There is a constantly increasing number of cases in connection with condensing plants for either high- or low-pressure steam turbines, where it is not obvious which is the best type of condenser to employ, and where, in fact, the wrong condenser is not infrequently selected. Little appears to have been written which is of use to power users in coming to a decision as to what type of condenser to adopt. In a recent issue of *The Engineer*, of London, an interesting article on "Jet versus Surface Condensers" was published. The following are excerpts from this article, with the exception that the English cost figures have been given their American equivalent, using $5 as the value of the pound.

In order to ascertain which plant it is best to employ in any nonobvious case, it is necessary to compare the capital outlay costs with the running costs. The former have a relatively greater importance compared with the latter if the plant has a low load factor, whereas with a high load factor the latter are of relatively

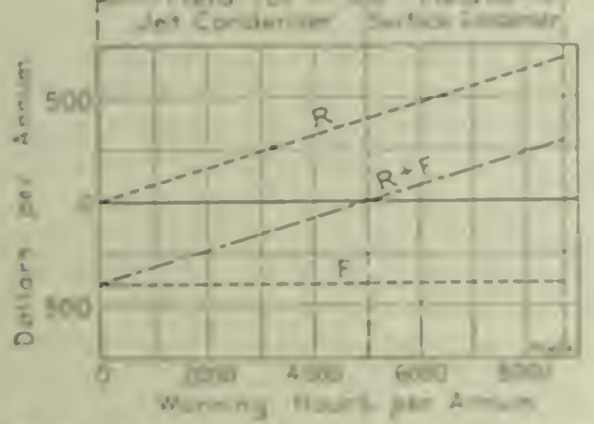


FIG. 1. TERMINAL PRESSURE AT TURBINE TWO POUNDS ABSOLUTE. CIRCULATING WATER 82 DEGREES FAHRENHEIT

great moment compared with the former. In the present investigation the condensing plant for a 3000-kilowatt turbine has been considered, and the fixed annual costs, which are proportional to the capital outlay, and are independent of the load factor, are taken at 15 per cent. of the capital outlay in the case of the surface condensing plant, including a cooling tower, and 13½ per cent. in the case of a barometric jet condensing plant, including a cooling tower. Where a cooling tower is not employed, 13 per cent. has been taken in the case of the surface plant, and 11 per cent. in the case of the jet plant.

The annual running costs, which are proportional to the load factor or to the number of hours that the plant is worked in a year, differ chiefly as regards the work absorbed in driving the air pump; and this work, with its incidental expenses, has been taken at 1.2 cents per effective horsepower-hour delivered to the air-pump piston rod or crank shaft.

Considering, in the first place, a case where a cooling tower is employed, and a turbine-terminal pressure of two pounds per square inch is desired, the cost of surface condensing plant is estimated at $19,300, which cost includes a natural-draft cooling tower capable of reducing the temperature of the condensing water to 82 degrees Fahrenheit. A barometric jet condensing plant, capable of maintaining the same terminal pressure, is estimated to cost $18,550. In arriving at the latter figure the pressure in the jet condenser has been assumed to be 0.13 pound per square inch less than at the exhaust end of the turbine to allow for drop in pressure in the long exhaust pipe and difference in level between the condenser and the turbine; 15 per cent. of $19,300 is $2895, which represents the fixed annual cost on the surface condensing plant; 13½ per cent. of $18,550 is $2500, which represents the fixed annual cost on the jet plant.

The ordinates in the figures represent annual cost, distances below the zero line being in favor of the jet condenser and distances above the line in favor of the surface condenser. The actual costs are not indicated on the diagrams, but only the differences between the costs of the rival plants. In Fig. 1 the line *F* represents the difference in the fixed annual costs between the surface and jet plants for the case just mentioned, that is, the difference between $2895 and $2500, which is $395. This is in favor of the jet plant, and is independent of the number of hours during which the plant is worked in the year.

As regards running costs the air pump of the jet condensing plant is estimated to require 14.12 horsepower, and, therefore, at 1.2 cents per horsepower-hour to cost 17 cents per hour at full load; and the corresponding figures for the surface condensing plant are reckoned to be 7.78 horsepower and 9.4 cents per hour; the difference in cost in favor of the surface plant is, therefore, 7.6 cents per hour at full load. The cost of driving the water pumps may be assumed to be the same in both cases. Line *R* in Fig. 1 represents the difference in running costs for any number of working hours per year from nothing up to 8760, which latter figure represents continuous working. The greater the number of working hours per year, the greater, of course, is the advantage which the surface plant possesses over the jet plant. The dotted line marked *R* + *F* is obtained by taking the algebraic sum of the ordinates of the lines *R* and *F*; and this line represents the net difference in annual cost of the two systems for any number of working hours per year. It will be seen that the jet condenser has the advantage up to 5000 hours per annum, and thereafter the surface condenser has the advantage. Where the working hours are less than about 5000 per year at full load, it is therefore advantageous to employ a jet condenser, but where the full power is carried for more than 5000 hours per year, it is better to employ a surface condenser.

As regards working at fractional load

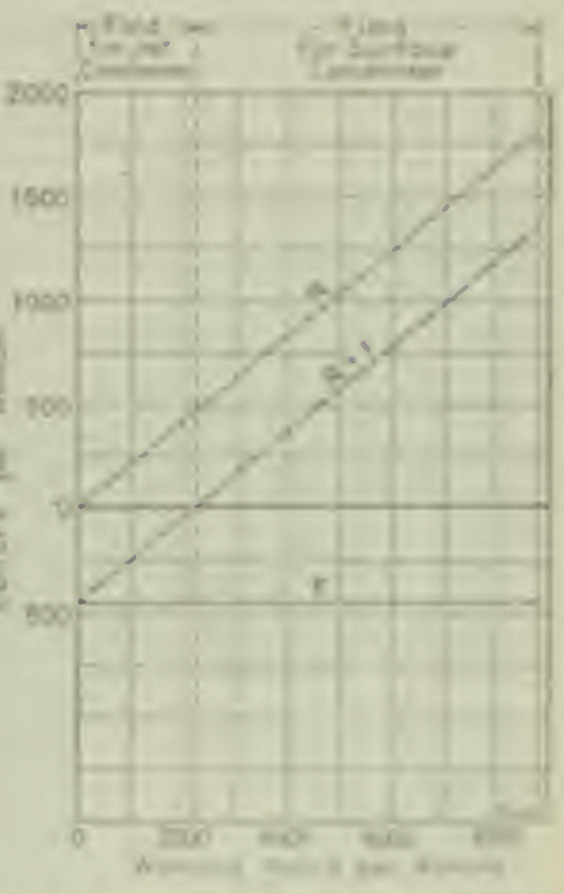


FIG. 2. TERMINAL PRESSURE AT TURBINE 1.5 POUNDS ABSOLUTE. CIRCULATING WATER 82 DEGREES FAHRENHEIT

the power consumed by the condenser auxiliaries then constitutes a greater percentage of the power of the main unit than in the case at full load. For the purposes of the present investigation, the motors driving the condensing plant are assumed to be designed so that they are able to handle a load considerably greater than the rated full load. A certain number of hours at a load which is a small percentage below full load may be taken as balancing an equal number of hours at which the load is about the same percentage above full load. Moreover, any hours at half load may be taken as equivalent to three-quarters of as many at full load; so that, for example, if the plant were ac-ways running at half load, the costs for jet and surface plants, instead of being the same at 4989 hours, would be the same at 6652 hours per annum.

Fig. 1 shows that, under the conditions assumed, namely, a terminal pressure at the turbine of two pounds per square inch, and the employment of a cooling tower, there are fields of considerable extent both for the barometric jet and for the surface condenser.

For terminal pressures greater than

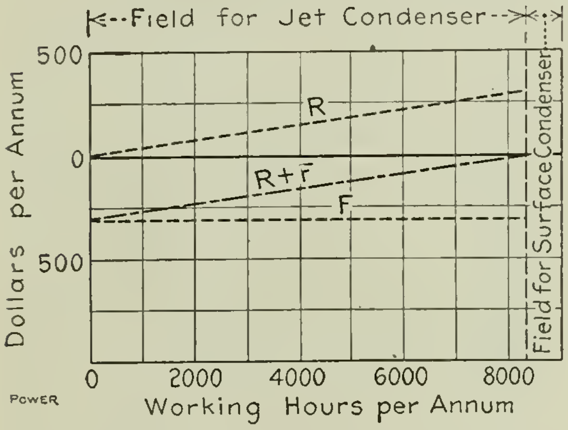


Fig. 3. Terminal Pressure at Turbine 1.5 Pounds. Circulating Water 60 Degrees Fahrenheit

two pounds per square inch, the field for the jet condenser is enlarged, and that for the surface condenser is reduced; but terminal pressures much above two pounds are seldom desirable for steam turbines.

For terminal pressures much lower than two pounds per square inch, the jet condenser has a very limited field. Fig. 2 corresponds to Fig. 1, but with plant designed for a terminal pressure of 1.50 pounds per square inch, a cooling tower being employed as before. The cost of the surface condensing plant is, in this case, estimated to amount to $21,600, and the jet plant is reckoned to cost $20,750. Fifteen per cent. on the former sum amounts to $3240, and 13½ per cent. on $20,750 amounts to $2800; the difference in the fixed annual costs is, therefore, in this case $440, and this is represented by the line *F* in Fig. 2. The working costs are higher in this case than in the last case, especially as regards the jet plant, which suffers not only from the greater specific volume of the air due to the lower pressure, but also from the greater weight of air admitted to the condenser due to the greater amount of condensing water required. The air pump of the jet plant is in this case estimated to require 26.8 horsepower, and, therefore, to cost 32.2 cents per hour at full load, while the surface condenser air pump is reckoned to require 10.09 horsepower, and therefore to cost 12.2 cents per hour at full load, the difference in running costs being therefore 20 cents per hour. The line *R* in Fig. 2 shows the difference in the running costs per annum for any number of working hours per annum; and the dotted line marked *R* + *F* represents the difference in total annual cost. It will be seen that the jet plant has the advantage only if the plant is worked per annum an amount equivalent to less than 2112 hours at full load.

Cases will now be considered where no cooling tower is employed, and where condensing water can be obtained at a temperature of 60 degrees Fahrenheit. The lesser amount of condensing water required in such cases enlarges the field for the jet condenser, so that for a terminal pressure of 1.5 pounds per square inch the jet condenser has the advantage over the surface condenser for practically any number of working hours per year. This is shown in the diagram, Fig. 3, which is of a similar nature to the previous two diagrams. The surface plant is in this case estimated to cost $8100 and the jet plant $6900. These two sums at 13 per cent. and 11 per cent. respectively represent fixed annual charges of $1055 and $760 respectively, the difference in fixed costs in favor of the jet plant being thus $295. The air pump of the jet plant is estimated to require 15.7 horsepower, and therefore to cost 19.8 cents per hour at full load, while the corresponding figures for the surface plant

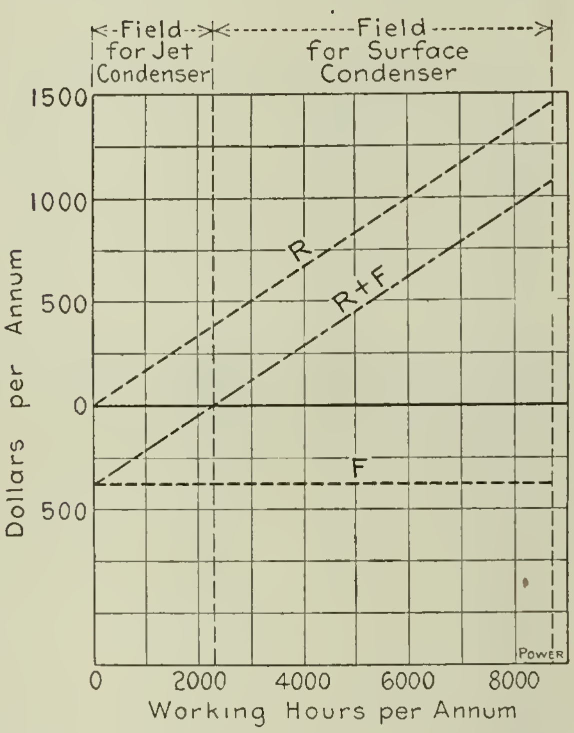


Fig. 4. Terminal Pressure at Turbine One Pound Absolute. Circulating Water 60 Degrees Fahrenheit

are 10 horsepower and 12 cents. The surface plant is, however, in this case estimated to cost 3.4 cents per hour more than the jet plant for water-pumping power, so that the difference between the running costs of the two plants amounts to

$$18.8 - (12 + 3.4) = 3.4 \text{ cents}$$

per hour at full load in favor of the surface plant.

Higher terminal pressures than 1.5 pounds with no cooling tower and with water at 60 degrees Fahrenheit need not be considered, as obviously the jet plant will have the whole field to itself. Terminal pressures lower than 1.5 pounds per square inch are, however, often desired, and Fig. 4 shows the fields for the two condensing systems when the terminal pressure is one pound per square inch. In this case the surface plant is estimated to cost $10,425, and the jet plant to cost $9000. Taking 13 per cent. of the former and 11 per cent. of the latter sum, the difference in the fixed annual cost is found to be $365. As regards running costs the air pump of the jet plant is estimated to require 28.4 horsepower, and therefore to cost 34 cents per hour at full load, while the corresponding figures for the surface plant are 11.4 horsepower and 13.6 cents. Allowing for a difference in cost of water-pumping power of 4.8 cents per hour in favor of the jet plant, the difference in running costs is 15.6 cents per hour in favor of the surface plant. The jet plant has in this case, compared with the previous case, a very limited field—only up to 2246 hours per annum—and for lower terminal pressures than one pound per square inch its field would be still further restricted.

An Inspector's Dream

By A. C. Terlene

It fell in my line of duty to go to a Central Western city to make the first inspection of six horizontal tubular boilers which had just been offered my company for insurance. This was a Sunday-morning inspection. The plant was a cereal factory which was in operation 24 hours per day, shutting down at midnight Saturday and starting up at midnight Sunday.

On arriving at the plant about 8 a.m., I was pleased to find that my coming had been prepared for, ashes and clinkers had all been nicely cleaned out from under the boilers, top and bottom manheads removed, boilers thoroughly washed, the furnace doors and flue caps closed and the damper opened so as to lower the temperature rapidly and remove all vapor from the interior. The tops of the boilers were all swept off nicely, smoke boxes cleared of soot and everybody was smiling and in good humor.

The chief engineer was on hand to greet me, took me into his engine room, which was nice and clean, and gave me a nice, clean locker in which to hang my clothes. The boilers were fairly hot, as might be expected, having been shut down so short a time, but by leaving the furnace doors and flue caps closed while inspecting above the flues it was quite bearable; then, when it came to going in under the flues I found that they kept a "buggy" for the purpose, this being a piece of 12-inch board 3 feet long with rollers under it. There was no scrambling along in an inch or so of dirty water in order to explore all the lower parts.

When the inspection was finished I could only report a few minor defects; the engineer, being a wide-awake man, had kept the plant in apple-pie order. I found that I had been provided with plenty of good hot water to wash up in and on leaving the plant I did so with a feeling that if all plants were like that an inspector's life would be much pleasanter than it really is.

But did I find the above? Emphatically no! That was only my dream, superinduced, no doubt, by the fact that when this inspection was finished I would go home for the first time in six long, dirty weeks. Here is what I found. On entering the plant at 8 a.m. I saw three or four firemen and helpers sitting around smoking and was pleased to hear one call out to the others, "Here's that feller; I was hoping he wouldn't show up."

One man went to the 'phone and called up the chief engineer and reported my arrival, asking for instructions. He reported that the chief said he would be down after a while and instructed them to "tear up" as little as possible.

On reconnoitering the plant I found that most of the ashes and clinkers were still under the boilers, no manheads had been removed and only two of the boilers were entirely empty. Of course, I could see breakers ahead but went to work to get the men to prepare the boilers for inspection. The head fireman said that they never removed the upper manheads as packing cost so much and the joints were so hard to make tight; besides it took so long to do it that he could not get his Sunday afternoon off. I insisted that all manheads would have to come out and he went back to the 'phone and held another séance with the chief, who apparently agreed that the upper manheads might be removed this time but that they could not make a practice of so costly a proceeding.

I hurriedly changed clothes in one corner of the boiler room, hanging my good clothes on nails against a dirty, smutty wall, wondering all the while if they would be in such condition that I would be allowed in the hotel when I got back to that place.

I found their statement as to not removing the back manheads borne out by the fact that it was necessary to use a short piece of railroad steel to butt them in and to make a run for it when we did, so as to avoid the gust of steam which poured forth. By twelve o'clock we had the boilers in such condition that I managed to get inside and found the passages between the tubes very generally stopped with scale, the back head being covered with nearly an inch of hard scale between the tubes. The internal extensions of the feed pipe were all disconnected at the point of entrance to the boiler; some of these pipes had evidently been forced off by the pressure of the feed pump as they were completely closed up with sediment and scale. Aside from a couple of broken braces, no defects were found in the boilers above the flues.

Below the flues I found that the front ends of the boilers were several inches lower than the back ends and as a consequence three or four inches of mud and water made inspection anything but pleasant as there was no "buggy" present. Externally, I found that several of the boilers were bagged on the front sheets above the grates, the girth seams were fire-cracked and leaking, the tube ends at the rear were nearly all burned off and a number of these were leaking badly. All but two of the soft plugs had been removed and replaced with solid plugs. I found only one safety valve that looked as if it had ever blown and the attendants stated that none of the others ever opened, one safety valve doing all the "popping" for six 72-inch by 18-foot boilers. Three of the water columns were 4 inches too low and gage cocks were conspicuous by their absence from the plant. The feed-water heater, of the closed type, was out of order, and the feed water was bypassed around it, so that the boilers were supplied with cold water. The chief did not show up at all during the day and we finished the inspection by about 4 p.m. Conditions were such that I deemed it advisable to stay over till next day and set the boilers in service and by so doing had an opportunity of meeting the chief engineer, also the officers of the company, which proved to be a new firm just taking over the plant. At the request of these men I staid over at this city three days, during which time their power plant was very thoroughly gone over, innumerable steam leaks were found and bad conditions generally were found. On visiting this plant three months later I found a great change.

The old chief had been given a permanent layoff, the boilers had been reset, a new feed-water heater installed, the pumps overhauled and such improvements made that four boilers now carried more load than six had formerly been able to do. Worst of all, a young man, one of the much berated "technical engineers," was in the saddle as chief. He had never shoveled a pound of coal and it is doubtful if he could have made up a decent pipe joint, but he knew how it all ought to be done and he was satisfied with nothing short of "right." Things done so that they would "do for a while" did not go with him. Many of us despised inspectors have seen parallel cases. My dream only showed the difference very distinctly between what some men are doing, as engineers, and what they should do or else prepare themselves to get out in favor of the technical man.

An Example of Incomplete Combustion

It requires but a glance at the accompanying illustration to see that a large amount of combustible was being but partly consumed. The photograph was taken at a fire that destroyed a storehouse of the Vacuum Oil Company at Weehawken, N. J., and several thousand barrels of lubricating oil.

Oil Fire at Weehawken, N. J.

Although the fire was marked by a pillar of smoke that rose two hundred feet or more, there was but very little flame to be seen. The heavy black smoke rolled up in great profusion.

Engineers are seldom given a better illustration of incomplete combustion, or an example of a fuel being burned so fast that the necessary air to produce complete combustion could not reach

Burning Small Anthracite Coal

By A. S. Atkinson

The lower cost of buckwheat coal has induced many plant owners to change over from the larger sizes, regardless of whether the equipment is suitable for burning the smaller coal; hence an apparent gain is often turned into a loss. A number of practical suggestions for burning buckwheat coal are given.

The inducements for plants to burn very small sizes of anthracite coal form a temptation to change from the larger sizes to No. 2 or No. 1 buckwheat, and this, in many instances, has resulted in loss rather than gain through lack of sufficient knowledge concerning the value of the various grades of anthracite. The lower prices of the small sizes are the chief factors in influencing owners of steam plants to adopt buckwheat coal, but frequently coal dealers in their eagerness to make sales will advise wrongly as to the results.

In order not to drift into an error that will cause trouble later, it should be understood that broken, egg, stove and even chestnut coal can be handled with great ease in furnaces without any great amount of chimney draft. They will generate steam in the most economical way, and as there is relatively little ash in these coals the operation of cleaning the furnaces is reduced to a minimum. Also, if the grates have wide openings between the bars the furnaces can be operated for long periods without cleaning. These factors make the larger sizes of anthracite popular among power-plant owners, and especially among firemen and engineers; but the smaller sizes can be purchased so much cheaper that there is a constant temptation to change to them. It is quite possible in many plants to make this change and save money, but the actual difficulties and drawbacks should be realized in advance; otherwise a money-saving proposition may be changed into a loss.

The first move should be to ascertain what changes must be made in the grates and chimney. If the latter is comparatively short, barely sufficient to furnish the draft required for burning the larger coal, it will not answer for the buckwheat sizes. This fact is so often disregarded in making a change of fuel that it should be particularly emphasized. However, with steam plants as ordinarily built, it is a simple matter to increase the draft without any material alteration.

If the chimney capacity is sufficient there still remains the problem of grates. The ordinary wide spaces between the grate bars, such as are suitable for large anthracite coal, would not be satisfactory for the small buckwheat sizes. A bar of the herringbone type with air spaces one-quarter of an inch wide probably gives the best results for all-round purposes where buckwheat coal is burned. This type of grate is superior to the pin-hole grates or bars of three-eighths of an inch in diameter for the reason that the latter have a very low percentage of air space. Frequently this is not more than 10 per cent., and they are suitable for buckwheat only when forced draft is used. The herringbone type, on the other hand, averages 25 to 35 per cent. of air space, which makes it suitable for either natural or forced draft. Some plants use grate bars with an air space aggregating 45 to 50 per cent., but this is entirely unnecessary; an average of 30 per cent. answers all purposes better and works for economy, as there will then be no leakage of coal to the ashpit. Everything depends upon getting the right grate bars, the right proportion of air space, and chimneys of sufficient capacity. With these as a start the rest of the work can be accomplished with good stokers and firemen who understand how to burn small coal economically.

In using buckwheat coal for steaming purposes there is no substitute for skilled operation. It is essential to ascertain how much buckwheat coal is required to produce the same amount of steam as is generated by a certain amount of the larger coal. There is a difference in the efficiency and heat values of the two coals, and this must be ascertained and kept in mind. To ascertain how much more small coal is required, it is necessary to find the difference between the amount of ash in the two coals. When this is found by actual test it is a simple matter to calculate how much more of the small size is needed for generating a given amount of steam.

Ordinarily, buckwheat coal contains about twice as much ash as egg, but this will differ considerably in various grades. Consequently each separate lot must be tested, and the ash determined before intelligent burning can be carried on. It is true that very few companies go into all of these details, but it is also true that many are burning the small sizes at a considerable loss in economy.

A number of tests have been made with small and large sizes of coals to ascertain the relative amounts of the two fuels required to produce a given amount of steam. Without going into the details of these experiments it may be stated roughly that for the ordinary furnace it will require nearly 10 per cent. more of buckwheat than egg coal to give the same steaming results. These calculations are based upon dry coal, and when the coal is bought in a wet condition allowances should be made for the moisture. This difference is quite important. In large-sized coal the moisture is not as great a factor, but in buckwheat it is very important, often representing a difference of as much as 10 per cent.; that is, 10 per cent. of the weight of the coal when saturated may be water, and the plant owner is paying for this moisture for every ton he buys. Dry pea or buckwheat coal alone should be purchased, and if delivered wet an allowance of 8 to 10 per cent. should be deducted from the gross tonnage. Dealers prefer to deliver coal in a moist condition, but keen buyers refuse to take it by the ton weight in this condition. Likewise, when stored the coal should be kept as free from moisture as possible.

When the necessary amount of buckwheat coal has been determined, the problem of obtaining the highest efficiency from it should next come up for solution. Here the fireman will determine the economy or loss resulting from the use of the new fuel. More skill is required for firing with buckwheat than many imagine. In the first place, it must be spread lightly and uniformly over the fire, and fired at frequent intervals. Any attempt to fill the furnace with sufficient coal to last as long as the egg size means a loss; yet this is the temptation to which many yield as it is the easiest way to fire the boiler. The grate will also need more frequent and thorough cleaning with the small sizes. This means more time and labor on the part of the fireman, and unless a good man is employed, it will be neglected. A competent and conscientious workman will, however, obtain as good efficiency from buckwheat coal as from egg if the conditions of the grate and chimney are satisfactory to start with.

The small particles of buckwheat coal form a much denser and more compact bed of fuel than egg coal, and in order to make this burn satisfactorily the draft must be stronger. There must be a greater suction or pressure to get the necessary air through the bed to insure perfect combustion, and here the problem of natural or forced draft is involved. If the chimney is of ample capacity, and the grate bars are wide enough to admit plenty of air, natural draft will suffice, but if there is not sufficient draft it will then be necessary to resort to artificial draft to secure the economical results aimed at. A little previous study and measurement of the chimney capacity and the draft at the boiler damper will obviate any trouble that may arise later.

A table based upon the results of a long series of experiments gives the following draft in inches of water at the boiler damper required for the combustion of pea coal under the best conditions:

10 pounds per square foot of grate per hour	0.[illegible] inch
15 pounds per square foot of grate per hour	0.[illegible] inch
20 pounds per square foot of grate per hour	0.7[illegible] inch
25 pounds per square foot of grate per hour	1.[illegible] inch

The engineer can increase the draft or increase the grate surface, or both, to obtain the desired results, but there must be careful study of the conditions before conclusions are drawn. Buckwheat coal can be used with very wide furnaces, and also with those that are quite deep. It is particularly suited for grates up to twelve feet in depth, which makes it a very economical fuel for certain work. The coal can be spread evenly over this large grate surface, and if spread uniformly it does not have to be worked and manipulated in order to get the fire even throughout. In this respect the buckwheat has an advantage over some of the larger sizes which must be raked and poked about at intervals to secure uniform heat. In ordinary shaking grates the small sizes cause more or less trouble and extra labor. In small grates, shaking and poking may prove satisfactory in cleaning the fires, but this will hardly answer in grates exceeding eight feet in width, in which case dumping must be resorted to. If the grate is provided with a good shaking and dumping arrangement, a fire can be kept clean and bright for long periods, and then, when needed, the grate can be dumped without materially cooling the fires for any great length of time.

Small anthracite is burned most successfully in plants with chimneys 200 feet or more in hight without forced draft, but in chimneys less than 100 feet some system of forced draft is usually necessary. It is even considered advisable in some cases to use forced draft where the chimneys are very tall, just to overcome weather conditions. In such cases the forced draft is not used except on such days as the weather makes burning with natural draft somewhat difficult. The cost of the forced-draft equipment is insignificant considering the results and the efficiency and economy obtained. Where the coal tends to form bad clinkers the forced draft should be supplemented by jets of steam passing through the fuel bed; this increases the efficiency of the boiler and saves time and labor in the cleaning.

There is quite a wide difference in the quality of small anthracite. Some will clinker badly under any but the most favorable conditions, and some grades will burn satisfactorily under very unfavorable conditions. This accounts in a measure for the difference in results obtained by plants which burn buckwheat coal; one will show excellent results without many of the modern improvements, and another will show poor results. It is the difference in the burning quality of the coal. For this reason the greatest care should be exercised in obtaining a good grade of coal at all times. The difference in the cost sometimes more than counterbalances the difference in the burning qualities.

A Remarkable Overload Boiler Test

The power plant for the repair shops of the New York Central Railroad at West Albany, N. Y., has recently been nearly doubled in capacity. The original boiler installation, consisting of four 500-horsepower Franklin water-tube boilers equipped with Taylor gravity underfeed stokers, has been supplemented by the addition of three 600-horsepower Edge Moor water-tube boilers also equipped with Taylor stokers. Two 500-kilowatt Western Electric alternating-current generators direct connected to 750-horsepower Ball & Wood horizontal cross-compound engines were installed at the same time. The original generating units consisted of two 600-kilowatt General Electric alternating-current generators driven by 900-horsepower Ball & Wood engines.

In order to meet the demands for power in the repair shops it is often necessary to overload the boilers greatly and this overload is likely to continue for some time. Accordingly, it was thought advisable to subject the new units to a very severe test to determine their capacity for handling a long continued excess load. To this end one of the new boilers located at the extreme south end of the boiler room and known as boiler No. 7 was tested for 16 hours under an average load of 1120 horsepower or 186 per cent. of the builder's rating. Furthermore, during the first 14 hours of the test the average horsepower developed was 1158, corresponding to 193 per cent. of the rating. The extreme severity of this test both on the boiler and the stoker may best be appreciated when it is considered that ordinary acceptance tests rarely exceed eight hours in length and the horsepower developed seldom exceeds 50 per cent. above normal rating. In general, for tests at higher rating, the time is cut down to six or even four hours' duration.

The test was conducted by the mechanical engineering force of the railroad from 9:15 a.m. on October 11 to 1:15 a.m., October 12. All the coal used was carefully measured on platform scales and the amount of water used was determined by means of calibrated barrels. The Hempel apparatus was used for analyzing the flue gases. Forced draft is obtained for this installation by means of a fan blower.

The principal dimensions and proportions of the boiler and stoker are as follows: Water-heating surface, 6129 square feet; grate surface, exclusive of area of the dumping plates, 70 square feet; number of tubes, 308; size of tubes, 4 inches in diameter by 18 feet long; spacing of tubes, 12 high by 20 and 21 wide; width of stoker grate, 12 feet 7 inches; width of furnace above stoker, 13 feet 4½ inches; length of furnace to the bridge-wall, 7 feet 3 inches.

The stoker used in connection with this boiler is of the seven-tuyer style; that is, there are seven coal-feeding chutes, each operated by a separate pair of plungers. The coal is fed in underneath the fuel bed and becomes thoroughly coked before reaching the surface of the fire. As the air supply is governed automatically by the speed of the stoker, there is no necessity for adjustment at different loads.

The principal reported data on this test follow:

CONDITIONS

	For 16 Hours	For First 14 Hours
Steam pressure, lb. gage	177.[illegible]	177
Draft in chimney, in. water	[illegible]	[illegible]
Draft over fire, in. water	—0.1	[illegible]
Draft in uptake, in. water	[illegible]	[illegible]
Temp. outside air, deg. F	48.6	[illegible]
Temp. feed water entering boiler, deg. F	[illegible]	[illegible]
Temp. air supply, deg. F	[illegible]	[illegible]
Flue gases in uptake, deg. F	[illegible]	[illegible]

FUEL DATA

Kind of coal	Clearfield, Penn., run of mine
Heat units per lb. dry coal (estimated) B.t.u.	[illegible]
Proximate analysis:	
Fixed carbon, per cent	[illegible]
Volatile matter, per cent	[illegible]
Moisture, per cent	[illegible]
Ash, per cent	[illegible]
	100.00

Sulphur separately determined, [illegible] per cent.

HOURLY QUANTITIES

	For 16 Hours	For First 14 Hours
Dry coal burned per hour, lb.	[illegible]	[illegible]
Combustible burned, lb.	[illegible]	[illegible]
Dry coal per sq.ft. of grate, lb.	[illegible]	[illegible]
Combustible per sq.ft. of grate, lb.	[illegible]	[illegible]
Combustible per sq.ft. of heating surface, lb.	[illegible]	[illegible]
Water evap. corrected for quality of steam, lb.	[illegible]	[illegible]
Equiv. evap. from and at 212 deg., lb.	[illegible]	[illegible]
Equiv. evap. from and at 212 deg. per sq.ft. of heating surface, lb.	[illegible]	[illegible]
Per cent. of priming	[illegible]	[illegible]
Factor of evaporation	[illegible]	[illegible]

HORSEPOWER

	For 16 Hours	For First 14 Hours
Average h.p. developed	[illegible]	[illegible]
Builder's h.p. rated	[illegible]	[illegible]
Per cent. of builder's rated h.p. developed	186	[illegible]

ECONOMY

	For 16 Hours	For First 14 Hours
Apparent evap. per lb. coal as fired, lb.	[illegible]	[illegible]
Equiv. evap. from and at 212 deg. per lb. coal as fired, lb.	[illegible]	[illegible]
Equiv. evap. per lb. dry coal, lb.	[illegible]	[illegible]
Equiv. evap. from and at 212 deg. per lb. combustible, lb.	[illegible]	[illegible]

EFFICIENCY

	For 16 Hours	For First 14 Hours
[illegible]	[illegible]	[illegible]
Boiler efficiency based on combustible, per cent.	[illegible]	[illegible]
Combined efficiency of boiler and grate based on dry coal, per cent.	[illegible]	[illegible]

Methods of Governing Steam Engines

By John Davidson

Serial with article under the above caption in the February 21 issue. In this instalment are discussed combined throttle and variable expansion governors and expansion governors for actuating trip gears.

Combined Throttle and Variable-expansion Governing

Most modern high-speed engines are now controlled by means of a combination of both throttling and variable expansion. The governor is fixed to the crank shaft, and actuates a throttle valve in the usual way, but in addition to this, it also controls the cutoff by slightly rotating the piston valve in such a way as to alter the lead. The piston valve for engines governed in this way is necessarily of special design, and is provided with ports of angular shape arranged to engage with corresponding ports in the liner.

Fig. 13 is an elevation of a high-speed engine showing the governing gear, and Fig. 14 is a detailed view of the spring box employed for the purpose of allowing the throttle valve to act quickly and independently of the cutoff mechanism. Fig. 15 shows the developments of the valve and liner surfaces. Referring to Fig. 13, governor *A* is fixed to the engine crank shaft and is inclosed by a casing *C*. The rocking shaft *D* of the governor carries two operating arms *E* and *F*, the former controlling the throttle valve through rod *G*, and the latter the cutoff. The lever *E* is provided with a spring attachment *J* at its outer end for the purpose of regulating the action of the governor. The end of the lever *F* works in a box *K* (see detail, Fig. 14), inside of which there is a spring *M*, in compression between the end of the box and a cap on the end of the lever. When the lever *F* is moved from right to left by the action of the governor, the spring *M* is compressed and through lever *O* causes the vertical shaft *N* to rotate. As this shaft rotates through a small angle, it actuates the system of levers, shown in the small plan view, which is similar to a Stanhope lever. This lever is connected to a shaft passing through the end of the valve chamber, which, in turn, is fixed to a spider *S* mounted on an extension on the slide valve *T*. Thus the movement of the governor balls causes the angular adjustment of the piston valve *T*, and this effects the acceleration or retardation of the cutoff in the following manner:

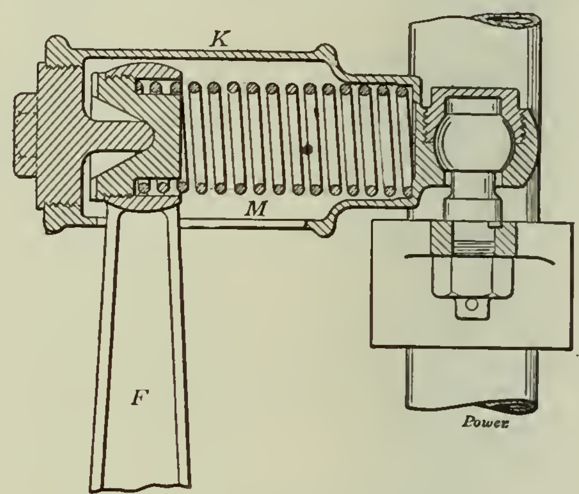


Fig. 14. Spring Box

The valve *T* is arranged to slide in the liners *U*, located at the top and bottom of the valve casing, these liners being provided with triangular ports *V*, while the valve itself has inclined cutting-off edges *W*. The triangular port is in the form of right triangle with the hypotenuse, which forms the steam edge of the port, inclined at 45 degrees. The cutting-off edges of the valve are also inclined at 45 degrees, so that an axial motion of the piston valve moves the cutting-off edges of the valve parallel with the inclined edges of the ports. The relative positions of these cutting-off

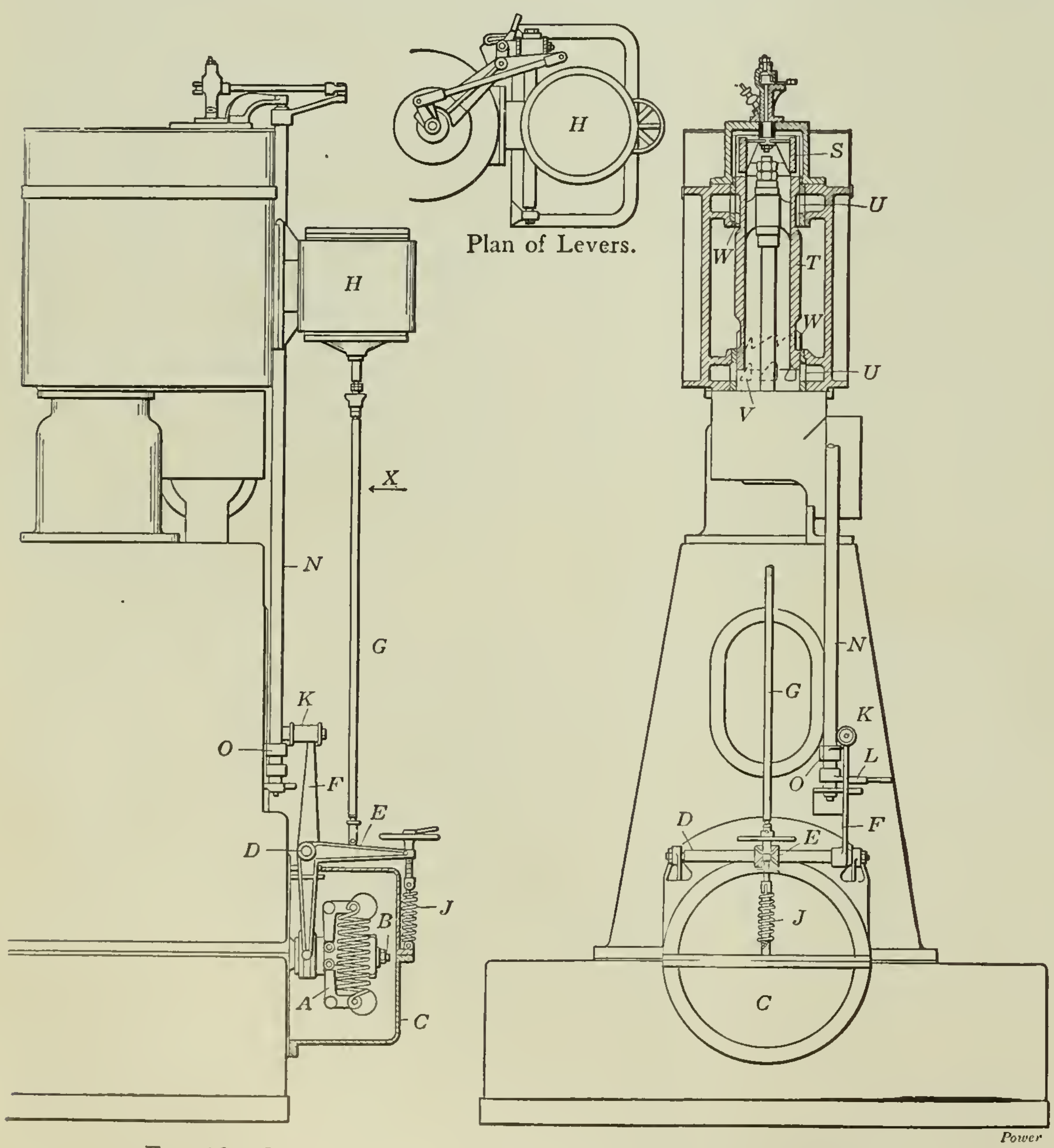


Fig. 13. Governing Gear for Small High-speed Engines

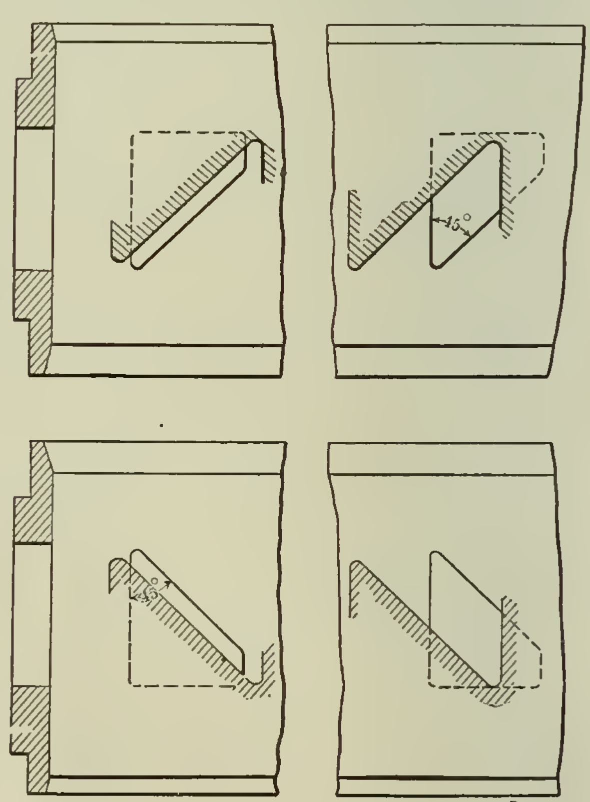
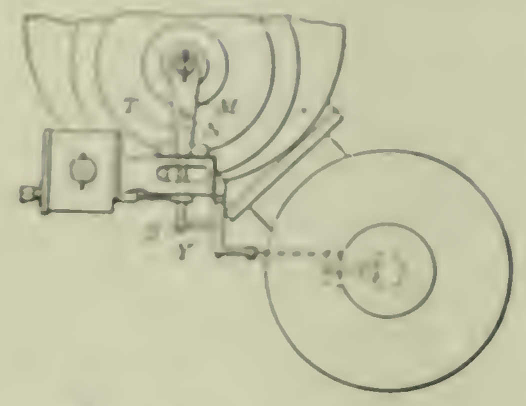


Fig. 15. Valve and Liner Surfaces

edges and ports are shown in Fig. 15, in which the left-hand view represents the relative positions when the valve is set to give the earliest cutoff, and the right-hand view the relative positions when the valve is set for the latest cutoff, these positions being taken at the same point in the travel of the valve. In order to cut off steam, the valve is required to move through a greater distance axially when in the latter position than when in the former. Also in the left-hand position the lead will be smaller than in the right-hand position, and the lap will be correspondingly greater. It has been found that with high-speed engines this reduction in the lead is no disadvantage, but has the effect of making the engine run more smoothly.

The operation of the gear is as follows: Assume first that the load has suddenly been taken off the engine. The consequent increase in speed will cause the governor balls to fly out and throttle the steam by means of the throttle valve in the casing H, Fig. 13. Meanwhile, the rotation of the slide valve will be much slower, owing to the intervention of the spring. The valve will, at first, be rotated through a considerable angle till that position is reached at which the speed is normal. When the point of earliest cutoff is reached, the engine is further governed wholly by throttling.

Now assume that the slide valve is at the point of earliest cutoff, the throttle valve is throttling the steam and the load is increased; the effect of this increase in load will be to open the throttle valve; meanwhile, the slide valve is not appreciably changed, owing to the action of the levers Q and P, but the throttle valve will continue to open until it ceases to throttle the steam. The arrangement of levers is so designed as to produce a material change in the position of the slide valve only after the throttle valve has ceased to throttle the steam. In this way the engine is governed at low loads by throttling, and at high loads by varying the expansion. By means of this gear it is possible to arrange for a variation in cutoff from 40 to 80 per cent. of the stroke.



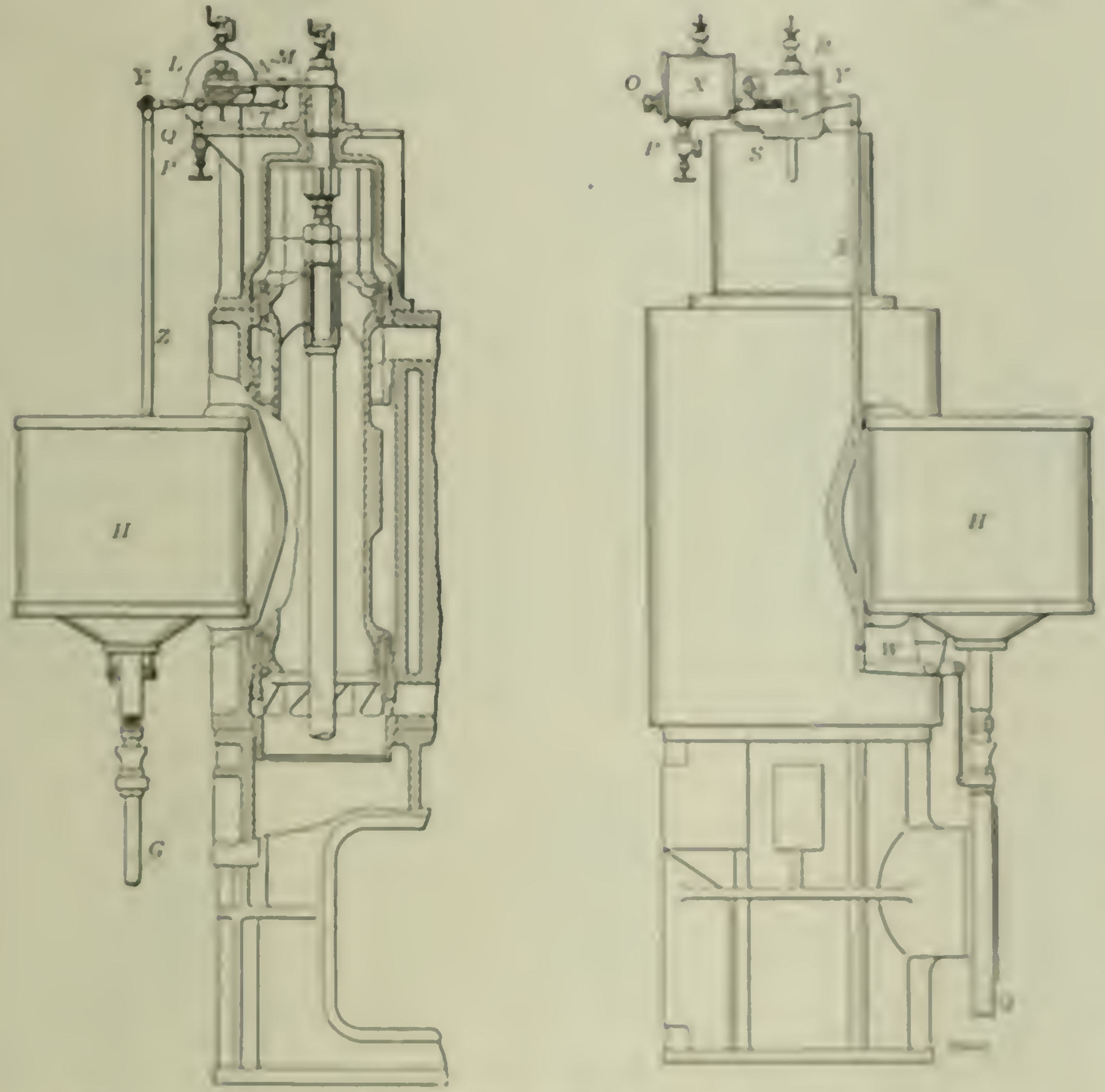


Fig. 16. Arrangement for Regulating Cutoff through Relay Piston

With large engines, it is usual to operate the cutoff valve through a relay cylinder, thus greatly relieving the governor, as it has then only to actuate a small piston valve in connection with the relay piston cylinder. Instead of using a spring and Stanhope lever, the gear illustrated in Fig. 18 is used. Here the spring is replaced by a small relay cylinder X and the Stanhope lever by a cam Y. The upward movement of the link G causes, through lever W, a downward motion of link Z which is connected to an extension on the cam Y. While this is taking place, the throttle valve in H is moved as in the case previously described. The motion of the pivoted cam at first produces no effect upon the cutoff because the cam is in the form of an arc with its center at the pivot. When, however, the throttle valve has been opened to such an extent that further movement has no effect upon the control of the engine, a raised portion R on the cam comes opposite a follower S, held in place by a spring. The follower is attached by means of a lever T to the

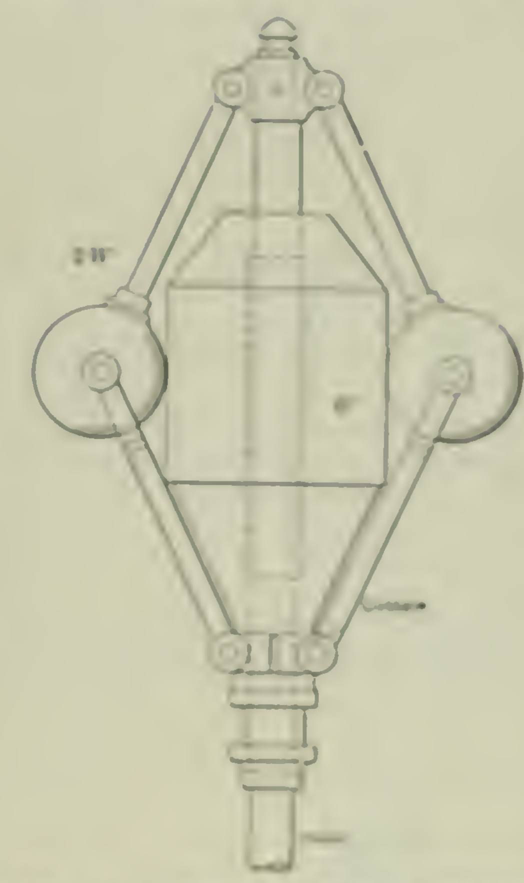


Fig. 17. Original Porter Governor

spindle L of a slide valve, which controls the admission of steam to the relay cylinder. Steam enters the valve casing Q by pipe P, and exhausts by pipe O.

The lever M is connected to the main slide valve of the engine, or, if the engine is of the multiple-expansion type, to the high-pressure slide valve, so that the valve is turned and controls the cutoff as described in the preceding case.

Lever T, which carries the cam follower, is pivoted at the end of spindle L and also at N to the lever M. As the lever M is moved in a counterclockwise direction under the action of the relay piston, and the follower S is moved clockwise under the action of the cam, the motion of the slide valve in the casing Q is made slower, and more accurate adjustment of the engine slide valve is rendered possible. In this manner, at light loads the engine is governed by throttling and at heavy loads it is governed by the cutoff.

Variable-expansion Governors for Actuating Trip Gears

The governor most commonly used for this purpose is the original Porter governor, illustrated in Fig. 17, but many firms have adopted a modified form of

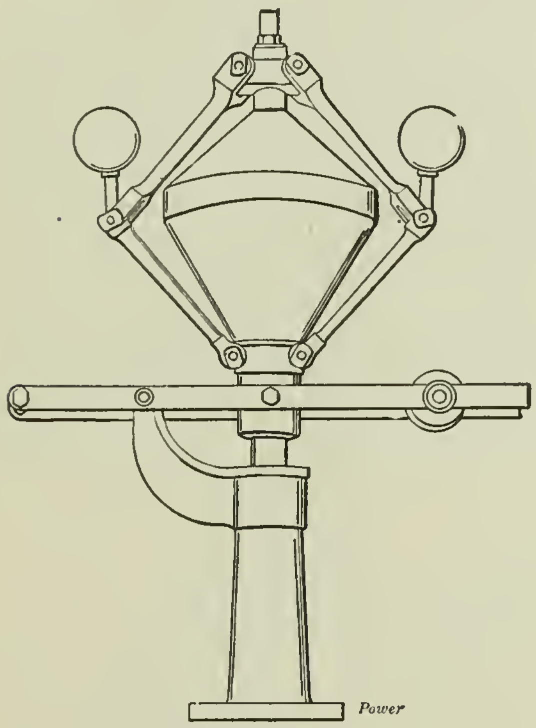
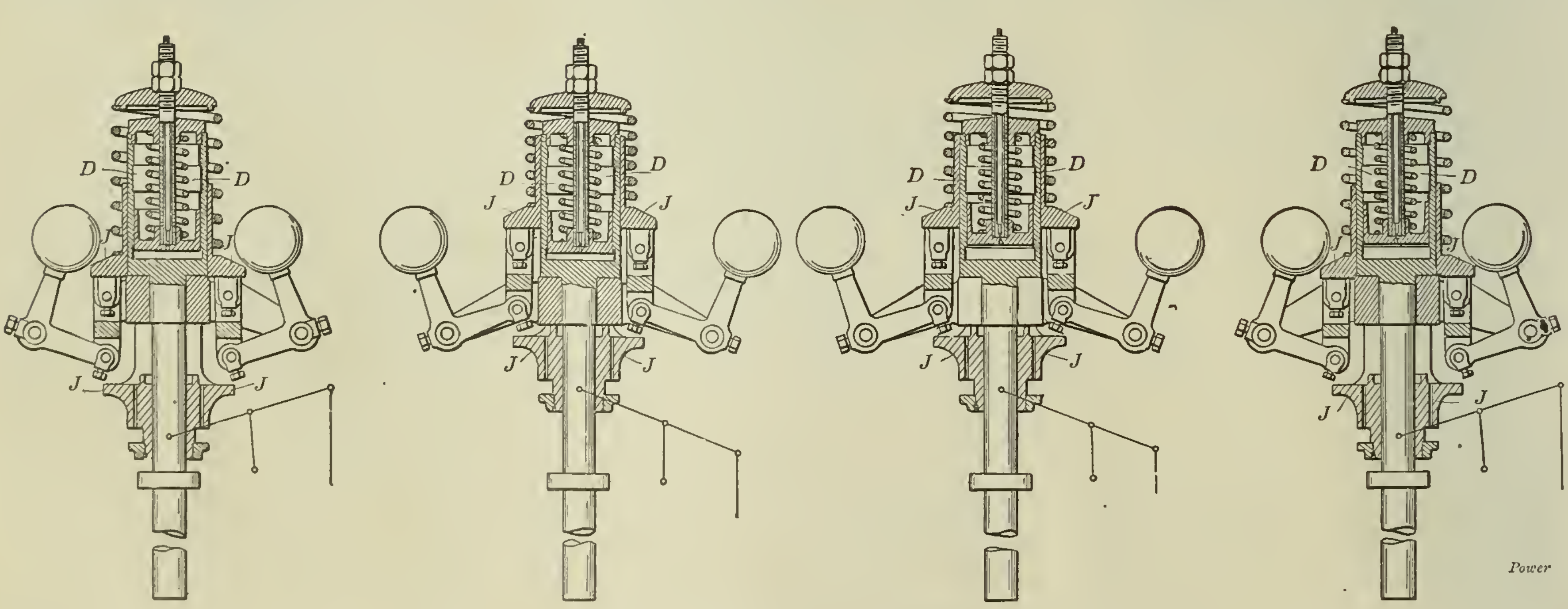


Fig. 18. Modified Proell Governor

Proell governor as illustrated in Fig. 18. The latter is very sensitive but does not possess much controlling power.

The Proell governor itself, which is illustrated in Fig. 19 is much more powerful, and at the same time is very sensitive. The governor flange D, which is secured to the top of the stand, has a



Figs. 20-23. Whitehead Governor in Various Positions

cylindrical sleeve, into which is fitted the hollow spindle A. This spindle has lugs at E and F, from which are suspended two hanging straps H_1 and H_2, carrying at E' and F' two pendulums P_1 and P_2 which, at their lower ends B and C, are pivoted to the movable sleeve S. By this peculiar suspension of the governor balls, they are guided in a straight line, and, when revolved, describe a plane, not an arc or spherical surface, as is the case with all other governors. The straps H_1 and H_2 are continued at their upper ends as bell cranks, and these carry the cross bridge R, at K_1 and K_2, on hardened knife edges. Into the center of the cross bridge and into the bottom of the spindle A are fitted two spring holders T_1 and T_2 which hold between them a strong spiral spring in tension; this counteracts the centrifugal force of the governor balls. Many governors have been constructed on the principle of balancing centrifugal force against spring power, but as the balls open in an arc, an equal angular opening does not vary the centrifugal force in the same ratio as the compression of the spring. In the Proell governor the increase or decrease of centrifugal force is proportionate to the increase or decrease of spring power, to whatever angle the governor may be opened. This construction, therefore, secures the most sensitive regulation obtainable, while the strength of the spring and the heavy weight of the balls exert great power. With the exception of the support D, the whole governor is revolved by the bevel gear W.

A governor, which is very quick in responding to changes of load and pressure, and at the same time maintains the speed of the engine constant, is the Whitehead governor llustrated in Figs. 20, 21, 22 and 23. The balls and bell cranks are mounted on and driven by a yoke or cross bar by means of the spindle, which, in turn, is actuated by gearing or belting. The top of the spindle is a cylinder, in which a piston works, the hollow piston rod passing through the cylinder cover. The cylinder is filled with oil, which is allowed to flow from one side of the piston to the other through passages provided for that purpose. The rate of flow is controlled by the spindle acting as a valve and by the set screw at the top of the piston rod, there being a small spring at the lower end of the spindle which tends to lift the valve off its seat when the set screw is released. This combination acts as a dashpot.

The essential feature of this governor is the employment of two springs, one compressed between the sliding collar

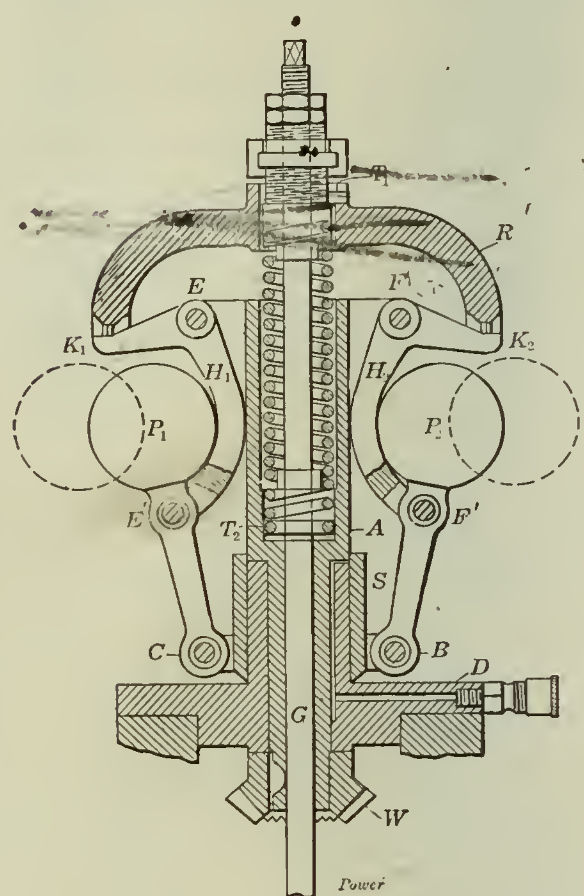


Fig. 19. Regular Proell Governor

and the plate, and the other between the piston and the cover of the cylinder. As both springs exert a pressure in opposite directions upon the plate, which is free to move under their influence, it is obvious that the two springs must have the same degree of compression, provided the oil in the cylinder permits a movement of the piston to take place; which will, of course, occur so long as any passage exists for the flow of the oil from one side to the other of the piston.

All ordinary governors, whether high or slow speed, sensitive or sluggish, must be designed to give a certain percentage of speed variation between no load and full load; that is, the speed at which the

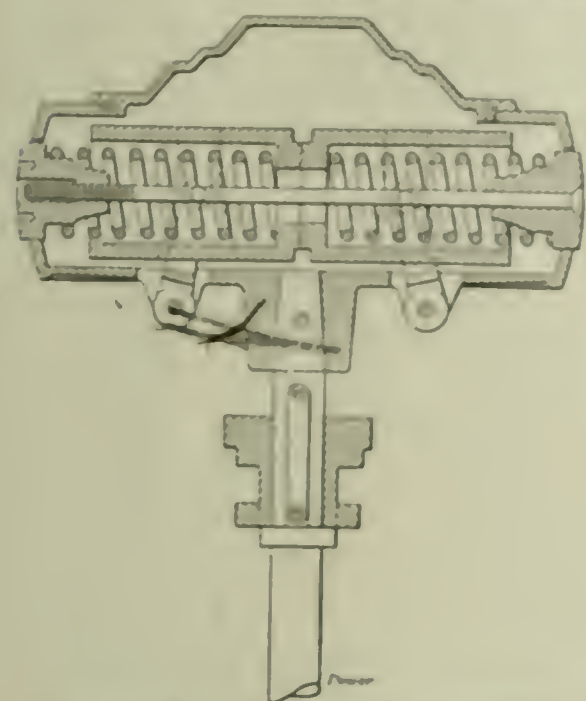


Fig. 24. Hartung Spring Governor

engine will work without hunting must always be higher with light than with heavy loads, for with light loads the engine must run faster than its normal speed in order to maintain the balls in a position to restrict the steam supply. On the other hand, the engine will slow down below the normal speed when an extra-heavy load comes on, so that in reality it maintains a normal speed at one load and steam pressure only, and is only approximately correct at all other loads or pressures.

The Whitehead governor, assuming that the outer spring only is in action, would have a variation of 12 per cent. between the bottom and top positions of the sleeve, but, owing to the equilibrium sought between the two springs, this 12 per cent. of variation is eliminated, and the governor is absolutely isochronous. In order to vary the speed of a spring-loaded governor, it is usual to slacken the spring if the engine is required to run slower and to tighten it if required to run faster. Upon this fact is based the operation of the Whitehead governor.

Fig. 20 shows the governor with the balls and the sliding collar in the bottom position giving steam to the engine. Assuming the governor is set to run at 200 revolutions per minute when the engine is running at its normal speed, the springs when working together exactly balance the centrifugal force of the balls at 200 revolutions in any position; therefore, the balls do not begin to spread or move outward until they attain that speed. Presuming that the load is suddenly thrown off the engine, the speed rises and the balls spread out, due to their centrifugal force. This lifts the sliding collar until it is in its top position, as shown in Fig. 21, thereby compressing the outside spring. If it were possible then to prevent the inside spring from compressing, and the top plate from moving upward, the governor, in order to keep the balls spread out, would have to run 6 per cent. faster, or 212 revolutions per minute; but, as the compression of the main spring transmits pressure through the piston rod and piston to the inside spring, the latter will compress and the piston will move up to the position shown in Fig. 22, thereby slackening the outside, which has the effect of producing a slower speed.

It was pointed out that the two springs together exactly balance the centrifugal force of the balls in all positions; therefore, when the inside spring has finished compressing, it will have relieved the outside spring so that a speed of 200 revolutions per minute will main the balls in their new position and the speed of the engine will again be normal.

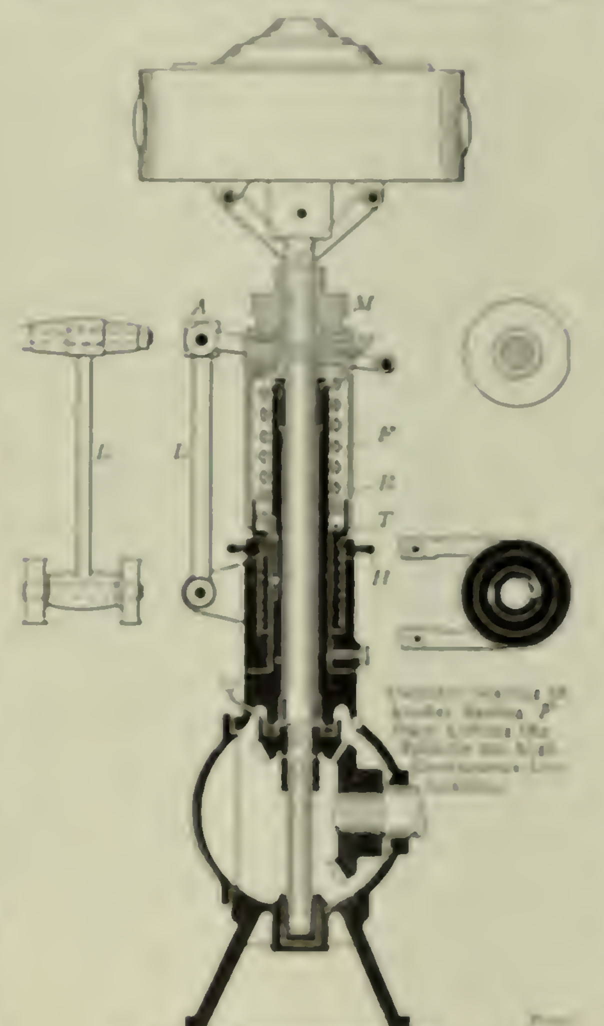


Fig. 25. Templin Governor

Presuming now that the full load is suddenly put on again, the balls drop back and the sleeve falls to the bottom position, as in Fig. 23. In this position the inside spring is still compressed as in Fig. 22 and, therefore, the outside spring is slackened until the speed drops 6 per cent., or to 188 revolutions; then the inside spring expands, and brings down the top of the outside spring until it is again in the position shown in Fig. 20, when the speed will have risen again to 200 revolutions.

In the foregoing explanation, in order to illustrate the action as clearly as possible, it was purposely said that the inside spring begins to move after the outside spring has been compressed or expanded by reason of the balls respectively spreading or coming in, so as to prove that the governor has its outside or governing spring automatically slackened or tightened by the inside or regulating spring. This statement, however, must be modified by stating that as soon as the outside spring has its pressure increased the inside spring feels the effect of this, and at once begins to compress. It is only prevented from doing so simultaneously with the outside spring by the necessity for the oil in the chamber having to pass to the opposite side of the piston; thus the inside spring lags slightly and only completes its movement after the outside spring has come to a state of rest. In this way any extraordinary excursion of the balls is checked and all hunting is obviated.

Hartung's Patent Spring Governor

A type of governor largely used on the Continent is the Hartung, illustrated in Fig. 24. This governor, although very sensitive, is extremely powerful. It has two hollow cylindrical weights revolving in a plane perpendicular to the axis of rotation, and inside these weights are two compression springs. The weights are hinged on bent levers which engage at their other ends with the governor sleeve, the weights thus being kept in their positions relative to the springs when revolving. In this way the action of the centrifugal force is opposed directly by the spring, so that no pressure

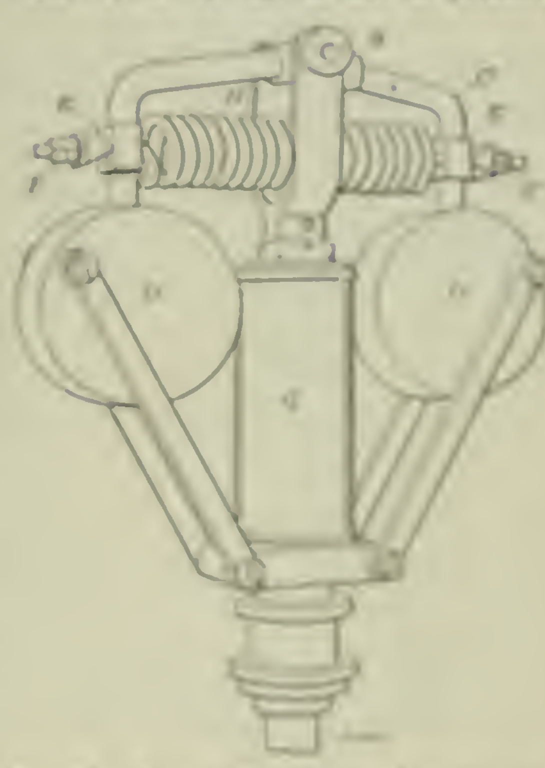


Fig. 26. [illegible] Governor Adapted to Engines of This Type

due to either of these forces acts upon the levers. In this way the friction is reduced to a minimum, and the wear in the sleeves themselves is due only to the action of the force necessary to alter the trip gear, and not by any undue pressure from the springs or centrifugal force of the weights. The governor is entirely inclosed in a circular casing which gives it a neat appearance, and at the same time, prevents dirt and dust from getting into the interior.

Another governor with weights arranged in a similar manner is "Temples

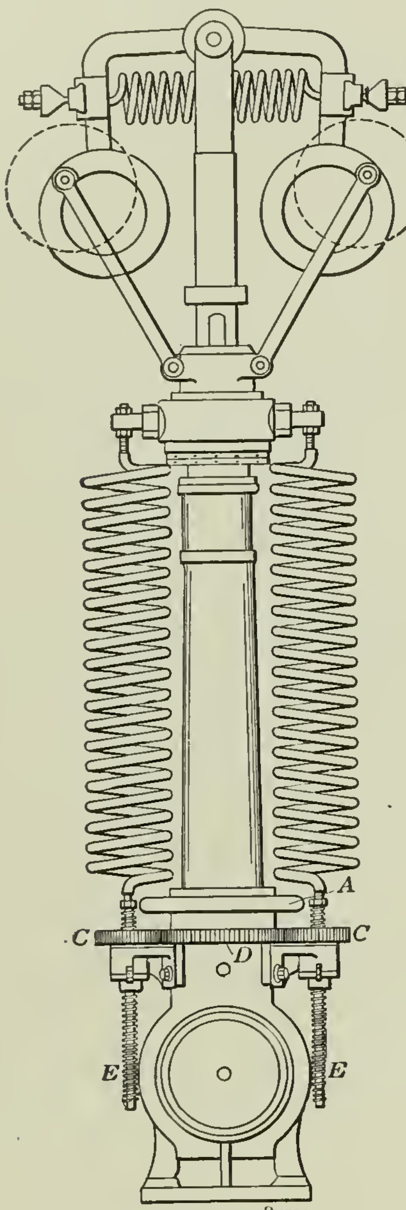


FIG. 27. TOLDES GOVERNOR FOR VARIABLE SPEEDS

patent," illustrated in Fig. 25. A change in speed is effected by means of a spring *F* coiled around the shaft of the governor; the lower end of this spring be-

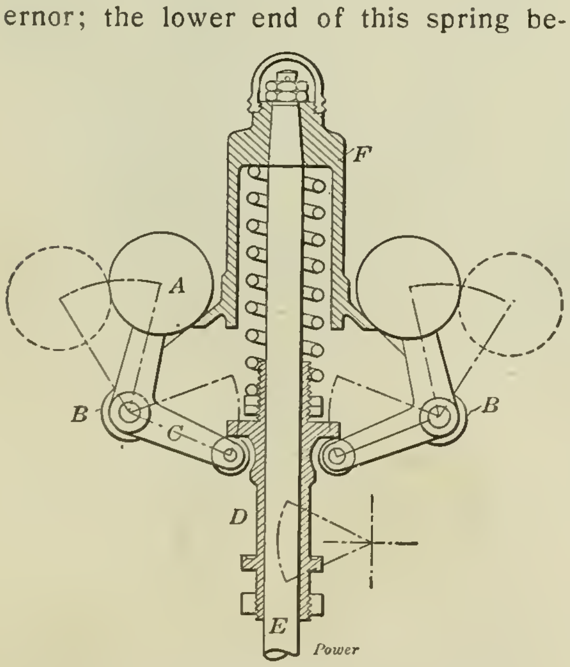


FIG. 28. HARTNELL GOVERNOR FOR SINGLE-SPEED ENGINES

ing secured by the cup *T* and the handwheel *H*, by means of which it may be more or less tightened.

The gear lever is secured by means of rod *L*, and the sliding ring can only move with the sleeve in a straight line. It is worthy of note that by this arrangement, the higher the number of revolutions, the lower the pressure of the spring, and *vice versa.* The wear of the sliding surfaces of the ring and the sleeve *M* is thus reduced to a minimum. In most other systems the loading of the sleeve has quite a different effect, for the greatest pressure corresponds to the greatest number of revolutions, which

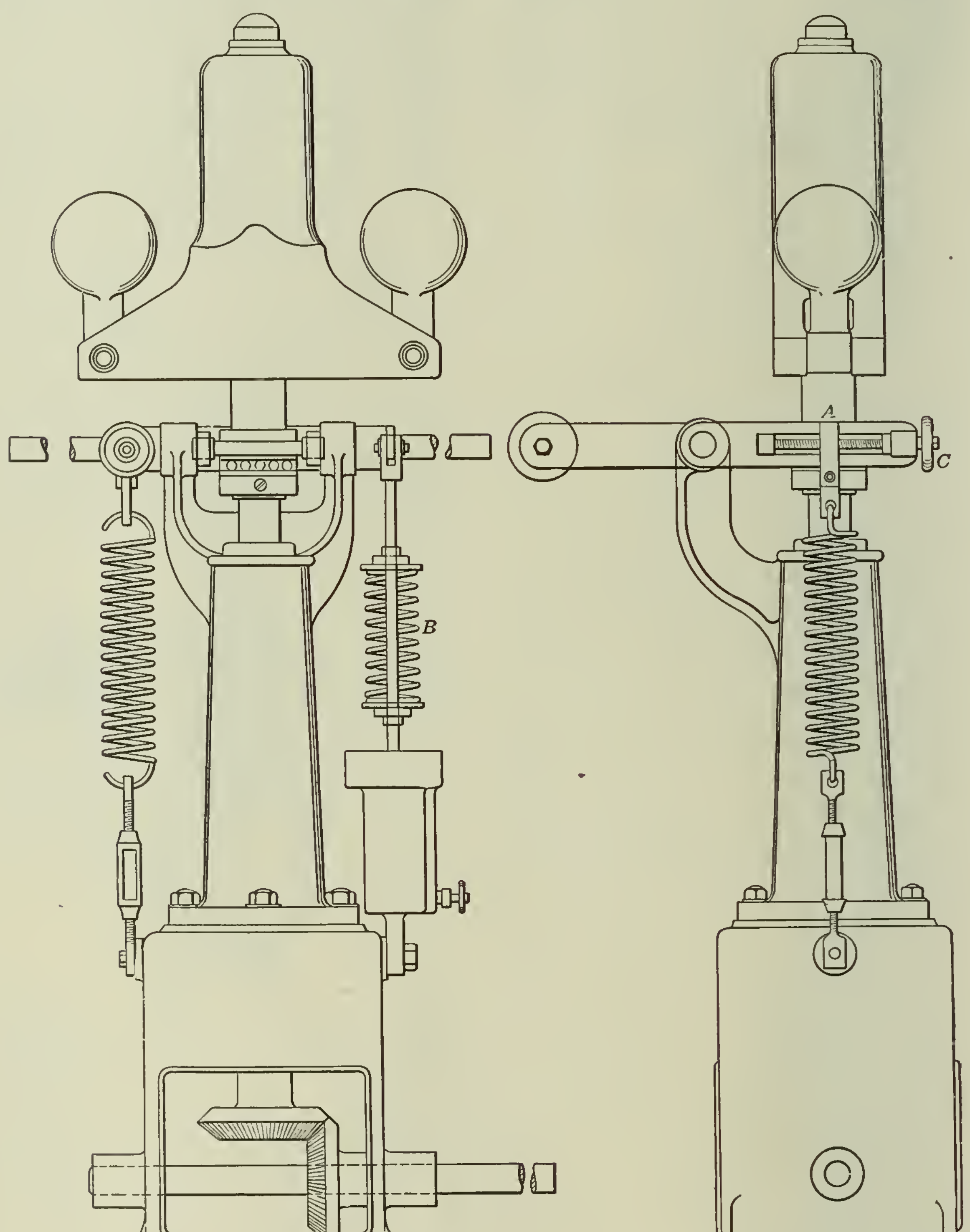


FIG. 29. HARTNELL GOVERNOR FOR VARIABLE SPEEDS

causes both heating of the sliding ring and quick wear.

Another type in which a large variation in speed is possible, is the Toldes patent governor, shown in Fig. 26, and made by Theodor Wiede's Maschinenfabrik, Saxony. The principal claim for this governor is that any change of the load on the spindle, tending to alter the speed within predetermined limits, does not affect the character of the governor in any way; that is, the degree of variation remains the same for every newly adjusted speed.

The governor consists of two weights *D D* suspended from a central pivot *B* by two bent arms *C*. The centrifugal force of the weights is balanced by the coiled steel spring *D* which acts through the knife edges *E*, the tension on the spring being adjusted by the nuts *F*. In the central casing *G* there is a smaller spring which acts on the central sleeve. If this spring is tightened the speed and energy of the governor are increased without in any way altering the degree of speed variation. If, on the other hand, the adjustment of the horizontal spring *D* is changed, the degree of variation is increased or decreased.

The governor illustrated in Fig. 26 is adapted for engines running at one speed only. When a considerable range in speed is desired, the central spring is replaced by two, as shown in Fig. 27, the two being adjustable simultaneously by means of the handwheel *A* actuating the gears *C C* through the central gear wheel *D*.

In Fig. 28 is illustrated a Hartnell governor. This is of the spring type and is very largely used. At *B* are pivoted the weights *A*, formed in one piece with the arms *C*, to the end of which are fixed rollers engaging a sleeve *D*; the latter slides on the vertical spindle *E*. The main governor spring is of the compression type, and is fitted between the sleeve and the cap *F*, to which are cast the lugs carrying the fulcrum pin *B*. Governors of this design are powerful and at the same time can be made very sensitive, in many instances the actual speed variation does not exceed 1 per cent.

For ordinary purposes, where an engine is only required to run at one speed, this arrangement of the governor is adequate. But where it is desired to vary the speed of the governor within moderate limits a spring is attached, as shown at *A*, Fig. 29. When the governor is used for actuating an expansion gear which will throw a reciprocating force on the governor, a dashpot is necessary; also, governors fitted to engines driving irregular loads, such as for rolling mills, etc., must not be very sensitive, and are better fitted with dashpots.

In cases where not only the speed of the governor has to be varied, but also the sensitiveness, it is necessary to vary the point of attachment of the spring. This is effected as shown at *A*, where the speeder spring is attached to a sliding block fixed to the arm, its position being adjusted by means of the small handwheel *C*.

In a few difficult cases, such as where the flywheel of an engine is small, or where there is a compound engine with a throttle valve, or with large intermediate space, or both, and where at the same time the mean speed of the engine must not vary to any extent, the governor spring is generally arranged to give a variation of, say 1½ per cent. from the mean speed. In addition there is a spring connected to the dashpot, as shown at *B*, and calculated to cause about 5 per cent. variation from the mean speed. Then, if the load be instantly taken off, the governor is at first controlled by the outer and inner spring and a considerable variation of load may take place, but as the dashpot yields the outside spring ceases to act and the engine returns to the mean speed, due to the governor only. In this case the dashpot also has a regulating screw.

All governors of the Hartnell type when used for electric-lighting purposes and where sensitive governing is required for considerable periods without stopping, are fitted throughout with ball bearings.

Modern Coal and Ash Handling System

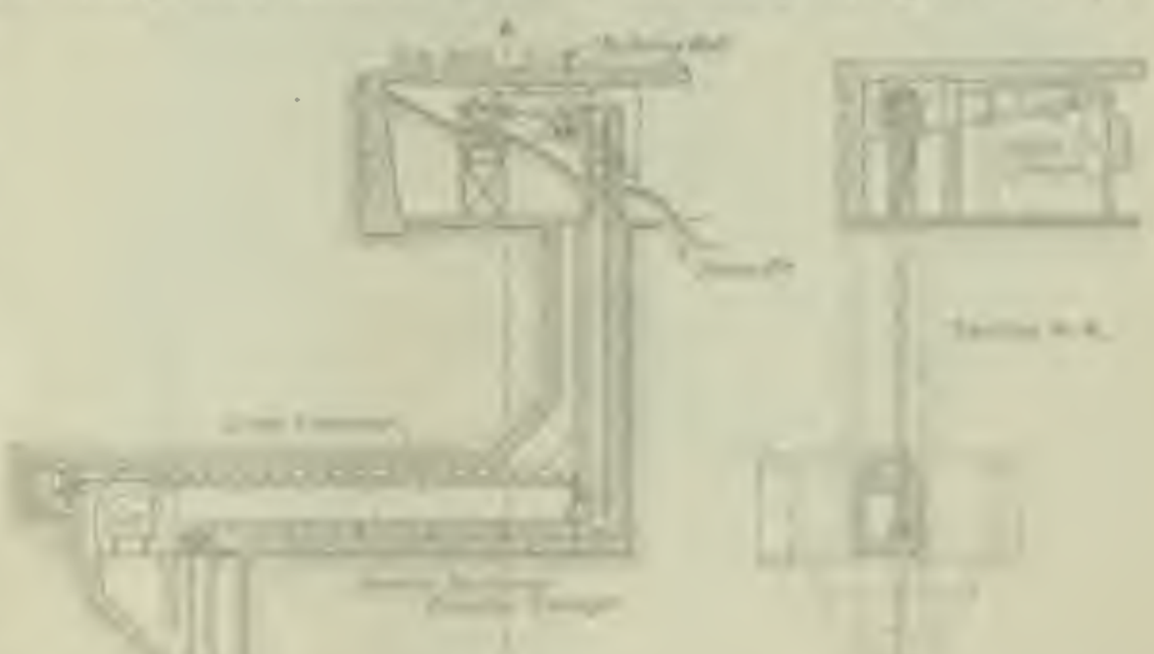
A combination coal and ash handling equipment taking coal from tunnel cars 45 feet below the street level and delivering it to the boiler room of an office building.

In the boiler room of the Merchants' Loan and Trust Company building, of Chicago, there has recently been installed a system of coal and ash handling which, although in a cramped space, shows a good efficiency.

The coal is delivered to the building in steel cars traveling in a branch of the Illinois tunnel 45 feet below the street level; these cars discharging into a concrete pit, from which the coal is taken by a gravity-discharge bucket elevator and conveyer. This machine is equipped with V-shaped buckets secured every 2 feet with malleable-iron attachments, to two endless conveyer chains; the speed of the buckets, when in operation, being 100 feet per minute. Referring to the illustration, it will be noted that the buckets, when traveling horizontally, push the material along in a steel trough and, when traveling vertically, automatically adjust themselves and lift it as does a bucket elevator.

The machine first lifts the coal 12 feet to the tunnel level, and conveys it to a point 30 feet away where it is again lifted 35 feet to the boiler room and discharged into the trough of a flight conveyer running at right angles to and in front of the boilers. The latter conveyer consists of a single endless chain running over two sprockets, placed at 30-foot centers and mounted on a steel frame. Fastened to the chain are steel flights, 2 feet apart, which, on the lower run, push the coal along in a trough. The coal is discharged through an opening in the trough and spouted to the storage pile in front of the boilers.

The present boiler equipment necessitates firing by hand, hence the storage pile. It is intended, however, to install new boilers equipped with mechanical stokers and the same conveying system will be adaptable to the new arrangement. The short flight conveyer will be removed and the gravity-discharge conveyer will be run up over the boilers and discharge into a 200-ton storage hopper, thence down and under the boilers where it will receive the ashes and convey them to the grating above the concrete chute shown in the illustration. The single machine will then be delivering the coal and hauling away the ashes in the most efficient manner possible, and this will practically do away with all manual labor in handling coal and ashes.



Elevation of Conveyor

At the present time the ashes are shoveled onto a grating through which they pass into the concrete chute, discharging into a special 16-inch cast-iron screw conveyer; this, in turn, conveys the ashes to the tunnel, where they are delivered into cars. This conveyer is equipped with a sliding steel trough at the tunnel end, which may be run out directly over the cars.

The gravity-discharge elevator and conveyer and the flight conveyer, are both driven through two gear trains by an electric motor, which is fitted with a rawhide pinion to eliminate the noise.

The present equipment is capable of handling 40 tons of coal per hour and was designed and manufactured by the Stephens-Adamson Manufacturing Company, of Aurora, Ill.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Jones; Trouble Killer

Second Talk on Power Factor

"Now this matter of power factor is simple enough," said Jones, when he and the engineer got back from dinner, "when you once get the hang of it, but I'll admit that it isn't easy to get the hang of it."

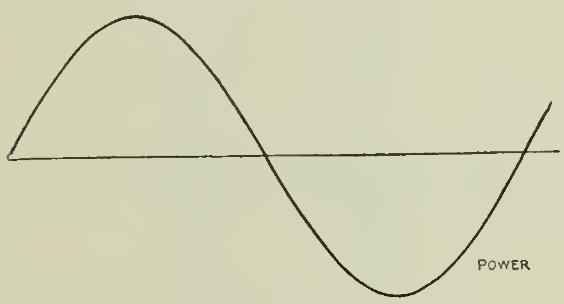


Fig. 2.

He fished out his loose-leaf book and turned over to a page of diagrams. Pointing out one that looked like Fig. 2, he said:

"You know what that is, of course."

"Sine curve," said the engineer, with conscious pride.

"Negative Power is Power Delivered to the Generator from the Circuit."

"Right. What does it represent?"

"An e.m.f. wave," said the engineer, swelling still more.

"What's an e.m.f. wave?" demanded Jones, regarding the engineer with a lively twinkle in his eyes.

"A—a—it's a wave of—a—wa—"

"A wave of electromotive force, eh?" suggested Jones with good-natured sarcasm. "It naturally wouldn't be a wave of sea water, now would it?"

The engineer rubbed his nose and dug hard into his mental recesses but they refused to deliver any inspiration. He shook his head slowly.

"I know," he said, "but I don't know how to say it."

"I know you know," said Jones, "and you know how to say it, too, but you're rattled a little, that's all. Tell me this: How many times does the e.m.f. represented by that curve rise to its maximum value?"

"Twice; once positive and once negative."

"All right. Now, what is it that is made up of a rise to positive maximum, a drop to zero, a rise to negative maximum and another drop to zero? What does that constitute?"

"One cycle."

"Of course. Then this sine curve representing an e.m.f. wave is a curve showing what?"

"The changes of pressure during one cycle," hastily replied the engineer.

"Now you're on the job," said Jones, with an approving extension of his grin. "You know that if a recording voltmeter could follow the changes of pressure exactly as they occur, it would draw a diagram like that for every cycle, don't you?"

The engineer nodded. "Just like a steam-engine indicator draws a diagram of steam-pressure changes that happen in the cylinder," he suggested.

"Correct," said Jones. "Of course, no voltmeter is sensitive enough to follow the changes of e.m.f. through a cycle, because of the inertia of its parts, and it couldn't be made to follow 'em accurately anyhow, the way voltmeters are made, even if it had no inertia. But that curve corresponds exactly to the steam-pressure curve drawn by an indicator."

"But what's that got to do with the power factor?" asked the engineer.

"Keep your shirt on; I'm coming to that as fast as you'll let me," responded Jones.

"If a recording voltmeter could be made to draw the e.m.f. curve showing the changes during each cycle," he resumed, "a recording ammeter made just like it would draw the same sort of a curve to represent the rise and fall of current in the circuit, wouldn't it?"

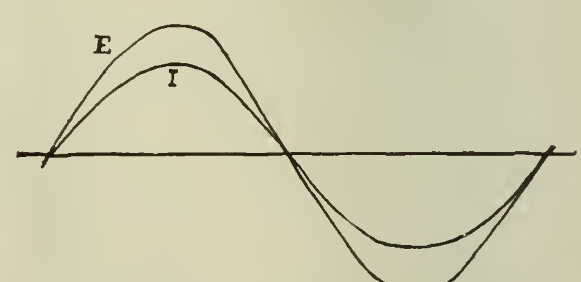


Fig. 3. Jones' Sketch

"Of course," agreed the engineer.

"And if you could arrange 'em to draw the two curves on the same sheet of paper at the same time, the diagram would look something like this, wouldn't it?" asked Jones, drawing Fig. 3.

"I dunno, but I sh'd think so," said the engineer dubiously.

"Well, it would," Jones assured him, "*provided*—now mind what I'm saying—

provided the e.m.f. and the current were in phase or in 'step' with each other."

The engineer nodded.

"But suppose the current lagged behind the e.m.f. in its rising and falling —didn't reach its highest point until after the electromotive force had passed its highest point and was falling. What kind of a diagram would your voltmeter and ammeter draw?"

The engineer brightened up. He had been rereading the old Electrical Catechism printed in POWER ten years ago and his memory was clearing.

"About like this," he suggested, drawing Fig. 4, "if the difference in phase wasn't very big."

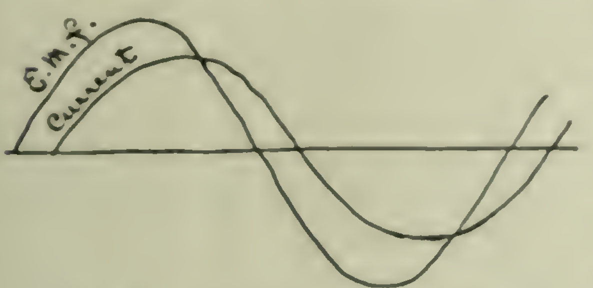


FIG. 4. THE ENGINEER'S SKETCH

"Good boy," Jones ejaculated, "you're getting close to the throne." Thumbing over the leaves of his book he pulled out another diagram, which is reproduced in Fig. 5.

"Here's a diagram of lagging current all scaled up for convenience in figuring the effects of the lag. Before going into that, though, do you understand why I've got the e.m.f. cycle scaled in three hundred and sixty divisions?"

"Because a cycle's got three hundred and sixty degrees, like a circle," ventured the engineer.

"Well, that's not exactly the right answer. A cycle hasn't any degrees, and there is no physical reason why it should be divided into three hundred and sixty any more than a hundred or a thousand or any other number. It is divided into three hundred and sixty degrees for purely mathematical reasons—merely because it makes easy figuring to consider a cycle as though it were a circle, which you know was divided into three hundred and sixty degrees for astronomical reasons."

"Dunno anything about that," protested the engineer, beginning to feel that he was over his head.

"You don't need to," said Jones reassuringly, "that's just a little off the track."

The engineer grinned. It was seldom he caught Jones in anything bordering on bad judgment and he enjoyed it.

"Well," resumed Jones, "as the cycle has been divided into three hundred and sixty degrees for scientific convenience, we may as well stick to that arrangement in talking about the physical part of the game. A half cycle, then, is what?"

"One hundred and eighty degrees," replied the engineer promptly.

"Right. Now look at my diagram and tell me how much the current is supposed to lag behind the e.m.f. in that diagram."

"Thirty degrees."

"What part of a cycle?"

The engineer scribbled on his scratch pad as follows:

$$30 \text{ degrees} = \frac{30}{360} \text{ of a cycle}$$

$$\frac{30}{360} = \frac{3}{36} \text{ and } \frac{3}{36} = \frac{1}{12}$$

"A twelfth," he announced.

"Right. Now, when the e.m.f. is at its maximum, which is a hundred and fifty volts, where is the current?"

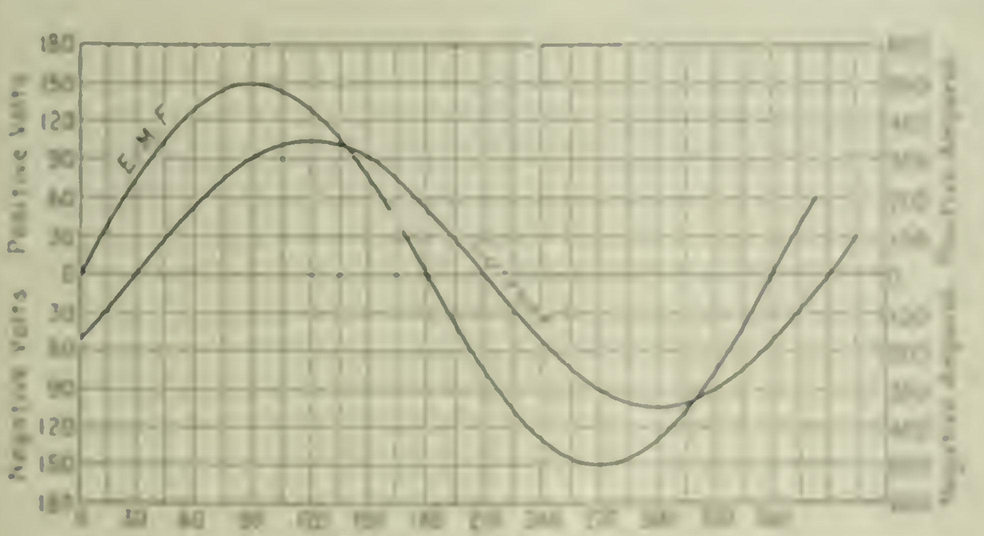


FIG. 5. E.M.F. AND CURRENT CURVES; CURRENT LAGGING 30 DEGREES

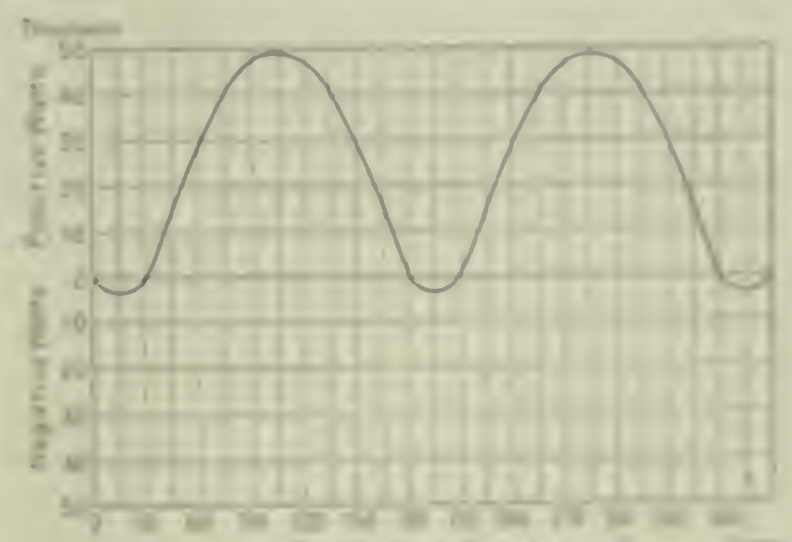


FIG. 6. POWER CURVE CORRESPONDING TO THE CURVES OF FIG. 5

The engineer scrutinized the diagram closely, and tried to find the scale value opposite which the current curve crossed the ninety-degree line.

"The current's three hundred and fifty amperes at the top o' the wave 'n' it looks like three hundred at the ninety-degree line," he said, "but I can't measure it fine enough."

Jones chuckled.

"Of course you can't," he said; "I just wanted to work you a little. Here's a list of the e.m.f., current and power values at each fifteen-degree division of the e.m.f. cycle," and he turned the diagram sheet over, showing on the back of the sheet the following table:

MOMENTARY VALUES OF VOLTAGE, CURRENT AND POWER, WITH CURRENT LAGGING 30 DEGREES

Point in the Cycle	Momentary Values		
	Volts	Amperes	Watts
Beginning	0	—175	0
At 15 degrees	+ 38.82	— 90.59	—3,517
At 30 degrees	75.00	0	0
At 45 degrees	+106.07	+ 90.59	+ 9,609
At 60 degrees	129.90	175.00	22,733
At 75 degrees	144.89	247.49	35,857
At 90 degrees	150.00	303.11	45,467
At 105 degrees	144.89	338.07	48,984
At 120 degrees	129.90	350.00	45,467
At 135 degrees	106.07	338.07	35,857
At 150 degrees	75.00	303.11	22,733
At 165 degrees	38.82	247.49	9,608
At 180 degrees	0	+175.00	0
At 195 degrees	—38.82	+ 90.59	—3,517
At 210 degrees	75.00		0
At 225 degrees	—106.07	— 90.59	+ 9,609
At 240 degrees	129.90	175.00	22,733
At 255 degrees	144.89	247.49	35,857
At 270 degrees	150.00	303.11	45,467
At 285 degrees	144.89	338.07	48,984
At 300 degrees	129.90	350.00	45,467
At 315 degrees	106.07	338.07	35,857
At 330 degrees	75.00	303.11	22,733
At 345 degrees	38.82	247.49	9,608
At 360 degrees	0	175.00	0

The engineer turned the sheet over and back several times, comparing the table with the diagram.

"Let's see," he began, a little uncertainly, "at fifteen degrees the e.m.f. is thirty-eight point eighty-two volts 'n' the current is ninety 'n' fifty-nine hundredths; multiplyin' one by the other gives thirty-five hundred 'n' seventeen watts—that right?"

"Not even warm," asserted Jones more enthusiastically than elegantly.

"But the watts go down to zero at thirty degrees from the beginning," said the engineer. "How's that?"

"What's the current at that point?" asked Jones.

"Zero—oh! You can't have any watts without both factors, of course," sheepishly. "Well," he continued, "what's a power table but it don't tell me much about power factor."

"It will if you look at this diagram at the same time," said Jones, producing Fig. 6. "That curve is what you'd get if you plotted the momentary power values given in the fourth column of the table."

"What do the little loops below the zero line mean?" asked the engineer.

"Negative power;" replied Jones, "that is, power that is delivered to the generator from the circuit."

The engineer stared at him, dumfounded.

"Look at the other diagram," said Jones. "During the first thirty degrees of the cycle the current curve is below the zero line, isn't it?"

"Yes."

"And the voltage curve is above, isn't it?"

"Yes."

"Well, what do those locations mean—what polarities?"

"Positive above and negative below," promptly.

"Right. Now, if you multiply a positive quantity by a negative quantity the product is negative, isn't it?"

"Yes, but ——"

"Never mind butting. Positive volts multiplied by negative amperes make negative watts. Negative watts mean power transferred from the line to the generator. Now look at the table and tell me what the maximum watts are during the first thirty degrees."

"Thirty-five hundred and seventeen," replied the engineer.

"That's negative power," said Jones, "that's why it's fenced off from the rest of the figures with the line across the table. You'll find another period of negative power during the first thirty degrees of the second half of the cycle; that's ruled off, too."

The engineer scanned the table and compared the diagrams with it.

"Then from the beginnin' of the cycle to the thirty-degree point the power's negative," he ventured inquiringly; "from there to the one hundred and eighty-degree point it's positive; from one hundred and eighty to two hundred and ten degrees it's negative again, and positive the rest of the cycle?"

Jones dealt him an approving thump on the back and nearly cut his own head off with his expanding grin.

"You're commencing to show signs of human intelligence again," he said. "Now tell me what's the biggest value of positive watts in the table."

"Forty-eight thousand nine hundred and eighty-three," replied the engineer, "and it happens at one hundred and five 'n' two hundred and eighty-five degrees."

"Right you are. Now what's the *average* positive watts?" he demanded, regardless of grammar.

"D'you mean the effective value?" asked the engineer.

Jones nodded.

"Forty-eight thousand nine hundred and eighty-three multiplied by point seven nought seven," began the engineer ——

"Hold on; the effective watts aren't figured that way," said Jones.

The engineer scratched his head and studied Jones' countenance for enlightenment, without success.

"Ain't the effective voltage seven-tenths of the maximum voltage?" he asked.

"It sure is," agreed Jones.

"Then ain't the effective power seven-tenths of the maximum power?"

"It sure is *not,*" said Jones.

"Give it up then," said the engineer in disgust. "I thought I did know that."

"You won't give it up, either," said Jones. "Suppose, for a moment, that the current and e.m.f. were in phase. The maximum watts would be figured how?"

"Maximum volts multiplied by maximum amperes."

"All right. Now reduce 'em to effective values."

"Effective watts are effective volts times effective amperes."

"Go on; what are effective volts and effective amperes?"

The engineer searched his partly confused brain. Then he got his pad and scribbled as follows:

effec. volts = 0.707 × max. volts
effec. amps. = 0.707 × max. amps.
Effec. watts = effec. volts × effec. amps.
Effec. volts × effec. amps. =
0.707 × max. volts × 0.707 × max. amps.

and submitted it to Jones.

"Correct," said that cheerful person. "Now multiply your two numbers together to make one factor of 'em."

So the engineer proceeded as follows:

0.707 × 0.707 = 0.5
Effec. watts = 0.5 × max. volts × max amps.
" " = 0.5 × maximum watts.

"Well I'll be ——"

"You probably will, sooner or later," interrupted Jones. "Now, get a move on you and follow out the power-factor business. Effective watts are equal to ——?"

"Half of the maximum watts."

"Then in the two diagrams and the table the effective positive power is what?"

"Half of forty-eight thousand nine hundred and eighty-three ——" scribbling on his pad —— "Twenty-four thousand four hundred and ninety-one and a half watts."

"Put it down on a clean spot. What's the effective negative power?"

"Half of thirty-five hundred and seventeen ——" more scribbling——"Seventeen hundred and fifty-eight and a half watts."

"Put it down under the other figure—that twenty-four thousand and something. Now don't you see that if the generator delivers power to the circuit part of the time and the circuit delivers power to the generator part of the time, the watts that get to the lamps and do work in the motors are the difference between the two?"

"It looks that way," admitted the engineer, thoughtfully gazing at the table and the diagrams. "But I don't get that power-factor thing yet."

"You're 'most there now," said Jones encouragingly. "Subtract the effective negative watts from the effective positive watts."

The engineer made the subtraction and showed the following to Jones:

24,491½
1758½
22733

"All right. Remember that's the real power—the true watts actually delivered to the circuit and requiring mechanical power to drive the generator. Now, the maximum voltage is one hundred and fifty and the maximum current is three hundred and fifty amperes; what is the *apparent* power in the circuit—the effective volt-amperes?"

The engineer made the following calculation:

350 max. amperes
150 max. volts
17500
35
2)52500 max. volt-amperes
26,250 effec. volt-amperes

"Twenty-six thousand two hundred and fifty volt-amperes; good. That, you understand, is what you mean when you talk about apparent power in a circuit."

The engineer nodded. "And the power factor's the real power divided by this," he said.

"You're on," said Jones, "figure it out."

The engineer divided 22,733 by 26,250.

"Eight hundred and sixty-six thousandths," he announced.

"Express that as a percentage and it's your power factor," said Jones.

The engineer fidgeted uncomfortably.

"What's the matter?" asked Jones.

"How do you express thousandths as a percentage?" asked the engineer.

"What does per cent. mean, baby?" demanded Jones somewhat impatiently.

"Per hundred," answered the engineer.

"Well, if you have eight hundred and sixty-six parts out of a thousand, how many is that per hundred?"

"One-tenth as much."

"Well?"

"Eighty-six and six-tenths?"

"Of course. Write it down in fractional form and you'll see it plain as the nose on your face."

So the engineer wrote:

$0.866 = \frac{866}{1000}$

and $\frac{866}{1000} = \frac{86.6}{100.0}$

and $\frac{86.6}{100} = 86.6$ per cent.

"Now," said Jones, "look at the table; tell me what the current is when the voltage is at its highest point?"

"At ninety degrees," said the engineer, following down the columns of the table with his finger, "the voltage is one hundred and fifty and the current is three hundred and three and eleven-hundredths."

"And your highest current is ——?"

"Three hundred and fifty amperes."

"All right. Divide three hundred and three and eleven-hundredths by three hundred and fifty and tell me the answer."

The engineer performed the division, hesitated, glanced at Jones and then went over the division again to make sure he was right.

"Well," he said, "it's the same as the power factor, but I don't see why."

"Just think what it means," advised Jones. "When you divided the momentary current that exists when the voltage is maximum by the maximum current, you got the same result as when you divided the true watts by the volt-amperes, didn't you?"

The engineer agreed that he did.

"Then it follows that *the power factor is the proportion of maximum current which exists when the voltage is at its maximum.* See?"

The engineer saw.

"Yes;" he said, "it's coming through slow. If the voltage and current were in step like this," indicating Fig. 3, "they'd reach the top at the same time, and you'd get all the power there was ——."

"Careful," cautioned Jones, "you get all the power there is anyhow, but the power used in the circuit is greatest when the voltage and current are in step. When they are not, the power is less because the product of momentary volts and amperes at any point in the cycle is less than it would be if they were in step."

"I can see that," said the engineer, "by lookin' at the thirty-degree point in this diagram," taking up Fig. 5. "The current's zero here at thirty degrees but if they were in step it would be something, anyhow—I dunno how much."

"Right you are," said Jones. "It would be one hundred and seventy-five amperes at that point. Now get your tables of sines, cosines and so on."

The engineer took a copy of Trautwine from his bookshelf.

"Find the cosine of thirty degrees," directed Jones.

"Naught, point, eight, six—well, I'll be hornswaggled," exclaimed the engineer, "that's the power factor of this diagram, too. How many more things figure out that way?"

Jones grinned.

"You knew that before," he said, "but you've forgotten most of your early training. How many degrees is the current behind the e.m.f. in that diagram?"

"Thirty."

"And the cosine of thirty degrees is naught, point, eight, six, six, isn't it?"

"Yes, and so's the power factor," said the engineer.

"Of course. The power factor of any circuit or machine is the cosine of the number of degrees by which the current lags behind the e.m.f. That is called the angle of lag, for mathematical convenience."

"But you just said the power factor was the proportion of maximum current that exists when the voltage is maximum," protested the engineer.

"So it is," said Jones. "Didn't you just figure it? That's the physical definition of it; this cosine business is the mathematical definition, and connecting the two gives you this rule: *The cosine of the number of degrees by which the current lags behind the e.m.f. is the proportion of maximum current that exists when the voltage is maximum; it is therefore the power factor.*"

The engineer gasped.

"That's an awful mixup of words to remember," he said feebly.

"Surest thing you know," agreed Jones, with bland indifference. "Don't try to remember 'em; put 'em down where you can get at 'em when you want to, sort of like a formula, so: Power factor is equal to cosine of the angle of lag; also equal to proportion of maximum amperes that exists momentarily when voltage is maximum."

"Well," said the engineer, writing the rule on the fly leaf of his copy of Foster's "Pocketbook," "I ain't quite sound on that angle of lag business."

"Give you that some other time," promised Jones, removing his heels from the engineer's desk and reaching for his data sheets.

"Wait a minute," said the engineer, pointing at the small loops in Fig. 5. "You didn't tell me how that negative power gets back from the circuit into the generator."

"That's another story and a long one," answered Jones, replacing the diagrams in his book, "and I've got to get over to Uniontown this afternoon. So long."

Railroad cars loaded with snow are not an unusual sight at crowded terminals where it is necessary to ship the snow out in order to dispose of it. One of the disadvantages of snow shipments has been the necessity of unloading the cars. The Illinois Central has, however, discovered a unique method of dealing with the unloading problem. They ship the snow far enough South to melt it on the way. The empty cars used in this manner are ready to bring coal back to Chicago at the termination of their Southern trip, so that the work of unloading the snow is dispensed with.

Storage Batteries in Alternating Current Stations

By W. H. Radcliffe

The storage battery from the very beginning of its commercial career in the early eighties has been a direct-current station adjunct, and only within the last decade has it become useful in strictly alternating-current stations. Its chief value in this important but rather unusual field lies in its reserve power being used as a protection against the failure in supply of the direct current used to excite the field magnets of the alternators. Although the direct-current dynamos used as exciters in alternating-current stations seldom go wrong, the increasing seriousness of an interruption in service makes it advisable to leave no stone unturned to insure continuous operation. Under modern conditions of everyday life an interruption of lighting or power current may produce public calamity; that is why central-station managers strive to provide against the possibility of even a temporary shutdown.

In the large power stations built within recent years the parallel and independent groups of coal compartments, boilers, pumps, engines, generators and switchboard panels have become characteristic features. Considering here merely the provision made for insuring against exciter breakdown, it might appear at first thought that the addition of one or two reserve direct-current machines would be preferable to installing the more expensive storage battery of equal capacity, and this would be the case where shutdowns of short duration would be tolerated, as in small power stations carrying light loads; but in a large station the reserve machines, if installed, would have to be kept in motion continuously in order to insure absolutely uninterrupted exciter service in case the regular exciters failed.

With a storage battery permanently "floated" across the exciter busbars, the instant an exciter breaks down the battery automatically comes to the rescue, so that the current supply is not interrupted at all. The exciting voltage may fall slightly on account of the drop in the battery when it first takes up the load, but the voltage can quickly be brought up to normal by advancing the number of active end cells or by means of the alternator field rheostats.

Storage batteries for use in the manner described may be of either the Faure (pasted plate) or the Planté type. The pasted plate retains its charge remarkably well when used only occasionally, costs considerably less and occupies less space than the equivalent Planté plate. Owing to its smaller weight and bulk it is also cheaper to install.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Compression and Expansion Ratios

By Cecil P. Poole

What is the compression ratio of a gas engine? What is the expansion ratio? Nearly every man operating one probably thinks he knows the answer until he "gets down to brass tacks" and starts to give it. The compression ratio is not the clearance percentage, nor the ratio of compression to admission pressures; nor is it anything else except a simple ratio of volumes. The expansion ratio is also a ratio of volumes.

Compression Ratio

If you measure the cubic inches of space in front of a piston when it is ready to begin the compression stroke, then measure the cubic inches of space between the piston and the cylinder head when the compression stroke is completed, then divide the larger volume by the smaller, the result will be the compression ratio. That is all there is to it. It is not affected by valve setting, mixture variation or any other adjustment unless the adjustment changes the length of piston stroke or the volume of the clearance space.

For example, suppose the volume under the piston shown in Fig. 1 to be 12 cubic feet and that the piston is forced downward until the volume under it is reduced to 2 cubic feet, as indicated in Fig. 2. Dividing the volume before compression by the volume after compression gives

$$\frac{12}{2} = 6$$

which is the compression ratio.

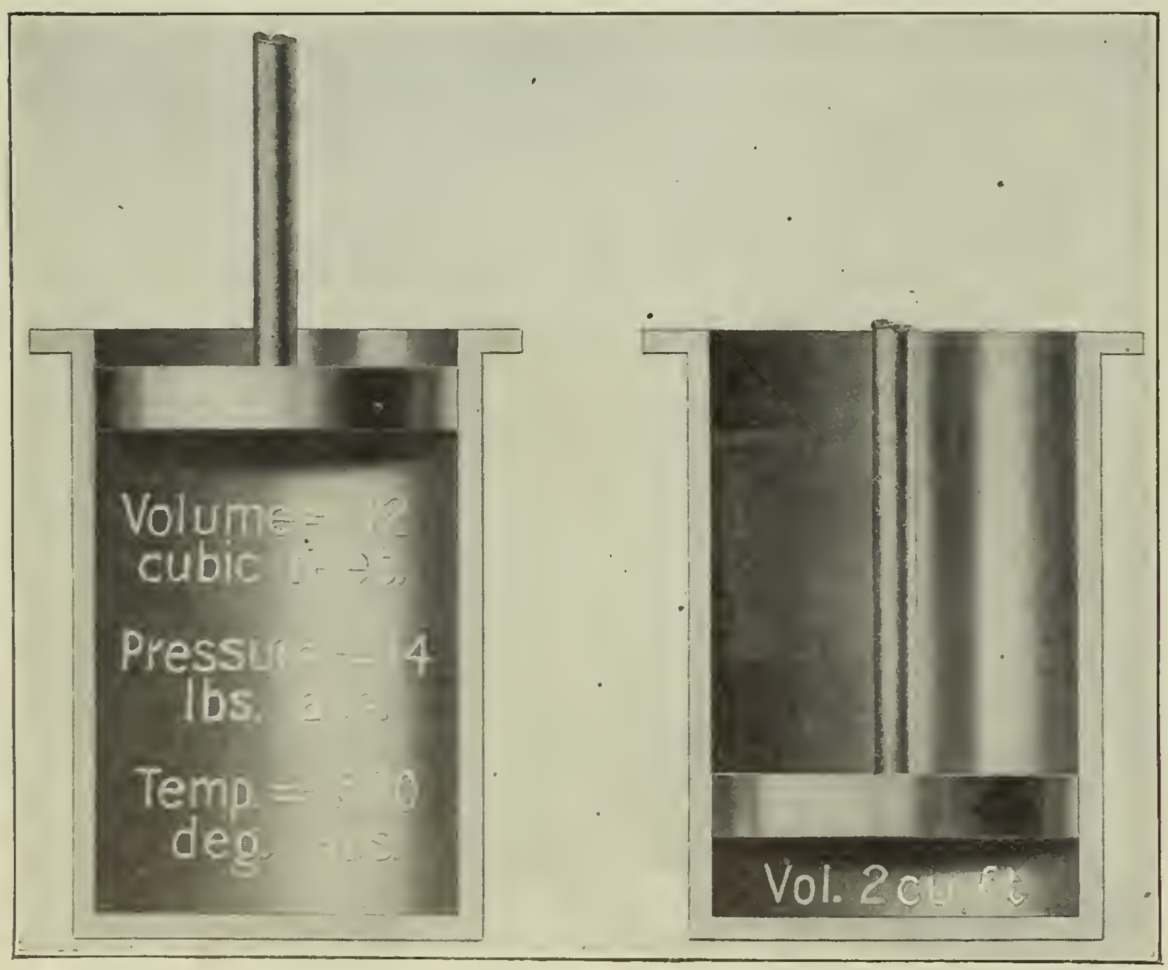


Fig. 1. Maximum Volume Fig. 2. Compressed Volume

If the pressure in the cylinder is 14 pounds absolute (0.7 of a pound below atmospheric) before compression it will be increased to about 150 pounds at the end of the compression stroke, if no more heat escapes through the wall than is usual with gas engines. The temperature will also increase, but not so greatly as the pressure; if the absolute temperature is 500 degrees absolute before compression it will be about 900 degrees absolute after compression. But the pressure and temperature changes do not affect the compression ratio; they are *results* of it.

In the case just assumed, the compression ratio is 6, the pressure ratio due to compression is about 10.7 and the temperature ratio about 1¾. Under certain operating conditions, however, the pressure ratio could easily be 9½ or 10 and the corresponding temperature ratio 1.59 or 1.67, although the compression ratio would remain 6.

Expansion Ratio

If the exhaust valve opened at the end of the piston stroke instead of a little in advance of the end, the expansion ratio would be exactly the same as the compression ratio because the cylinder volumes at the ends of the stroke are the same in both cases. In other words, the volume of gases would increase exactly as much during expansion as it decreased during compression. If four cubic feet were compressed to one, then the one cubic foot would expand to four during the outstroke.

For example, if the cylinder in Fig. 2 contained a mixture of gas and air and the mixture were lighted with the piston in the position shown and the crank on the dead center, the pressure and temperature would rise rapidly—almost instantaneously. As soon as the crank passed the dead center the gases would push the piston outward, and if the exhaust valve opened wide when the piston reached the position in Fig. 1, at which compression began, the expansion ratio would be

$$\frac{12}{2} = 6$$

exactly equal to the compression ratio.

The exhaust valve does not open at the extreme end of the expansion stroke, however, and the expansion ratio therefore is less than the compression ratio in all modern engines working on the four-stroke cycle.

Fig. 3 illustrates this difference. At *A* the piston is shown at the beginning of the compression stroke; at *B* it is at the other end of the stroke, the crank then being on the opposite dead center; at *C*, just before the piston reaches the end of the outward stroke, which is indicated by the dotted line, the exhaust valve is supposed to open.

The volume in the cylinder at *A* (represented by the symbol V_a) is assumed to be 0.45 of a cubic foot; at *B* it has been reduced by compression to 0.1 of a cubic foot, making the compression ratio

$$\frac{0.45}{0.1} = 4\tfrac{1}{2}$$

When the piston moves outward from the B position to that at C, where the exhaust valve opens, the volume V_c (0.1 of a cubic foot) increased to V_e, which measures 0.41 of a cubic foot. The expansion ratio, therefore, is mechanically

$$\frac{0.41}{0.1} = 4\tfrac{1}{10}$$

Effectively, it is a little greater because the exhaust valve does not open wide all at once and even when it is wide open the port is not large enough to allow

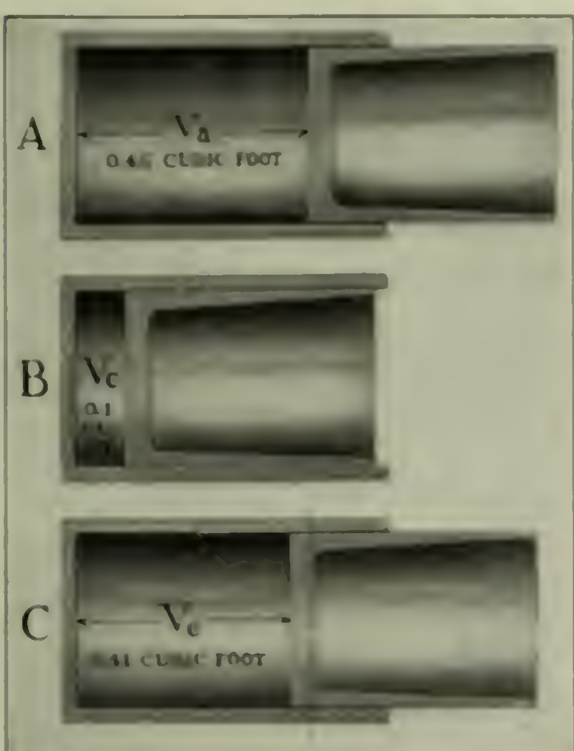


FIG. 3. ILLUSTRATING DIFFERENCE BETWEEN COMPRESSION AND EXPANSION RATIOS

the gases to fall instantaneously to atmospheric.

RELATION BETWEEN COMPRESSION AND EXPANSION RATIOS

However, the effect of the exhaust valve's movement may as well be ignored just now. The important fact to be remembered is that the compression and expansion ratios are "tied together," hard and fast, in the ordinary four-stroke engine.

Referring to Fig. 3 again, suppose the stroke of that engine were increased one-seventh. As it is represented here, the piston displacement is 0.35 of a cubic foot, the clearance being 0.1 and the maximum volume (displacement + clearance) 0.45 of a cubic foot. If the stroke be increased one-seventh without changing anything else, the piston displacement will be increased from 0.35 to 0.4 of a cubic foot. The maximum volume (displacement + clearance) will then be

$$0.4 + 0.1 = 0.5,$$

or one-half cubic foot and the compression ratio will be increased to

$$\frac{0.5}{0.1} = 5.$$

If the exhaust valve opens when the piston has traveled the same percentage of its stroke as in the first case, the volume V_e will be 0.4543 of a cubic foot and the mechanical expansion ratio will be

$$\frac{0.4543}{0.1} = 4.543$$

as compared with 4.1 in the first case.

In other words, the expansion ratio in the first case was

$$\frac{0.41}{0.45} = 0.91$$

(or 91 per cent.) of the compression ratio; in the second case, the expansion ratio is

$$\frac{0.4543}{0.5} = 0.909$$

(or practically 91 per cent.) of the compression ratio.

The only way in which the relation between the compression and expansion ratios can be changed appreciably is by altering the timing of the exhaust-valve opening. If the exhaust valve opens in all cases when the piston has traveled the same percentage of the expansion stroke, the relation between the expansion and compression ratios must remain practically constant no matter what the compression ratio may be. With a compression ratio of 4 and the exhaust valve opening at nine-tenths stroke, the expansion ratio is 3.7, or 92½ per cent. of the compression ratio; with a compression ratio of 8, which is seldom if ever used, the expansion ratio would be 91¼ per cent. of the compression ratio.

In other words, the ratio of expansion to compression is only 1.35 per cent. smaller with a compression ratio of 8 than it is with one-half that ratio. Moreover, instead of obtaining a relative increase in expansion, which would give lower release pressure and temperature, the increase in expansion is less than the increase in compression, so that the pressure and temperature at release would be higher, notwithstanding the increase in the expansion ratio.

With the same compression ratio and the same exhaust-valve timing, the relation between the compression and expansion ratios is absolutely unchangeable, no matter what the size of the cylinder, relation of stroke to bore, or other features or conditions. It is impossible to obtain a greater expansion of gases unless the compression is increased and if that is done, the temperature and pressure of the gases at the moment of release will be raised.

EXAMPLES

To illustrate by figures instead of reasoning, suppose there were three gasoline engines, one 4x4 inches with a compression ratio of 3½; one 4x5 inches with the same ratio and one 4x4 inches with a ratio of 4. Further, suppose that all three engines work under the following conditions:

Pressure in cylinder before compression	[illegible]
Compression-curve exponent	[illegible]
Rise of pressure due to combustion*	[illegible]
Expansion-curve exponent	[illegible]
Portion of expansion stroke completed when exhaust valve opens	[illegible]

A normal cycle in the three cylinders would work out about as follows:

Engine	A	B	C
Bore and stroke	[illegible]	[illegible]	[illegible]
Piston displacement, compression	[illegible]	[illegible]	[illegible]
Clearance volume	[illegible]	[illegible]	[illegible]
Compression ratio	[illegible]	[illegible]	[illegible]
Compression pressure†	[illegible]	[illegible]	[illegible]
Rise by combustion	[illegible]	[illegible]	[illegible]
Maximum pressure	[illegible]	[illegible]	[illegible]
Piston displacement, expansion	[illegible]	[illegible]	[illegible]
Expansion ratio	[illegible]	[illegible]	[illegible]
Release pressure	[illegible]	[illegible]	[illegible]

The comparison between A and B shows some of the results of increasing the stroke without changing the compression; the expansion ratio is not changed and, as the compression ratio is unchanged, the explosion pressure is also unchanged, giving exactly the same release pressure as before.

The comparison between B and C shows that increasing the compression by making the clearance smaller (the bore and stroke remaining the same) increases the expansion ratio, but it also causes the explosion pressure to go higher; consequently the greater expansion does not produce a lower release pressure. On the contrary, it is slightly increased.

The only way by which the expansion ratio can be made greater than the compression ratio is by making the compression stroke shorter than the expansion stroke. Although this is impractical mechanically, as the natural death of the Atkinson engine has demonstrated, the compressor effect of a shortened stroke can be obtained by holding the inlet valve open during the first part of the compression stroke and forcing some of the mixture out of the cylinder, or by cutting off the admission of mixture before the suction stroke is completed, as in the Sargent engine. Without the use of some such unusual method of operation the ratio of expansion must be slightly less than the ratio of compression in all engines working on the four-stroke cycle.

*The rise of pressure is greater with high compression than with low because [illegible]

†Since the exponent of the compression curve is taken at [illegible] [illegible]

[illegible]

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Water Hammer Burst Valve

A serious case of water hammer, caused by carelessness, occurred in the boiler room of a Government building in Washington, D. C., some time ago, which burst a 6-inch angle-stop valve on one of the boilers, seriously injuring a coal passer.

Orders had been given to an extra man on duty to slowly fire up No. 1 boiler, which had been out of service several weeks for repairs, and at the time he went off duty 20 pounds pressure showed on the gage. The 9-inch header passes over the front of the boilers, each of which is connected by a 6-inch long bend with a gate valve, without a bypass at the header, and a 6-inch angle valve at the boiler, both of which were shut when the fire was started.

The gate valve is 4½ inches lower than the globe valve, and such is the arrangement on all the boilers, and it is supposed that the section of pipe between the two valves was partly full of water.

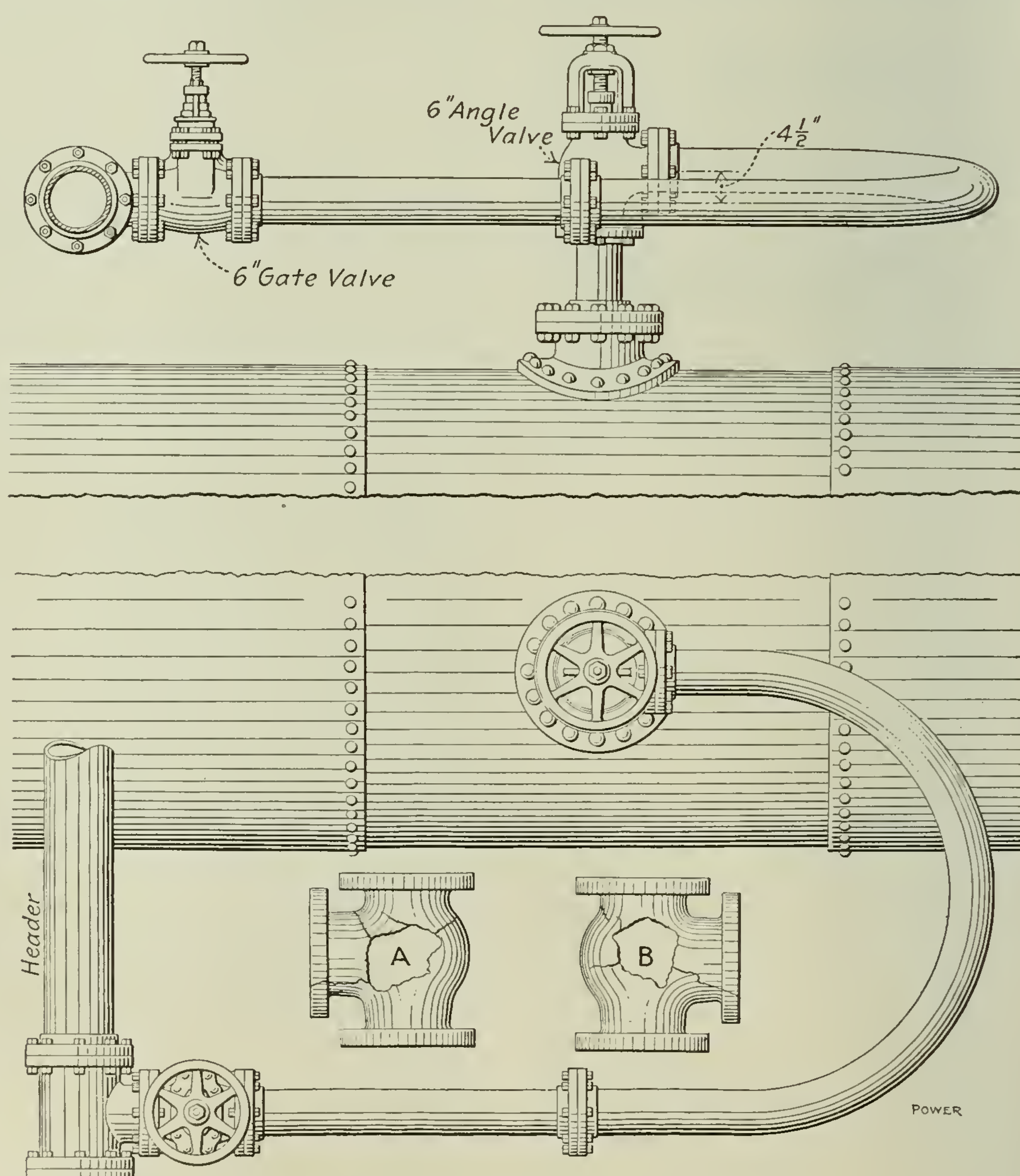
Soon after the extra fireman went off duty, orders were given to the coal passer, who, by the way, was an ignorant colored man and had only been employed in the boiler room a short time, to go up and open one of these valves. Instead of opening the angle valve as he should have done, he opened the gate valve about two turns when a violent water hammer was heard by the fireman, who told him to shut the valve, but for some reason he opened it wider and the second or third hammer burst the angle valve, as shown at *A* and *B*, the unshaded portion being the shape of the piece that was broken out of either side. The coal passer was knocked off the boilers and badly bruised and burned.

All of the boilers were connected to the header in the same manner, as shown in the figure, and without a bypass or bleeder between the valves.

In cutting out a boiler it has been customary in this plant to close both valves on the branch and to open the angle valve when the fire is first started to raise steam, but in this case it was overlooked by the fireman and the boiler was cut into the line by means of the gate valve. Even with the angle valve open the pipe will not drain, because it is 4½ inches lower at the header than at the angle valve. This leaves a pipe full, or nearly so, of water, the result being that the water goes into the steam line when the gate valve is opened and there is danger of breaking the 9x9x6-inch tee. The gate valve should never be closed except in case of emergency or repairs to the angle valve and the boiler should be cut in by means of the angle valve only.

J. Case.

Hyattsville, Md.



Arrangement of Piping and Valves

Connecting Ammonia Compressors

I am engineer in a refrigerating plant and a consulting engineer advised me to connect a 50-ton and a 35-ton machine to one condenser.

The large machine compresses through a 2-inch, three-way valve into a 2-inch header; the coils are also of 2-inch pipe. The small machine has the same size discharge pipe expanded into a 5-inch header at the condenser and does better work than the large machine.

Will these machines do good work if they are connected to the same condenser through the 2-inch, three-way valve? The condenser has a capacity of 54 cubic feet.

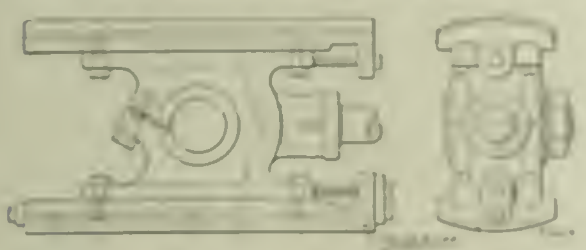
H. S. Free.

Harrisburg, Penn.

Loose Crosshead Shoe

The crosshead shoe of a large steam engine worked loose one night while the engine was carrying the peak load. As this was the main engine it was necessary to repair it at once.

I disconnected the shoe from the crosshead and drilled six 1½-inch holes through the babbitt and shoe body, and countersunk the holes in the babbitt with a drill ground for the job. Next, some copper rivets were made with which to rivet the babbitt to the shoe, as shown.



How Shoe was Fixed

To make sure of the job, two stops were made and fastened to the shoe, each overlapping the babbitt about ½ inch.

This repair job proved very effectual and is still doing as good service as when repaired six months ago.

R. E. Cooper

Cleveland, O.

Damper Regulators

I would be glad to hear from experienced engineers as to what has been found the best practice regarding the use of damper regulators.

In some cases, equipment of this kind is, no doubt, essential to good economy in boiler-plant operations and I would like to know what conditions would justify such an installation.

Some time ago, I consulted one engineer on this subject who stated that there are certain kinds of operation and conditions where regulators would be detrimental rather than otherwise, citing as an instance a boiler plant supplying steam to hoisting machinery where steam at a maximum pressure and volume is needed very quickly and at irregular intervals. He believed that a regulator in such a case would not operate quickly enough to be of any benefit.

Then, again, there are plants that supply steam to electric generating engines having constant loads where no great surges of steam occur and where there is no necessity for the safety valves blowing off.

I can readily see the advantage of proper damper regulation where there are a number of steam consumers scattered throughout a plant driving mill machinery that has varying loads and that uses a maximum amount of steam only intermittently. In such a case it would be rather difficult to maintain a constant steam pressure in the boilers without such an equipment.

[illegible]

Pittsburg, Penn.

Boiler Setting and Steam Jet

I would like to know the opinion of engineers regarding my boiler setting which is illustrated in the accompanying sketch. Could I burn anthracite coal with any degree of economy? Run-of-mine coal is used and the analysis shows 12,880 B.t.u. per pound; it costs $2.70 a ton, delivered at the plant. Anthracite pea coal will cost $5.40 a ton, delivered, or double the cost of bituminous. Will a ton of the Pennsylvania anthracite pea coal produce as much heat as a ton of bituminous run-of-mine coal?

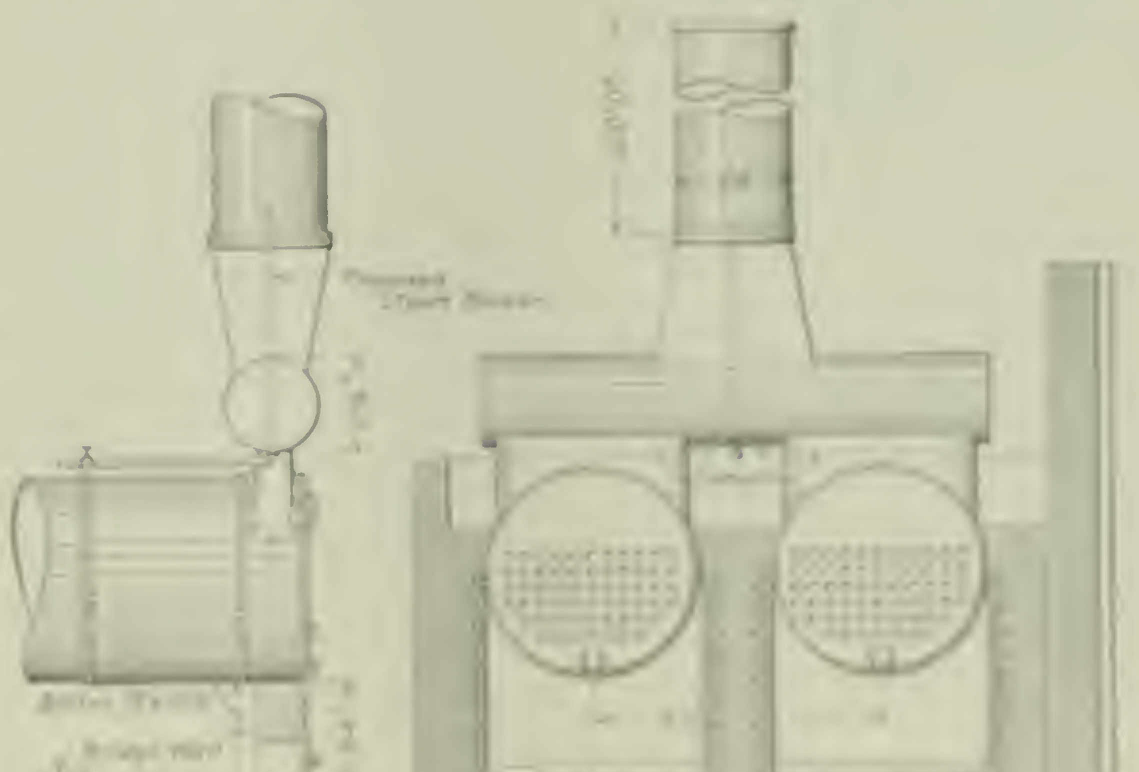
There is not much chance to make a saving in fuel, as the plant only operates about three months each year, but as the factory puts up a food product, I would like to burn anthracite coal so as to do away with the smoke, soot and dust of bituminous coal.

I would also like to see suggestions published on how to keep a boiler room clean. I use a tube blower, and it does good work as far as cleaning the flues is concerned, but it blows soot and fine ashes all over the room every time it is used. Our fronts do not fit very tight and I thought possibly a good steam blower in the stack would create enough draft to overcome the trouble. If so, how large should the steam pipe be; should it have a jet around the nozzle the same as the exhaust on locomotives, or will the nozzle in the uptake be sufficient?

I have a large, well ventilated boiler room and I like to see things kept neat and clean, but I want to let the fireman have time to read or otherwise employ himself instead of cleaning fronts all the time. I do not have to crowd the boilers. When the plant is working up to capacity, I burn from 10 to 12 tons in 24 hours.

F. B. DeMotte

Washington, Ill.



Showing Boiler Setting and Steam Jet Arrangement

Scale in the Exhaust Pipe

There is a large open heater in the plant I am in charge of, that is fitted with the usual baffle plates for the water to flow over. The exhaust entrance was about midway between the heads and discharged to the atmosphere through a 6-inch pipe.

Soft scale collected very fast in the heater and had to be thoroughly cleaned out once a month. An overflow pipe connected at the bottom and extended above the water line. In case of a back pressure in the heater the water would blow out of this pipe as soon as the scale began to form in the openings through the heater. If a sudden, heavy load was thrown on, the water would overflow; cleaning the heater would always eliminate this trouble until the last cleaning, when it failed.

The top plate in the heater was so near the top of the opening in the heater that the exhaust outlet could not be seen, and the exhaust head prevented me from looking into the other end. After closing down at night, I went inside the exhaust head and put my hand into the 6-inch pipe and found it partly closed with scale. I took the pipe down the next Sunday and found that the scale had reduced the pipe opening to a 1½-inch hole from the bottom to the top.

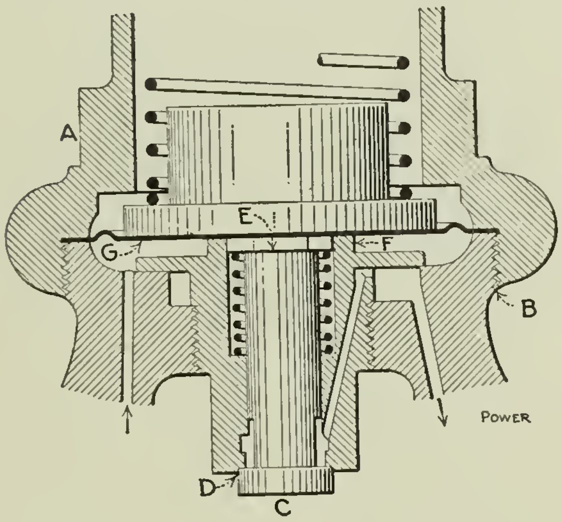
E. W. [illegible]

Los Angeles, Cal.

Reducing Valve Trouble

I once had occasion to overhaul several reducing valves which had been in use a long time. The valves were taken apart and cleaned and valves and seats reground. After reassembling them they were tested and all worked nicely with the exception of two which would not reduce the pressure in the least. These two were taken apart again and seemed to be all right, but upon a second trial they still refused to work.

With steam on the valve a wrench was put on the bonnet *A*, which was unscrewed a little, when the valve started



Sectional View of Reducing Valve

to work as it should, but steam escaped from the joint *B*.

After a little thinking I took the valves apart again and found that repeated grinding of the auxiliary valve *C* had worn down the seat *D* so that the nut *E* projected to far above the shoulder *F* and when the bonnet *A* was screwed down tight the diaphragm *G* would force the auxiliary open and hold it open, thus preventing the reduction of pressure.

The top of the nut *E* was filed enough to make up for the metal removed at *D* and the valves then worked satisfactorily.

Myron D. Place.

Foxboro, Mass.

Loose Stud Caused Click

A Corliss engine in a factory had an unaccountable click in the cylinder for a long time. Various conjectures were offered from time to time as to the probable cause.

It was not until a breakdown occurred, however, that the real cause was found.

A stud had broken off in the piston at the end of the threads, tearing about two inches of its length loose in the hole.

Apparently a little bur was all that held the loose stud from dropping out of the piston into the cylinder as the engine passed over the head-end center. It would come partly out during the travel of the piston toward the crank center; then, upon the reversal of the piston travel, it would slip back to place, making the mysterious click.

The crisis came at last when the supposed bur wore away and the stud dropped into the cylinder. The cylinder head was not knocked out, although the engine was considerably damaged. The loose stud lodged in the exhaust port where the lower edge of the piston struck it and bent the stem. The piston rod was also too badly bent to be packed steam tight.

Edward T. Binns.

Philadelphia, Penn.

Preserving Bolt Heads

A good substitute for expensive brass heads for bolts, where chemical action prevents the use of iron, has been found in babbitt.

A mold is made and a rack to hold the bolts in a vertical position. The babbitt is then poured around the iron head and allowed to cool.

F. H. Stacey.

Montreal, Can.

Dash Pot Troubles

I have frequently seen the question asking why a Corliss engine will govern perfectly with a normal load, but will race more or less when the load is light. The answer usually given is that the governor is not properly adjusted.

This trouble occurs more frequently with engines equipped with multi-ported valves, and the trouble is due to the action of the dashpots and not to that of the governor. A Corliss dashpot must lift quite a distance in order to produce sufficient vacuum to close the valve quickly. In the single-ported type, the valves usually have much more lap than the multi-ported valve, and in order to open the valves the dashpot plunger must be lifted about 9/16 inch with a 30x48-inch engine. In a multi-ported engine of the same size the lap will frequently be not more than ¼ inch.

A dashpot plunger must ordinarily lift at least ½ inch in order to produce a prompt cutoff. If the plunger does not drop its full stroke the valve will remain slightly open until the hook returns to pick up for the next stroke, when the valve will be closed by the hook pushing down on the dashpot rod. Of course, so long as the steam port is open, steam will follow the piston and the engine will race.

Multi-ported valves are more prone to leak than single-ported valves, on account of the smaller amount of lap. It is quite evident that the more lap a valve has the less will be the leakage.

I have sometimes thought that where an engine runs under a very variable load and a condenser is available that it would be a good plan to connect the vacuum chamber of the dashpots to the condenser, having check valves in the connections so that the dashpots would operate when the condenser was shut down. This would give a pretty constant pull on the dashpots; regardless of the lift. This scheme could only be applied where the dashpot has a cushion chamber separated from the vacuum cylinder.

C. A. Green.

Cleveland, O.

Regrinding Valves

A short time ago it became necessary to reface the valve seats in a boiler-feed pump, as they were badly pitted. As the reseating machine could not be used

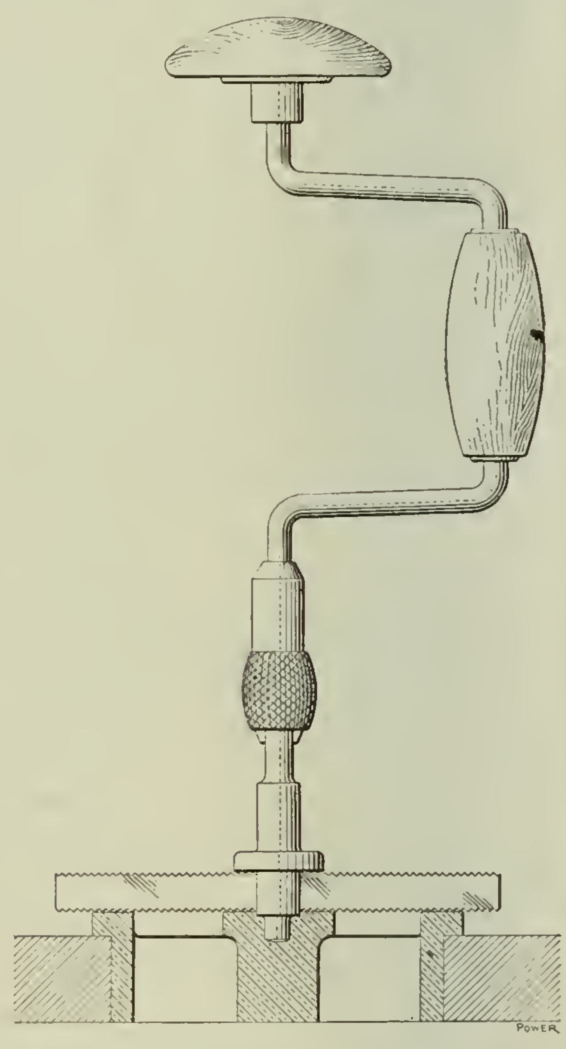


Fig. 1. Regrinding a Valve Seat

on the valve decks without some kind of special rig to hold it, the method described herewith was tried.

A second-cut-file was annealed and a piece cut off a little longer than the diameter of the valve seats. A hole, the size of the valve stud, was drilled and tapped in the center to hold the spindle which went into the stud hole. Then I hardened the file cutter. The spindle fitted in the

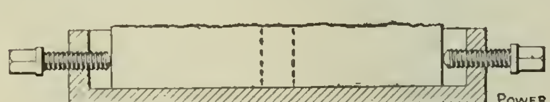


Fig. 2. Worn Valve in Holder

hole in the cutter and was held in a bit stock at the other end. The cutter was turned, thus facing off the seat.

I then thought that truing up the valve would help, so a holder was made, as shown in Fig. 2, which is a box fitted with a set screw to prevent the valve from turning. The box is held in a vise while the valves are being faced.

D. F. Crowther.

Boston, Mass.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Leakage through Piston Valve

I read with interest the articles discussing the report published in the October 11, 1910, number of the piston-leakage tests by Mr. Mitchell. I agree with Mr. Schoemaker in the January 3 issue that the pressure-plate valve leaks as much as, if not more than, the piston valve.

In the January 11 number, Mr. McGahey gives further examples of valve leakage. I think that Mr. Schoemaker and Mr. McGahey have lost sight of the fact that the amount of leakage through a valve when it is in a state of rest is much less than when it is in operation, and such a test, while showing the presence of valve leakage, does not indicate the amount under operating conditions.

Those interested in this matter may refer to *The Engineer* (London) for March 24, 1905, page 289, in which is given a report of the Brush Steam Engine Reseach Committee. It is there stated that the leakage through a slide valve is independent of the speed, but directly proportional to the difference in pressure on the two sides and that in most cases with perfectly balanced valves, the leakage is even greater than 20 per cent. of the steam entering the engine.

Asa P. Hyde.

Binghamton, N. Y.

Engineer and Machine

I differ with some points in the editorial in the February 14 issue entitled "The Engineer and the Machine." I wish to defend the supervising engineer—the "peripatetic supervisor." According to present practice the supervising engineer is engaged principally in looking after the operation of small private plants when there is no one who corresponds to the consulting mechanical engineer or the superintending engineer of the large power house or industrial plant. The only reason why he is "peripatetic" is because one private plant alone does not offer enough work *in his line* to keep him busy.

There are good men and bad. This applies to supervisors as well as to any other class of men. He who comes around and advises the boss that the engineer should be in line for a "cut" or is not needed at all is the one who is so set on "economy" that the plant will soon be on the high road to the scrap heap. This supervisor will sooner or later lose his job anyway, because he will become unpopular with the "boss."

There are honest supervisors doing business. Their work is to take certain responsibilities off the operator's shoulders and to help him bring the plant up in efficiency. If the supervisor and the engineer work together and realize that they can help each other and the boss better results can be obtained than were ever before dreamed of.

H. B. Lance.

New York City.

Where Do You Stand?

An advertisement in a recent issue of Power calls attention to a condition which is prevalent, judging from the evidence found in the advertising pages of all of the technical papers of the day. Briefly, the situation is this: A consideration, in the form of a "present," a "prize" or a "premium" is often used to influence the recommendation of the man who knows.

It reminds me of a story. We had changed from one brand of boiler compound to another and thought that we were getting better results when a salesman for the discarded brand dropped in and said that we had a condition which I would probably like to investigate after he had given me a tip.

I told him to unburden himself.

He said, "You know your engineer has been using our preparation with good results and now he has substituted So-and-So's and can give no good reason for so doing. I just want to tell you that it is a very common custom to pass a V or an X over the shoulder or under the coat tail to obtain desired results in selling boiler compound."

I replied that I knew that such things were done, but was not much interested. I had seen some literature sent out privately to engineers by a company which had an Eastern representative who was given a certain sum for advertising and who thought that the best way in which to advertise was to distribute the advertising money among the engineers in the form of presents, jewelry, etc.

Dismissing the salesman, I went down to see the old engineer. He hated me from the bottom of his heart, cordially and frankly, and I knew it and he knew that I knew it and neither of us cared; I also knew that he was honest and I would take a good beating rather than let anyone tell me that he was a crook. Nevertheless, I asked him if he was in the habit of accepting presents in consideration of his specifying any certain boiler compound.

He said, "No, but I just had a good chance to."

If your wife should go to the grocery and buy a pound of tea with a twenty-five-cent cup and saucer thrown in for sixty cents, she would get thirty-five cents worth of tea and that would be her business. If she should get a pound for her neighbor, keep the cup and saucer and give her neighbor the pound of tea in exchange for her sixty cents, there probably would be two women folks who would not speak to each other any more.

Enough said.

W. R. Smith.

Alton, Ill.

Small Refrigerating System

I read with interest the communication of R. C. Turner in the January 31 issue regarding a small refrigerating system. He describes the refrigerant as "Pictet" fluid. Presumably, he meant the Pictet mixture of sulphur dioxide with 3 per cent. of carbon dioxide.

As all compression-refrigerating machines depend for their operation upon the same thermodynamic principles, and differ by only comparatively small amounts in efficiencies when the various refrigerating mediums are employed, we may expect this small machine, of excellent mechanical efficiency, to produce refrigeration with an efficiency of 60 to 80 per cent. of that of the large machines, small machines being in general inferior to larger ones by some such ratio. The work required to make one ton of ice in the large ammonia machine being 2½ to 3 horsepower for 24 hours, this machine would hardly make 1 ton of ice for less than 3 to 5 horsepower; wherefore, we must conclude either that the 2-horsepower motor was greatly overloaded, or that Mr. Turner meant to say that the machine produced a refrigerating effect equal to that produced by the melting of one ton of ice—commonly called "a ton of refrigeration." In that case, the horsepower developed by the motor would probably need to be 60 per cent. of 2 to 3, or say, 1½ to 2 and, giving the machine the benefit of the more favorable figure, we may conclude that the 2-horsepower motor was working, at least, something under its full rating.

Mr. Turner gives 12 kilowatt-hours as costing 36 cents, an evident rate of 3 cents per kilowatt-hour. As a 2-horsepower motor will hardly have an efficiency better than 80 per cent. at full load, we may calculate a probable electrical input of

$2 \div 0.80 = 2\frac{1}{2}$ *electrical horsepower,*

equal to $1\frac{7}{8}$ kilowatts. Electricity at the rate of $1\frac{7}{8}$ kilowatts for 24 hours would cost, at 3 cents per kilowatt-hour, $1.35, which is the power cost of the ton of *refrigeration*, not of a ton of ice, which would cost about

$1\frac{2}{3} \times \$1.35 = \$2.23.$

Adding the labor cost of 25 cents and a depreciation and interest charge of only 10 per cent. on a probable first cost of $600, equal to $6\frac{2}{3}$ cents per day, we find the total cost of one ton of refrigeration to be $1.66 nearly, and of a ton of ice, $2.75.

Even at that, the machine furnishes refrigeration equal in cost to ice purchased at $8\frac{1}{2}$ cents per hundred pounds ($1.70 per ton)—which ought to satisfy any reasonable man content with mechanical possibilities.

S. H. Bunnell.

New York City.

Binding "Power"

I have just finished binding my 1910 copies of Power according to the method described by Mr. Lambowin in the issue of January 10, except that, finding that his method did not produce volumes that would probably stand the service to which I expected to subject them, I reinforced them by putting two wire staples clear through each.

As it was difficult to punch the holes and put the staples through a whole volume at once I made a gage out of sheet iron by taking a strip as long as a copy of Power and about ¾ inch wide and bending ⅛ inch over at one side and one end. I then punched holes through it so as to locate the staples about ¼ inch from the edge and about 1½ inches from the top and the bottom. With this gage I punched holes for the staples in each copy separately. The staples I made of No. 20 gage wire. I then strung the papers on the staples one at a time as I glued them together, beginning with the first copy of the first month and going right through to the last copy of the last month of the volume. I chose to put only two months' issues in a volume. After all were glued together I clinched the staples and put on the backs and covers as described by Mr. Lambowin.

After I had the binding completed I printed labels on the typewriter to put on the backs. These labels show the months and the pages in each volume and the volume containing the index is indicated.

G. E. Miles.

Salida, Colo.

Boiler Operation

I read in Power for January 31 the "Confessions of an Engineer," by R. O. Warren. He states that fuel can be saved by cutting out one boiler and running the remaining ones with open drafts and dampers. I have had fifteen years' experience in firing and I wish to say that with more boiler room, and when steam can be kept with dampers closed, much more fuel is saved than when the boilers are strained to their full limit and when in order to keep the steam pressure the dampers have to be open all the time.

F. Van Valkenburg.

Chichester, N. Y.

Water Gages

I think that H. F. Heyrodt is too severe with C. R. McGahey in his letter in the February 7 issue under the above title. I do not think that Mr. McGahey meant that the water column should be set as shown in the sketch. His letter explains that the lowest water line should not be less than 3 inches above the top row of tubes. I may not understand Mr. McGahey's letter correctly, but I cannot find anything wrong with it.

Mr. Heyrodt considers the use of gate valves on water columns poor engineering; I consider the use of globe valves on water columns poor engineering, and no valves at all a great deal worse.

William Swope.

Tiffin, O.

Homemade Belt Dressing

In the February 14 issue, Mr. Van Antwerp gives a recipe for making belt dressing.

I have had some experience with rosin as a belt dressing. It is efficient in making a belt stick to the pulley while it lasts. But, an application of rosin to a slipping belt will last only a short time. It has been my experience that where a leather belt is dressed with rosin it soon becomes hard and rotten and cracks and the holes where the belt is laced soon pull out. With canvas and rubber belting I never noticed any depreciating effects.

If anyone has a large, expensive leather belt that is giving him trouble, I would advise the use of some good oil, such as castor or neatsfoot. This makes the belt soft and pliable so that it conforms to the shape of the pulley and adds to the life of the belt.

Edgar Altmann.

Cincinnati, O.

On Lending a Hand

The first-page editorials in Power for January 17 and January 24 bear close analogy, they go hand in hand and are distinctly applicable to the element, found in all walks of life, that "isn't telling all it knows." Dealing with the power business, the engineer that gets "results" such as depicted in the later issue, the extremely "practical" man, who has little use for any literature regarding his profession, who scoffs at technical papers and sneers at the advertisements contained in them, is usually the one who "won't help the other fellow," and who is keeping all he knows to himself—as a rule, this is very little. This is the class that "knows it all." From the engineer of this type we learn much of "past performances," of what he has done and what he has been through and in full completion there is often a missing link, "how." But this is the secret, it fails to appear either because it is as much of a conundrum to himself as to the other fellow or because the other fellow might accidentally glean a kink. When anything goes wrong he is the one who is the quickest to blame it on another operator. I am acquainted with a very "practical" man who has adorned the engine room with a patent safe, a breadbox fitted with a padlock; into this is placed his "records and private data"; the desk, supplied by the company, is too public and the engineer on the following watch might see something. To have a motto, "Let the other fellow learn the way I did," isn't showing full appreciation of the fact that possibly you learned considerable from someone yourself; it must be excessively hard to go through life in this frame of mind.

To a man of character and business sense, there is nothing like extending a helping hand; because one man's experience is not on a par with another's, is no disgrace; none of us can ever know too much, and when we begin to realize that we can learn something, that we do not "know it all," it is the first signs of judiciousness. The young engineer, the man trying to make progress in his chosen profession, should be assisted and encouraged, not discouraged; when mistakes occur, he should be shown where he has erred, not taunted; he should be helped on, not held back. Nothing will have such a demoralizing effect upon the fellow trying to learn, as the man with the big head and infused with self-conceit; it downs him in his purpose and ambition, and makes him impressed with "What's the use"?

There is an old saying, "Chickens come home to roost," and its full significance should be understood. Power points out that there is a feeling of great satisfaction to the man who knows he has helped another and there is certainly no comparison between this and that other sensation, "he didn't get any information from me."

L. R. W. Allison.

Los Angeles, Cal.

Specialists

I sometimes wonder, from the letters occasionally printed in these columns, if there are any experts alive. I often read letters from some dinky little one-horse engineer like myself telling how he had to put the bricklayers right with their mortar, etc., although probably the men had been doing boiler brickwork for years. Then, the machine erecters changed their plans when shown where they were wrong. Next, the men putting up the shafting were shown a point or two, and so on. Not one of these experts was right—at least, so our engineer will inform us at three "plunks" or so per column. Any right-minded man should know that such contributions must be from some gassy engineer spouting rot. No man is perfect, but the erecters and experts sent out by manufacturers seldom make many mistakes at this date.

To say that any man, even a chief in a first-class plant, is an expert in all branches of steam engineering is wrong.

C. F. Scott, of the American Institute of Electrical Engineers, said (in 1908) that if all the studies were included that had been suggested as essential or desirable in the training of an engineering student, the college period would need to be 30 years in length. This is 1911, so I guess it would mean 40 years by now.

Prof. L. B. Stillwell, in the same year, said that men who rise highest in the engineering profession, generally speaking, are the men of broader education. Employers have little trouble in finding draftsmen and competent calculators, but the demand for "all-round men" always exceeds the supply. Now, if he meant men with several college degrees and 10 or 15 years' practical experience, anyone would know as much without being told. But, if employers who require good all-round men, that is, men with good practical experience and some technical knowledge, will put a two-line ad in Power, I venture to predict that they will get hundreds of answers from real good men, always providing that the salary is adequate for a good man, say $2500 to $4000 per year. Surely a man is worth that who has spent probably half a lifetime to make himself as proficient as possible.

James Scotch.

Toronto, Ont.

Steam for Preventing Clinkers

Referring to the February 7 issue, in which Charles H. Parson makes comments in regard to the reply to a question asking if steam jets under the grates will prevent the formation of clinkers and if their use is economical practice, I think the answer which the editor gave to the question is as nearly correct as could be stated.

Mr. Parson's statement that ash does not melt at all is entirely wrong, and he contradicts himself by saying, "Clinkers are caused by the fusing of certain elements in the fuel. These elements may be sand, silica, sulphur, etc." If sand, silica, etc., are not ash, what are they?

It is generally believed that as steam passes through a fuel bed, the steam is decomposed into hydrogen and oxygen and absorbs heat from that part of the fuel bed where the decomposition takes place. The hydrogen formed from the decomposition of steam in the fuel bed is probably burned above the bed and, hence, the furnace temperature as usually measured may be very little different than that obtained when the steam jet is not in use.

E. G. Bailey.

Boston, Mass.

Smoke Abatement

Henry D. Jackson, in a recent issue, offered his solution of the problem of smoke prevention. Several very good suggestions were given. He suggests the old coking method of firing for the prevention of smoke. But, how many men are there who are physically able to fire in such a manner; also, how many plants are there in which such a plan could be followed without losing the steam pressure? How can better results be obtained than by the spreading method of firing? Some of the most skilled firemen use the alternate method. Is it not true that the percentage CO_2 depends greatly upon the temperature of the fire; also, that greater capacity can be secured by firing lightly, evenly and often? Then, why do so many indorse the coking method when the spreading method is used in perhaps nine cases in every ten?

I certainly approve of paying a fireman all that he is worth. In addition, I am much in favor of the bonus plan. It engenders enthusiasm and vigilance which are kept up because the bonus must be earned, whereas an increase in wages only serves as a temporary stimulant.

Waldo Weaver.

Middletown, O.

Burning Pulverized Coal

I was much interested in the article in a recent issue on burning pulverized coal. There were two items in the results of the test that seemed peculiar.

The duration of the trial was only six hours. This is entirely too short for a boiler test if any dependence is to be placed on the results.

The temperature of the flue gases as given, 380 degrees Fahrenheit, is extremely low when it is taken into consideration that the temperature of the steam at the pressure given would be about 371 degrees Fahrenheit, there being a difference of only 13 degrees in temperature between the flue gases and the steam. No mention was made of an economizer. An explanation of this temperature should prove highly beneficial to those of us who are interested in boiler economy, even if we do have to burn lump coal.

John Bailey.

Milwaukee, Wis.

Writers Among Engineers

As has been stated, the starting bar or a monkey wrench is a far handier tool than a pen in the hands of most engineers. To buckle down and compose a four- or five-hundred word article which will be rewritten two or three times before it is considered sufficiently good to trust to the tender mercies of the editor, and then go around in a cold sweat for the next two weeks expecting every mail to bring it back marked "N. G." or "not available," is more than most engineers can stand.

Some men write for the pleasure it gives them to lend a helping hand. Some write just to see their names in print. Others write for the money to be gained, which is very acceptable to all.

I find that there are from 20 to 30 articles in each issue of Power which are from one-half to one and one-half columns in length each that I would take to be written by the men "on the job." I also find that the circulation is about 33,000. Suppose 13,000 copies go to libraries, professors, retired engineers, students, etc., leaving 20,000 to go to the men on the job. Of these 20,000 men there should be at least 10,000 who could write at least two articles per year on some accident, kink, saving, or what not that he has had to deal with during the year. This would give us a little over 380 articles per issue as compared with 20 or 30 now. Of course, such a number could not be used, but this shows what a small amount of writing it would take to make a rousing old paper out of our friend Power.

I think that if the editor would give us a few front-page talks on the writing of articles, and the most acceptable subjects, going into detail on some of the points connected therewith, some of these days, very soon, such a pile of letters would drop at 505 Pearl street that someone would have to dig the whole office force out.

C. E. Beckwith.

Spokane, Wash.

Indicator Diagram Defects

A suggestion in reply to Mr. Binns in the February 7 issue: Perhaps the piston is traveling past the indicator hole. I have had trouble of my own in this respect.

Also, was a spring of the right scale used?

J. L. KEZER.

Bradford, Penn.

Referring to the indicator diagram submitted by Edward T. Binns and published in the February 7 issue, when admission occurs at the head end, the pressure causes the indicator piston to rise abnormally high, due to excessive lead. As the piston is well balanced, that is, it moves with perfect freedom, the vibrations due to inertia are set up.

The reason why vibrations are not present in the crank end is because there is not so much lead.

J. P. COLTON.

Ohio City, O.

The Position "Higher Up"

The question asked by Mr. Richmond in the February 14 issue is answered in the various editorials in POWER and in the little squibs tucked away in the corners of the pages.

I stepped out of the fire room into my first job as chief. How I did it may be interesting but I have always accepted it as a matter of course. I had been firing a pair of boilers for over three years and had got the trick down so fine that the boiler manufacturer noticed it and used to borrow me once in a while to fire boilers for him when they were under test. I always got as high an evaporation as the coal and boiler would stand and the boiler man always got his money.

While going out on these jobs, I noticed the men who were conducting the tests taking indicator diagrams. This interested me and, although I was working seven days a week and twelve hours a day for $40 per month, I managed to save enough money to buy a cheap indicator and to find time in which to indicate engines wherever I had acquaintances.

One day the mechanical engineer who built the plant dropped in as I was taking some diagrams from our engines. He looked at the diagrams and asked me if I knew what I had when I got one. I told him that I did and showed him some diagrams from about twenty other engines on which I had laid out the point of cutoff and the theoretical expansion curve. He seemed to be impressed and, after a while, told me that he had a pair of Corliss engines in another plant that were not doing very good work and that if I would set the valves and bring him diagrams, taken before and after setting the valves, all figured up, he would give me $20. I took a day off, indicated the engines, set the valves and spent the night figuring up the diagrams. The next day, I got an hour off and took the diagrams to him, got my $20 and went back to work at my firing job.

But that experience taught me something. There was a vast difference between $20 for a day's work and $20 for two weeks' work. So I got busy, saving money to buy books and more instruments and nearly had nervous prostration from studying and experimenting. I think the only time I ever lost from work, when I wanted to work, was at this time, when I had to go to a hospital to have my eyes treated and later on when I went to a hospital to get some burns treated which I received while trying to conduct a fire test of a sample of oil with a homemade flash pot and a gasolene torch.

Some time after indicating those two engines my mechanical-engineer friend came around and said that in a plant somewhat similar to the one in which I was firing the chief engineer was due to walk the plank. He asked me if I thought that I could handle the job. The wages were to be $21 per week, only five and a half working days per week. Although the offer nearly took the breath out of me, I told him that if he was willing to try me I was willing to take a chance and that if I failed it would not be because I had not tried.

The long and short of it is that he gave me the position, and I have held that and similar positions almost without interruption ever since.

One of the principal requirements of a chief engineer is executive ability and this is hard to acquire. Another qualification is fair bookkeeping ability. I studied probably all of the technical journals for ten years and could figure out any of the problems relating to a stationary engineer's work. Then I saw a new light. Today, I do not believe that I could figure out the horsepower of a boiler or engine or do any of the lever safety-valve problems without consulting a book. But, I can figure out the cost per kilowatt-hour of every item entering into the daily operation of the plant, lay out the load curve, figure the load factor and the boiler performance, show the difference between the last twenty-four hours' operation and that of the preceding day and account for that difference. Any or all of the foregoing information I can put on the manager's desk by ten o'clock in the forenoon. Such things are what really count and are what the company wants.

I am not a paragon of virtues and meet engineers every day to whom I take off my hat. In fact, I have had them working under me and have in several instances managed to turn over my job to them when I got ready to quit. I never noticed an engine-room clock except to see that it was correct and still running, for I always considered that I was paid for twenty-four hours per day. I have always respected my employer if I did not respect the man. I have never asked for a raise in salary in my life and my employer has always paid me *all* of the salary I received.

I work hard and long and expect the men and machines under me to operate at as near full capacity as possible. In return for the coöperation of the men, I see to it that they get all the money that the company will stand for and I do not work them on twelve-hour shifts. It may sound strange, but I have found that a sure way in which to bring down the cost per kilowatt-hour, and that is all that I think and dream about, is to see that the men get all the money within reach and work short shifts.

EDWARD ADAMS.

Reading, Penn.

Under the above head in the issue of February 14, Oscar J. Richmond wishes suggestions on the matter of obtaining better positions.

It is generally admitted that the first move is self-education, which results in increased personal efficiency. A difficulty mentioned, and it is a real one, is the fact that a power-plant engineer is tied down for the greater part of every day with a minimum chance for meeting influential men and thus furthering his ends. He has, however, the same use of the United States mails as his employer. All "improved" engineers are conscientious readers. In reading they are continually noting the affairs of others and news with regard to new undertakings. If in search of an opening, many ideas should be gleaned in this way. New power plants in the course of construction will soon need engineers. Improvements in old plants will need better talent. New companies forming will need expert talent. A card index or other means of tabulating should be instituted and business methods applied to the subject in hand—that of getting a better job.

Letters should be written by the dozen and the replies graded as to prospect. It must be remembered that letters are proxies and as such should truly represent the writer. A slovenly letter may not always indicate a slovenly man, but in the absence of other evidence the effect is the same. The rent of a typewriter would amount to a few dollars a month, and a little practice makes one fairly proficient. And if the end is worth having at all, the typewriter is a part of the job-getting business. Another way would be to turn the letters over to a friend who is a stenographer, or still another, have them copied by a public stenographer. In the quest of a position, do not send a letter written in long hand to a stranger; in most cases it is suicidal.

Blind advertising is all right in the search for men, but as a means of obtaining a position it is practically useless. The head of a plant has too many opportunities to reach people directly, and the blind advertisement carries with it an atmosphere of distrust.

Engineering societies and clubs do much to raise the standing of men who take active part. There are those whose fortunes were made by this method, sometimes called "self-advertising."

Above all things, if you really want a new job, go after it in a whole-hearted manner. You cannot leave a stone unturned and do justice to yourself.

L. F. WILSON.

Chicago, Ill.

Binding "Powers"

In the February 7 issue, Mr. Levy tells how he takes care of his copies of POWER.

I have been a regular subscriber to POWER for a number of years and I have every copy that was ever sent to me. I have a case in the engine room for them; in it I place each copy after I have read it. I can get any number I want without the slightest trouble. I keep the titles of such articles as I need in a ledger. I think I have a better method than any I have seen described.

E. O. FOULK.

Pioneer, La.

Vacuum for Reciprocating Engines

I take exception to the opinion expressed in the article under the above in the issue for January 31. The old-fashioned and impractical idea of 26 inches of vacuum being the limit for economical engine performance should be discarded with the innumerable other practices now obsolete in engineering.

Why should the author, as is customary with engineers discussing the subject from the same viewpoint, base his figures on the steam delivered to the low-pressure cylinder? If the steam requires more volume with the higher vacuum than is provided in this cylinder, why not change the cutoff in the high-pressure cylinder and adjust the receiver pressure accordingly? The decreased back pressure will allow of a shorter cutoff for the same power output. After putting the condensing apparatus into first-class shape and obtaining the highest vacuum possible, the valve setting should be adjusted to correspond. In some plant-betterment work, which I conducted recently, the vacuum for the engines was changed from 25 and 26 inches to 27 and 28 inches with marked improvement in the coal consumption per kilowatt-hour. The dashpots in several cases acted badly under the new conditions but the trouble with the *dashpots* was eliminated by better adjustment.

Parallel with this mistaken idea is the practice in many plants of dropping the steam pressure during the light load at the noon hour. The reason for this generally is on account of the poor regulation under the lighter load with the short cutoff. There is no excuse for this in a reputable engine and it will usually be found that a better adjustment of the governor, dashpots and valve gear will eliminate the trouble.

Let us forget obsolete practices!

THOMAS J. WALSH.

Boston, Mass.

Change of Cutoff

In a recent issue a correspondent wanted to know how to change the cutoff of a Brown engine.

The engine takes steam while the valve is going up. If the engine will stand a little more lead, a later cutoff will be obtained by increasing the lead, and an earlier cutoff by decreasing the lead.

I have an idea that the engine is overloaded and that a little later cutoff is desired.

H. JONES.

Wylam, Ala.

Central Station vs. Factory Plant

The instances of greater cost of power obtained from central-station current than of power produced by the independent factory plant cited by Henry D. Jackson in the issue of February 14, are but examples of scores of cases where the central-station agent would "never have gotten further than a look in" had the owners gone to the small trouble and expense of having a disinterested examination made of the actual conditions and of the possibilities of saving power, or money, by changing from the belt drives of a factory plant to electrical power and transmission. Saving of space, greater cleanliness and greater convenience are advantages possessed by electric power and transmission over the ordinary factory-plant belt drives that can be turned to good account in almost any manufacturing establishment; but the power which will be saved by the elimination of belt transmission is usually much overestimated.

Electric-line losses and losses due to imperfect insulation of motors rarely amount to less than 5 per cent and, placing the average working efficiency of motors at 85 per cent, it can be seen that the electrical horsepower read at the switchboard must be about 20 per cent in excess of the net power delivered by the motors.

From an experience of testing many hundreds of factory plants, I can testify to the fact that shafting friction in nearly all lines of manufacture has been found to be nearer 10 per cent, than 20 per cent, of the total power required, in many cases being less than 10 per cent, of the power that would have to be delivered to the same points by motors.

In the average factory, shafting, pulleys and belting are the most conspicuous features of the power plant, and to the uninitiated they are impressive of the idea that they absorb most of the power required for the whole establishment. It is no wonder that owners are profoundly impressed with arguments of savings of power that are to be realized by the employment of electrical transmission, especially if they are not "wise" to losses that are inevitable in the conversion of electrical power at the switchboard into actual power.

In a case where it is proposed to change from belt transmission to electric driving and where cost of power is a consideration, it will pay to make careful tests to determine the power loss in transmission, and it is of equal importance to demand guarantees of motor and line efficiencies. The loss or saving resulting from the installation of electric motors can then be determined in advance in place of waiting until after the central-station service bills are presented and the plant has been equipped with a lot of expensive motors.

Quite recently I was called in to consider a case where the proprietors of a plant were greatly disappointed to find that the central-station charges for current supplied to the motors amounted to nearly double their former cost of power generated by the old factory plant. Enormous savings had been looked for. Transmission by belts had been replaced by electric motors installed in groups, main belt drives abandoned, a good Corliss engine power plant shut down, the engineer discharged and only a fireman retained for making the steam necessary for the manufacturing processes and for warming the buildings with live steam.

The only improvement was in one department where the speed was more uniform than formerly. In this case the old transmission had been by vertical belt and the condition of the lower pulley showed that slippage took place on account of the belt dropping away from the driving pulley, a trouble which any millwright engineer would have corrected by giving slope to the belt or by equipment of a ready-made belt tightener for less than 5 per cent. of the cost of the new electrical equipment. In this case electric motors were employed for driving the old line shafts. The only transmission that had been dispensed with was the jack shafts which I am satisfied would not have absorbed more than about 3 per cent. of the power which they transmitted.

This was a case where the claim of saving power by electrical transmission was absurd and the central-station rates will have to be materially reduced in order to meet the cost of operating the old plant.

[illegible]

Paterson, N. J.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Horsepower of Gas Engine

Is there a formula for estimating the horsepower developed by a gas engine?

E. D. R.

For a four-stroke cycle engine using illuminating gas or gasolene the output that will probably be obtained is given by the formula:

$$\frac{d^2 s n}{12{,}500} = \textit{horsepower}$$

in which

d = Diameter of piston in inches;
s = Length of stroke in inches;
n = Number of revolutions per minute

For a two-stroke cycle engine use 8000 instead of 12,500 for the divisor.

Pressure Required to Compress Air

What pressure per square inch will be required to compress air to ⅔ and also to ½ its original volume?

P. C. A.

The volume of a gas varies inversely as its pressure and the product of pressure into volume is constant, provided the temperature remains constant. To compress a given volume of air to ⅔ of the original volume will require $\frac{3}{2}$ of the original pressure and to ½ the original volume will require twice the original pressure. If the air to be compressed is at atmospheric pressure the pressures will be

$$3/2 \times 14.7 = 22.05 \textit{ pounds absolute}$$

and

$$2 \times 14.7 = 29.4 \textit{ pounds absolute}$$

respectively.

At any pressure other than that of the atmosphere the method will be the same.

Efficiency of Boiler and Furnace

How is the efficiency of a boiler and furnace determined?

E. O. B.

By dividing the heat transmitted to the water by the heat in the fuel.

Brass and Babbitt Bearings

Which is better for engine-shaft bearings, brass or babbitt metal?

B. E. B.

Under all ordinary conditions babbitt metal is preferable.

Dead Weight Safety Valve

What is a dead-weight safety valve?

D. W. S.

It is one in which the valve is loaded by weights acting directly on the valve without the interposition of a lever.

Cause of Reversed Rotation

What would cause an engine to run backward?

R. C. R.

A sufficient change in the position of the eccentric.

Point of Cutoff

At what point in the stroke will cutoff take place in an engine of 20 inches stroke, valve travel 5 inches and outside lap 1⅜ inches?

P. O. C.

The point of cutoff will vary slightly with the lead. With 5/16-inch lead the period of admission will continue through 62 per cent. of the stroke.

$$20 \times 0.62 = 12.4 \textit{ inches}$$

With no lead, cutoff will occur at 66.6 per cent. of the stroke.

$$20 \times 0.666 = 13.32 \textit{ inches}$$

A valve having the lap and travel as stated would give a port opening of 1⅛ inches.

Pohle Air-lift Pump

Will you please explain the construction and operation of the air-lift pump?

P. A. L.

The air-lift pump consists of a vertical water pipe the lower end of which is submerged in the water of a deep well, and a smaller pipe delivering air into the lower end of the water pipe. The air rises in bubbles, and the column of air and water inside the pipe being lighter than the solid water outside, it is forced upward by the unbalanced pressure.

Vacuum Gage on Suction Line

Kindly explain the theory and use of a vacuum gage on the suction line of a cold-water pump. Is it proper to locate the gage on the suction gas chamber? Will its showing be the same there as on the main suction line? Explain the gage reading; what it should read on, say, a 20-foot suction lift, and what information does the engineer get from the reading that is of practical use to him in operating the pump?

G. S. L.

A vacuum gage on the suction pipe from a pump may give much or little information to the pump operator, depending entirely on the conditions under which the pump is working. Attached near the pump it tells the vacuum required to draw water to the pump at all times. With clean water and steady service this may not be much, but with the suction pipe drawing water from a source filled with seaweed, dead leaves or grass, the strainer may become clogged and the vacuum gage tells that the supply is being restricted long enough before the pump fails to allow for cleaning. It is proper to attach the gage to the suction chamber, and it will read the same as though attached to the main pipe near the pump; but the farther from the pump it is attached, the lower the reading will be. With a large suction pipe and a slow running pump, the gage should read 18 inches for a 20-foot lift, but with a long pipe with numerous ells and with the pump running at a high rate of speed, it may read as high as 28 inches.

Factor of Safety of Old Boilers

What rule is followed by boiler inspectors in reducing the working pressure on horizontal tubular boilers with lap seams on account of age?

T. M. D.

Boiler inspectors follow no general or regular rule in reducing the allowable working pressure on a boiler due to its age. They rely upon their judgment and experience. The Board of Boiler Rules of the State of Massachusetts prescribes that the lowest factor of safety used for boilers, the shells or drums of which are exposed to the products of combustion and the longitudinal joints of which are lap-riveted construction, shall be

5 for boilers not over 10 years old;
5½ for boilers over 10 and not over 15 years old;
5¾ for boilers over 15 years old and not 20 years old;
6 for boilers over 20 years old.

These factors are considered by many engineers to be altogether too small, and that 6 should be the lowest factor of safety allowed on a new lap-seam boiler and that the factor should be increased each year to such an extent that it will put the boiler out of use at the end of 10 years.

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Contents

Reduced Grate Area at Light Loads

It is generally conceded that with a properly designed furnace the highest grate efficiency is obtained when burning the maximum amount of coal per square foot, consistent with complete combustion. Opposed to this, however, is the efficiency of the boiler itself. With a fixed heating surface, increased combustion is accompanied by a higher stack temperature and this means increased heat losses. There is a mean between the boiler and the furnace efficiencies and in good design this point should represent the rated capacity. Boilers are often forced considerably beyond their ratings, with only a slight loss in economy, but this is explained by the introduction of other factors, such as increased velocity of the gases, etc.

On the other hand, through lack of judgment or to meet certain conditions, boilers are often installed having a rated capacity far in excess of the load to be carried. In such cases it is customary to reduce the draft to suit the load; this results in more or less incomplete combustion and tends to lower the efficiency of the unit. Here it would be much better to reduce the grate area and maintain a high rate of combustion. Instances are on record where this has lowered the fuel consumption as much as five per cent.

The Cost of Power

To one who got his knowledge and impressions of the subject from the recent joint meeting of the American Institute of Electrical Engineers, and the American Society of Mechanical Engineers, the man who runs an engine and generator when he can buy current from a central station would appear a blithering idiot.

It is not surprising that a meeting, all of the papers for which were written by central-station men and most of the prearranged discussion prepared by their friends, should have turned out so preponderatingly and exaggeratedly onesided as to have excited the risibility even of central-station sympathizers; but it is surprising that the managements of the societies involved should have turned the forum of American engineering into an arena for the mental gymnastics of the central-station enthusiasts, and the "proceedings" of a great national professional society into a reference book for him who seeks to justify high rates.

To the engineer whose interests are not involved with those of the central station it is quite possible to conceive a condition where the owner of a department store, hotel or office building having to have steam plant anyway for heating and other purposes, can put in an extra engine, run it as a reducing valve between his high-pressure boilers and his heating or low-pressure service and make what current he needs more cheaply than a central station can make and deliver it to him at a profit. In fact there are records available where such a thing has been done. In fact, again, there is something very exceptional about a case where an industrial establishment or building of size worth considering cannot be run on less money, when heating is as much of a factor as it ordinarily is in any but southern latitudes, if it makes its own electric current than if it buys it.

Try the shoe upon the other foot. There are people whose interests are with the isolated plant rather than with the central station: manufacturers and salesmen of engines and generators and power-plant supplies, consulting engineers who have advised against central-station service when it appeared to them that their clients could make current cheaper, engineers of public plants shut down by the usurpation of the central station, high-class operative engineers of the professional type who are in charge of large installations and know what it costs to run them. Suppose that some of these wanted a meeting held under the auspices of one of the great national professional societies to present their side of the case.

Could they get it?

Having got it, would there be any kind of a howl if they monopolized the meeting with the perverted statements of the most unreasoning of their adherents; watch and gavel in hand, would shut anybody who approached the subject from the other side; if, after all their ammunition had been spent, many of the audience had left and all were ready to go they threw the discussion open at a minute a head, and then published the performance as the "proceedings" of a national scientific institution?

We know of nothing which would be more interesting and profitable than a dignified professional discussion of "The

Cost of Industrial Power," backed by statements of initial cost and of actual accomplishment. There is plenty of information of this kind to be had. There are plenty of men who are qualified to discuss it intelligently, even the accountants' side of it. It ought to be discussed without prejudice and with no more warmth than the interest warrants, from a purely engineering point of view; and when one class of men claim that they can make a kilowatt-hour for a cent and another class claim that it is really costing them fifteen but that they do not know it, there ought to be enough brains in a free-for-all meeting to find out whether the difference is one of fact or of bookkeeping.

We should like to see such a meeting arranged, in the interest of the truth; not organized for and by those whose aim is to boost the popular conception (and especially the Public Service Commission conception) of the cost of power nor of him whose interest lies in reducing that conception, but for the manufacturer, the engineer, the power user who wants to get at the facts in the matter.

Pending such a meeting the columns of POWER are open to any who have real information upon the subject.

Interest and Sinking Fund

If the life of an installation of power plant is assumed to be twenty years, then it would appear at the first glance as though there must be charged against operation one-twentieth, or five per cent., of its cost each year, as it uses up that amount of plant each year on the average, as well as coal and other supplies. But if five per cent. of a sum be set aside each year and be put at compound interest at six per cent. it will amount to 184 per cent. of the original sum at the end of the twenty years. It is necessary to set aside only 2.7 per cent. in order that the full sum may accumulate and accrue and be ready to replace the plant at the end of its assumed lifetime.

At the recent New York meeting of the American Institute of Electrical Engineers, held to discuss power costs, one of the central-station solicitors maintained that it was not right to so reduce the sinking-fund charge because inquiry upon his part had revealed the fact that nobody invested the money thus charged annually to the plant at compound interest.

Well, what do they do with it? They don't put it in a safety-deposit vault, or soak it away in a stocking. They keep turning it over in their business and make it earn twenty or thirty per cent. If the steam plant were credited with that rate of interest its sinking-fund charge would be low indeed. But that would not be fair, for the owner could borrow at six per cent. for his commercial or manufacturing operations.

And in the face of this refusal to credit the plant with ordinary interest upon money which they insist it shall earn and set aside for its own replacement, the central-station men want the man who is considering the installation of an isolated plant as against buying current to virtually charge the plant with interest at the rate of profit in his most profitable department, upon the plea that he had better use the money there than to put it into power plant if the plant cannot beat the most profitable department as a money maker; which would be true if the department were capable of such extension as to absorb all the capital and the owner were "broke."

Inertia

Inertia is defined as the inability of matter to set itself in motion, or of a moving body to change the rate or direction of its motion. A broader application of this definition covers those peculiar attributes of the human mind which induce many to bury themselves in a rut or a ditch so deep that their horizon is limited by the blank wall in front of them. When study for improvement is suggested, it is often met with the abject confession, "I didn't have much schooling an' those things are beyond me." No man's education ceases at the school door unless he wilfully shuts his eyes and his ears when he tosses his school books aside. In fact, the largest part of anyone's education comes outside of books. Some of the most ignorant men have had all of the advantages afforded by schools and colleges and have failed to profit thereby, while some of the best educated men in the world have been entirely self-taught. A man's education commences the instant he begins to see and only stops when he ceases to see. In this he is governed by his own inertia or his lack of it—the inertia that prevents a man from advancing himself, the initiative which prompts a man to seek out the explanation of those phenomena which daily life presents.

At the close of his paper on the "Art of Cutting Metals," presented by F. W. Taylor, when retiring from the presidency of the American Society of Mechanical Engineers, are found the following words:

"And let me point out that the most important lessons taught by these experiments, particularly to the younger men, are that several men when heartily cooperating, even if of only everyday caliber, can accomplish what would be next to impossible for any one man even of exceptional ability.

"Expensive experiments can be successfully carried on by men without money, and the most difficult mathematical problems can be solved by very ordinary mathematicians; provided only they are willing to pay the price in time, patience and hard work. The old adage is again made good that 'All things come to him who waits,' if he only works hard enough in the mean time."

The same amount of time and energy that the average man devotes to memorizing the standing of the different baseball clubs and the players would, devoted to a subject connected with his occupation, render him an authority on that line.

The corrosion of condenser tubes is one of the serious items of expense and trouble about a power station. In one of the large New York stations the surface condensers have to be entirely retubed after a service of not more than three years. It is pleasing to learn, therefore, that the Institute of Metals, of Great Britain, has appointed a committee to investigate the subject of corrosion, and that the first subject which they will take up is that of condenser tubes. Sir Gerard Muntz, the president of the Institute, is naturally much interested in the subject, and G. D. Bengough, of the metallurgical department of Liverpool University, is in charge of the scientific work.

That a chain is no stronger than its weakest link is an old and familiar maxim. The same reasoning applies to many other things besides chains. One weak spot in the insulation of an armature, for example, can cause the destruction of an otherwise sound generator. A set screw of insufficient size or "bite" can wreck the finest steam engine ever built, by allowing the key to back out of the connecting-rod strap. A cheap, unreliable ignition system will "kill" a $100,000 gas engine just as effectually as the use of rotten material in the crank shaft, though equal mechanical damage would not be caused.

Having awakened to the advantages of electric ignition ten years late, our British cousins are about to make the parallel discovery that the hit-and-miss method does not embody all of the cardinal virtues of regulation for gas engines of moderate output.

But those same English cousins have keenness of vision when it comes to discerning the buttered side of a slice of bread. They don't figure crank pins and such with a margin of $2\frac{9}{16}$ per cent.

The National Assembly of Panama has recently voted $100,000 in aid of the proposed world's fair to be held in Panama City in 1915. The more, the merrier, providing it does not interfere with Louisville or San Francisco.

If everybody had the moral courage to tell the whole truth always, we'd all know "where we're at" and everybody would be really more contented.

Notes on the Cost of Industrial Power

Two papers and the discussion of them at a joint meeting of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. The original papers deal with methods to be used in arriving at the cost of power in isolated plants as viewed from the central station standpoint.

On Friday evening, March 10, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers held a joint meeting at which were presented several papers upon the cost of producing power.

John C. Parker, of the Rochester Railway and Lighting Company, delivered a paper entitled "Comments on Fixed Costs in Industrial Power Plants." Beginning with the initial investment he pointed out the necessity of including the cost of real estate, building, equipment and all labor involved in connection with the erection of a plant, depreciation being charged against the labor and supervision items as well as the equipment itself. It was shown that boilers depreciate more rapidly than engines which, in turn, depreciate faster than buildings and so on; hence, a separate rate should be applied to each, the basis for calculation being that the life of any plant is the length of time for which it can be run economically.

Regarding insurance, if the installation of a plant increases the fire hazard on the property as a whole, the net increase of insurance should be charged against the plant which occasioned the increase. Furthermore, to the ordinary fire insurance must be added accident and liability insurance. This expense is existent whether such insurance is actually carried, or not, as a sum equal to the insurance premiums must be laid aside to provide for such contingencies for which the insurance is carried.

An "obsolescence" charge, meaning the supersession of the apparatus initially installed by a more efficient piece of apparatus which may be developed before the initial apparatus has reached the scrapping stage, was not considered important, even though the supersession take place under stress of competition. For this would not be undertaken unless the new apparatus could save enough to justify the expense, in which case the saving must take care of that much of the new investment as is not already covered by the sinking fund.

Mr. Parker laid considerable stress upon what he termed the "marginal principle." This, briefly stated, is to the effect that if any part of a business requires time, material or investment which could have been utilized in any other part of the business, the cost thereof should be taken as the amount such time, material or investment would have earned if applied to the most profitable part of the business which is capable of extension. To illustrate this he cited the case of a department store in which, for every $1000 invested in the china department, a yearly profit of only $100 is made, whereas each $1000 invested in the clothing department yields a yearly profit of $300. Hence, according to the marginal principle, the $1000 invested in china actually showed a loss of $200 per annum which should be charged against the china department. If, then, an enterprise is making a net profit of 10 per cent. per annum on the average—and not less and probably more than this on certain details of the business—[illegible]

TABLE I

Items	Cost	Life, Yrs.	Depreciation	
			Rate, Per Ct.	Amt.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aggregate	[illegible]			[illegible]
[illegible]			[illegible]	
Freight and rigging	[illegible]		[illegible]	[illegible]
Total	[illegible]			[illegible]

	Per Cent.
Marginal interest	[illegible]
Amortization	[illegible]
Taxes and insurance	[illegible]
Fair profit ratio	[illegible]
Aggregate	29.15

BALANCE SHEET

PURCHASED POWER

Fuel

For heating, based on 10 pounds evaporation:

Day coal	[illegible] tons
Night coal	[illegible] tons
Banking coal	[illegible] tons
Total	[illegible] tons
Cost at $2.[illegible] per ton	$1,[illegible]

Ashes

Ash, 12 per cent. Total ashes, [illegible] tons; removal cost at [illegible] cents per ton 16

Labor

1 fireman [illegible] weeks at $1[illegible]	$[illegible]	
1 fireman [illegible] weeks at $1[illegible]	[illegible]	
		$1,[illegible]

Supplies and Repairs

$[illegible] per horsepower per year, [illegible] horsepower installed ..... [illegible]

Water

[illegible] 10 per cent. loss in system; cost at $[illegible] per 1000 pounds 12

Electric Service

Present maximum demand ..... [illegible] kilowatts
Estimated future maximum demand ..... [illegible] kilowatts
[illegible]

Month	Kilowatt-Hours [illegible]	Bill [illegible]
June	[illegible]	[illegible]
July	[illegible]	[illegible]
August	[illegible]	[illegible]
September	[illegible]	[illegible]
October	[illegible]	[illegible]
November	[illegible]	[illegible]
December	[illegible]	[illegible]
January	[illegible]	[illegible]
February	[illegible]	[illegible]
March	[illegible]	[illegible]
April	[illegible]	[illegible]
May	[illegible]	[illegible]
	[illegible]	$[illegible]

Total ..... $[illegible]

Heating Service

Present installation, estimated cost ..... [illegible]

Fixed Charges

Estimated value of heating plant, $[illegible]; fixed charges at [illegible] per cent ..... [illegible]

Manager's Time

[illegible] ..... [illegible]

Total ..... $[illegible]

ISOLATED PLANT

Fuel

[illegible] kilowatt-hours at [illegible] pounds coal per kilowatt-hour ..... [illegible] tons
Banking coal ..... [illegible] tons
Total ..... [illegible] tons
Cost at $[illegible] per ton ..... $[illegible]

Ashes

Ash, 12 per cent. Total ashes [illegible] tons; removal cost at [illegible] cents per ton ..... [illegible]

Labor

1 day engineer at $[illegible] per hour
1 night engineer [illegible] per hour
1 fireman [illegible] per hour
Total ..... $[illegible] per hour
All labor on for [illegible] weeks
Total cost per year ..... $[illegible]

Supplies and Repairs

[illegible] ..... [illegible]

Water

[illegible]
Cost per year ..... [illegible]

Electric Service

[illegible]

Heating Service

Present installation, estimated cost ..... [illegible]

Fixed Charges

Estimated cost of plant, $[illegible]; fixed charges at [illegible] per cent ..... [illegible]

Manager's Time

[illegible] ..... [illegible]

[illegible] ..... [illegible]

is at least a 10 per cent. loss per annum on the investment of money in a power plant, if the money earns only the fixed items of taxes, insurance, interest, depreciation and supervision, and the amount lost is just what could have been gained by the investment of such a sum in the most profitable part of the business.

As an illustration of the methods laid down, Mr. Parker appended figures intended to show the cost of supplying a large mercantile establishment with power from an isolated plant as compared with central-station service. The plant selected was of 150 kilowatts capacity and the fixed charges were assumed at the rates given in Table 1.

The second paper of the evening was by Aldis E. Hibner, of the Toronto Electric Light Company, and was in part as follows:

There are in general three factors involved in every industrial-power problem: the investment charges, operating charges and the cost of heating or the use of low-pressure steam. The investment charges are understood to cover the interest, amortization, insurance, taxes and profit on the capital invested in the plant. The operating charges include coal, labor, repairs and supplies. The cost of heating is the investment and operating charges of the boiler plant necessary for heating the building and supplying steam for manufacturing processes.

TABLE 2.

Heating Plant Investment.		
Boiler, piping and auxiliaries (A)	$1,500.00	
Building and stack (B)	2,500.00	
Total investment	$4,000.00	
Fixed Cost.		
Interest 6 per cent. on $4000	$240.00	
Insurance and taxes, 2 per cent. on $4000	80.00	
Amortization on A, 4½ per cent., 15 year life	67.50	
Amortization on B, ½ per cent., 50 year life	12.50	
		$400.00
Operating Cost.		
Coal, 475 tons @ $3.00	$1425.00	
Fireman @ $15.00 per week	780.00	
Supplies and repairs	100.00	
		2305.00
Total cost		$2705.00

Assume as a typical example of the conditions ordinarily found, the Blank Shoe Company, which has outgrown its present quarters and has decided to build a new factory having a floor area of 60,000 square feet and a cubical content of 750,000 cubic feet.

One of the first things which must be determined before starting construction is whether power shall be purchased or supplied from a private plant. The first step in the solution of this problem is to determine the cost of heating the building. A heating plant is necessary in any case, as the conditions of manufacture are such that the temperature of the building must be kept above fifty degrees during the winter months.

The coal consumption is based on an evaporation of seven pounds of water per pound of coal, one change of air per hour in the factory and the supplying of radiation losses. During zero weather 90 boiler horsepower will be required. Having determined the size of boiler plant necessary the next step is to take up the cost of heating. Table 2 gives the investment necessary, together with the fixed and operating costs of the plant.

Replacement of the plant has been provided for by a sinking fund drawing 5 per cent. interest compounded semi-annually, based on a life of the various parts of the plant as given in the table. The time of the fireman has been figured for the entire year, as steam at high pressure is required the entire year for industrial purposes. It is of interest to note that the cost of coal represents only a little over 50 per cent. of the total cost of heating, and that a variation of 25 per cent. in the amount of coal burned causes only 13 per cent. variation in the total cost.

Having determined the expense which is absolutely necessary in connection with the power requirements, the question asked is whether it is advisable to go a step further and make the additional investment necessary for generating power, or whether it shall be purchased from a power company. The answer, obviously, depends upon the additional cost of producing this power and the rate at which power can be purchased. Having determined the former, the rate at which power can be purchased to advantage is fixed.

The concern under consideration has a maximum demand for 100 kilowatts of power. The average load is 80 kilowatts, giving an 80 per cent. ten-hour load factor. The engine is of the Corliss noncondensing type, requiring 30 pounds of steam per indicated horsepower-hour. The boiler evaporation is taken at seven pounds of water per pound of coal, giving a coal consumption of 4.3 pounds per indicated horsepower-hour. The efficiency from steam cylinder to switchboard is 78 per cent., giving a coal consumption of 7.39 pounds per kilowatt-hour or 5.51 pounds per horsepower-hour at the switchboard. The factory runs 300 days per year.

Table 3 gives the investment cost, fixed cost and operating cost of the plant, allowance being made for the cost of heating, as calculated.

Among the items of fixed cost will be found one covering a profit on the additional investment required for a power plant. It is clear that a concern is not justified in investing in a power plant unless the capital so invested returns the same profit as if invested in the most profitable part of the business still capable of extension. When the added risk is taken into consideration, this could safely be raised to 10 or 15 per cent. It is evident from these results that if power can be purchased for 2.3 cents per kilowatt-hour there is no advantage in installing a steam-power plant.

TABLE 3.

Complete Power Plant Investment.		
Capacity, 100 kilowatts.		
Engine, generator, switchboard, wiring (A)	$5,500.00	
Boilers, steam piping, auxiliaries (B)	5,000.00	
Building, foundations, stack (C)	5,000.00	
		$15,500.00
Steam-heating plant		4,000.00
Additional for power		$11,500.00
Fixed Cost of Power Plant.		
Interest, 6 per cent. on $15,500	$930.00	
Profit, 5 per cent. on $11,500	575.00	
Insurance and taxes, 2 per cent. on $15,500	310.00	
Amortization on (A), 3 per cent. (20-year life)	165.00	
Amortization on (B), 4½ per cent. (15-year life)	225.00	
Amortization on (C), ½ per cent. (50-year life)	25.00	
		$2,230.00
Fixed cost on heating plant		400.00
Additional for power		$1,830.00
Operating Cost of Power Plant.		
240,000 kilowatt-hours.		
Coal @ 7.39 pounds, 887 tons @ $3.00	$2,661.00	
Banking, 181 tons @ $3.00	543.00	
Night heating, 202 tons @ $3.00	606.00	
Engineer @ $18.00 per week	936.00	
Fireman @ $15.00 per week	780.00	
Water	100.00	
Oil, waste, supplies	150.00	
Repairs	200.00	
		$5,976.00
Operating cost of heating plant		2,305.00
Additional for power		$3,671.00
Total additional for power		5,501.00
Cost per kilowatt-hour		0.0229
Cost per horsepower year		51.40

At the present time, however, an engineer would scarcely make any decision without investigating the cost of producing power by means of a gas-producer plant. The most active competitor of the steam engine for power production is the gas-producer plant. This type of plant, which has developed since 1900, has shown remarkable economy of coal consumption when handled by experienced operators. The United States Geological Survey report on gas-producer plant shows that for an average of a great many tests the noncondensing steam plant requires 2.7 times as much coal per unit as the producer plant. Their results give a thermal efficiency at the switchboard of 4.86 per cent. for the steam plant and 13.5 per cent. for the producer plant. The maximum attainable efficiency is probably 10.3 per cent. for the steam plant and 21.5 per cent. for the gas producer under present conditions. In view of this known economy a great many producer plants have been installed in the last few years.

For the factory under consideration the conditions will require the installation of a 175-horsepower engine and producer, and in addition a heating plant for heating the building. As this heating plant is required in any event, the cost of heating is eliminated as a comparative factor in the problem. The investment, fixed costs and operating costs of this plant are given in Table 4. The cost of the plant is somewhat higher than the corresponding steam plant. The life of the plant is also shorter. This gives a higher fixed cost than for the steam plant.

TABLE 4

GAS PRODUCER PLANT

INVESTMENT		
Engine and producer (A)	$11,900 00	
Generator, switchboard, wiring (B)	2,500 00	
Building (C)	2,500 00	
	$16,900 00	
FIXED COST		
Interest, 6 per cent on $16,900	$1,014 00	
Profit, 5 per cent on $16,900	845 00	
Insurance and taxes, 2 per cent on $16,900	338 00	
Amortization on A, 15-year life, 4½ per cent	535 00	
Amortization on B, 20-year life, 3 per cent	75 00	
Amortization on C, 50-year life, ½ per cent	12 50	
		$2,819 50
OPERATING COST		
240,000 kilowatt-hours		
Coal, 3 pounds per kilowatt-hour at $4.00 per ton, 360 tons	$1,440 00	
Engineer at $18.00 per week	936 00	
Oil and waste	125 00	
Repairs	300 00	
Water	133 00	
Emergency service	300 00	
		$3,234 00
Total		$6,053 50
Cost per kilowatt-hour		0 025
Cost per horsepower-year		56 20

The operating costs of the producer plant are only about one-half that of the steam plant. This, however, is counterbalanced by the cost of heating. The final result gives a slightly higher cost for the gas-producer plant. The ratio of the fixed cost to operating cost in the two cases, however, produces a very marked effect where the load factor is poor. The only items affected by the output of the plant are coal and water. These represent only about 27 per cent of the total cost, as against 50 per cent with the steam plant, the result being a very much higher cost for the gas producer at low load factors. The poor fuel economy on light loads would further exaggerate this effect.

DISCUSSION

Mr. Moses: I think Mr. Parker's paper is typical of the central-station point of view, in that it exaggerates each item of the cost and the result is a great exaggeration. He says that since the installation of a plant costing $10,000 to $20,000 will constitute a physical improvement to the property, it is obvious that the taxes will be increased. I have installed a number of plants in this city and do not know of a single case where the taxes have been increased. Furthermore, I do not know of any cases where the taxes have been decreased, owing to a plant having been discontinued.

On the subject of insurance, Mr. Parker allows a charge of 3 per cent. In the modern fireproof building the insurance on the contents is about one-quarter of one per cent. In addition to this there is the liability and accident insurance. This, in New York State, under the new law is about 3 per cent. of the cost of labor, and of the labor in the boiler and engine rooms about one-half is chargeable to the heating. In a plant costing $20,000, the labor will be about $5000 per annum; hence, this charge would be about $75 per year, which is about three-quarters of one per cent. upon the investment.

Considering the cost of the equipment in the typical isolated plant selected by Mr. Parker, the cost of a 100-kilowatt engine and a 50-kilowatt engine is given as $4195. We recently purchased two 100-kilowatt engines for $3000.

Mr. Bolton: I wish to controvert the statements of the previous speaker in so far as they refer to conditions in this city. The insurance on hazardous labor has now risen in this State until it amounts to nearly 6 per cent. Mr. Parker has amortized his depreciation at a rate of compound interest which we are not able to get in this city, namely, 6 per cent. Referring to the table showing the rate of amortization, I would say that, capitalized at 3 per cent., which is the rate obtainable in most savings banks, the average would be more like 4.5 per cent. on the total; hence the figure given in Mr. Parker's table should be increased by about 2 per cent.

The use of exhaust steam as a byproduct depends upon climatic conditions; the nearer the plant is to the North Pole, the more efficient the use of the exhaust steam; and the nearer to the Equator, the less efficient its use becomes. The following statistics, showing the percentage of live steam used based upon the total steam supplied, are taken from the records of a large steam company in this city: October, 3.2 per cent.; November, 7.2 per cent.; December, 15.5 per cent.; January, 25.7 per cent.; February, 22.6 per cent.; March, 20.6 per cent.; April, 5.2 per cent. The corresponding figures for a large office building situated only a few blocks from the other plant, were as follows: October, 13.4 per cent.; November, 12.9 per cent.; December, 14.8 per cent.; January, 15 per cent.; February, 13.9 per cent.; March, 16.1 per cent.; April, 13.73 per cent. If anyone can make these fit together, I should be glad to know it.

Mr. Williams (New York Edison Company): I am compelled to take issue with Mr. Parker and Mr. Hibner; they have not placed the cost of current, at least under conditions existing in such a city as New York, at anywhere near its true value. In Mr. Hibner's paper the amount allowed for heating the building with an average steam-heating load of 62 horsepower is altogether too high; $2800 should cover the investment instead of $4000, and upon this basis the annual fixed cost upon the investment would be $300 and not $600. As to coal, for heating alone the cost appears overstated. Four hundred tons, for an average of 62 boiler horsepower for the heating season, would be sufficient, which, at $3 per ton, would cost $1200. In the matter of labor, a fireman's wages for a full year have been charged. Assuming that one would be sufficient, the wages chargeable to heating for thirty instead of fifty-two weeks would be $450. Making these changes, the yearly cost of heating the building would be about $2000 instead of $2705. I would summarize the fixed charges at 15 per cent., and, making this allowance, the final result becomes 5.5 cents per kilowatt-hour instead of 2.29 cents.

Referring to gas-producer plants, they are hardly more reliable in their operation and hardly longer in life than an automobile engine. Therefore, I would change the ratio of depreciation on the total investment to 20 per cent.

Mr. Parker estimates 2.03 per cent. as the annual depreciation, but I do not know of any case where annual depreciation is actually put aside in a fund upon which interest is accumulated from year to year. Therefore, I would change the general depreciation rate to 7.5 per cent. Two causes for depreciation have been given—obsolescence and physical life; however, there is a third, and that is, the moment that a competing service becomes available at a cost not exceeding the cost of operating the private plant, then the depreciation of that plant has become 100 per cent., and as long as its operation is continued, it must be apparent that operation is continued at a loss to the operator.

Some years ago Mr. Parsons presented a paper in which he gave the average number of pounds of coal consumed per kilowatt-hour in a number of plants. I believe there were three apartment houses, three hotels and three clubs, representing in these three classes the most difficult service with which a central station in a large city must compete. I have never seen the accuracy of Mr. Parsons' figures questioned, but I have seen them confirmed in many ways. They show as high as 25 pounds of coal per kilowatt-hour generated, including the coal required for heating. The average was 17.3 pounds, and the average of all, divided by the kilowatt-hours required, was 15.5 pounds of coal per kilowatt-hour. Contrasted with this it is customary to have preliminary estimates of from 6 to 7 pounds of coal per kilowatt-hour.

Mr. Kimble: In Mr. Hibner's paper the basis of profit is taken at 5 per cent. I do not think any manufacturer will go into business on the basis of a 5 per cent. profit, with the anxiety and worry and chance of failure, when that profit can be obtained by the purchase of any ordinary good bond on the market. I called up a half dozen manufacturers in Brooklyn and asked them what turnover they would consider it necessary to have on $15,000. The lowest man of the six gave a turnover of 15 per cent., on the basis of 5 per cent. for the use of the money, thus giving a net profit of 10 per cent., twice the amount given in the paper. The highest man of the lot gave a turnover of 30 per cent., stating that they turned over their money on an average of ten times a year, with a profit of 3 per cent. each time. Between these two extremes it would be safe to take 15 per cent. as a fair profit.

As to the amount of coal, my experience in plants of this size has shown that about ten pounds of coal per kilowatt-hour is a conservative figure. If that is taken into consideration, together with the increased profit, it will bring the cost per kilowatt-hour to 2.84 cents. If allowance is made for part of the manager's time, this, together with either of the other items, will bring the cost of power, based on Mr. Hibner's figures, to over three cents per kilowatt-hour. Any large public-service corporation would be very glad to supply power to such a plant for three cents per kilowatt-hour on a term contract.

Mr. Ripley: I would like to have it go on record that the Commonwealth Edison Company, of Chicago, to my own certain knowledge, owns and operates three isolated plants in the basements of buildings. If these industrial-plant owners need any further encouragement, as far as depending upon these certain engines is concerned, I will say that the Commonwealth Edison Company depends upon the Ideal engine and upon the Corliss engine, as well as high-speed engines, and I cannot see but that the owners of industrial plants can likewise depend on similar apparatus designed by the same people.

Mr. Fowler: When I received the notice of this meeting tonight it struck me that we were coming here to discuss a problem that was about as easily solved as it would be to discuss the size of a piece of chalk the length of a piece of string. It is a very easy thing to sit down and tell what a plant should do, but it is almost impossible to sit down in advance and tell what it actually will do. It is not difficult to go into a plant and make an analysis of what they are doing and get the figures, but to sit down in cold blood in an office and figure out what it is doing, with all the variables that must be taken into account, is almost an absolute impossibility.

Mr. Parker: I want to clear the ground ethically. Mr. Moses refers to the paper I offered as being characterized by central-station animus. I tried to keep it from that as much as possible. It is manifest that a central-station man would be decidedly idiotic if he attempted to exaggerate the claims at all in favor of himself. I answer that statement by the obvious statement that the only thing a central-station man can offer to do is to make his claims as reasonable as possible. Mr. Moses misunderstood the statement of the insurance charge. Insurance is not claimed to be 3 per cent.—taxes and insurance are said to be 3 per cent., and that would cover casualty insurance on both patrons and employees.

The rental value of the space is, I believe, absolutely right. The proprietor of the store acknowledged the figures used in the table as being right. The basement of a department store handles five-, ten-, twenty-five and thirty-cent articles, which sell with a tremendous margin of profit, and in tremendous volume. That is good rental space in a department store. The figures are given as representative of what obtained in the specific plant in question. I do not mean that the rental value for power-plant sites given in this table would apply to every type of building necessarily. The actual cost figures given are unquestionably large, but these prices were actually paid by responsible manufacturers for the plant delivered in place ready to operate. The figures for the engines cover the holding-down bolts, putting the engine together, limbering up and getting ready to turn over, and as to the latitude of the figures elsewhere, the point is made that synthetic plant costs are different from form quotations, which a man will make good on. Form quotations are 50 to 75 per cent. higher than the synthetical plant cost.

I cannot too heartily indorse what has been said in regard to the pernicious practice of retaining engineering service in connection with industrial-power work. Having a man work on salary for a public-service enterprise, or having him work on commission, is rather objectionable, because I know, personally, that with the best motives in the world a man finds it very hard not to be biased by his own personal interest. I believe that the salvation of such a situation will come in this way—that the industrial engineer employed by a public-utility company will recognize that the best interests of his company consist not in taking all the business there is in sight, but in taking only that business which he, as an independent consulting engineer, would recommend a client to take. The central-station engineer doing that will get away from the prejudicial results of his personal bias. The man in private practice should not work on commission; he should work for a retainer or for a fixed sum, and that sum should be amply large. I think that most of the industrial-engineering work today is being done for utterly miserable fees, and the result is that the pressure is very great on a man to sacrifice his highest ethical standard or to allow his judgment to be governed by his personal interest in the way of trying to bolster up his commissions.

The written discussion, which was not given at the meeting, will follow in a later issue.

Blowoff Tank Accident

The bottom of a cast-steel blowoff tank was blown out, on February 21, at the Pittsfield Y. M. C. A. building and the engineer was badly scalded. The plant consists of two 54-inch boilers, two turbines and auxiliaries and apparatus for filtering the swimming-pool water and lighting and heating the building. One boiler was being blown down under 125 pounds pressure. The 2-inch blowoff pipes from the boilers united in the 2½-inch line which led to a 36x36-inch tank. The 2½-inch sewer outlet was sealed with water and there was a 2-inch vent to atmosphere as usual. The flat bottom of the tank apparently dropped out under pressure and the tank lifted, bending a steel I-beam above it and breaking several 3-inch water pipes. It is supposed that the bottom of the tank was filled with scale and so prevented the sewer outlet from working.

Coal Land Frauds

It is reported in the daily press that the Government investigation into alleged Alaskan coal-land frauds involving approximatelly 48,000 acres of land, valued at more than $50,000,000, has resulted in the issuance on March 6 of an indictment by the Federal grand jury at Detroit, charging seven individuals with conspiracy against the United States.

The contention of the Government is that the defendants conspired to induce between 200 and 300 individuals to become stockholders in the Michigan-Alaska Company by making fraudulent and fictitious locations of certain Alaska coal lands," thereby violating the land-entry laws of 1910, which made it illegal for more than four persons to form a company for locating Alaska coal lands and taking out patents on more than 640 acres. It is alleged that several stockholders or coal-land claimants were led to believe that they were locating the lands for their exclusive use, "but in truth and in fact for the use and benefit of the seven defendants and the Michigan-Alaska Development Company."

The Michigan-Alaska Development Company was organized under the laws of Arizona. W. W. McAlpine is the president. The coal lands involved are situated at Juneau, Alaska, and several contiguous tracts in the vicinity of Homer, upon the westerly end of Kenai peninsula, bordering upon Cook inlet. The claims are said to have been located by about two hundred Detroit and Michigan residents and a hundred other claimants from New York, Chicago, San Francisco, Seattle and other points.

Donkey Engine Boiler Explodes and Kills Seven

On March 4, the boiler of a donkey engine in the logging yard at the river mill of the Portland Railway, Light and Power Company near Estacada, Ore., exploded and caused the instant death of five men, the injury and subsequent death of two others and the serious injury of still another. The boiler rose 500 feet in the air and fell to the ground a quarter of a mile away. For several days, it is said, the safety valve on the boiler had not been working satisfactorily and experiments had been carried on with a number of improvised devices. On the very morning of the explosion one of the contractors had started for Portland with the express intention of providing a new valve, but he had only gone a few miles when reports of the explosion caused him to retrace his steps.

Wisconsin Engine Company Makes Extensive Additions

The Wisconsin Engine Company, of Corliss, Wis., which is about twenty miles from Milwaukee, has just made a considerable addition to its equipment and working capital. Hitherto the company has been controlled by strong Pittsburg interests, but on account of its location it became desirable to bring Milwaukee capital into the company, and two of the new directorate are prominent business men of the latter city. E. T. Adams has been made president of the company.

Heretofore the principal business of the Wisconsin Engine Company has been the manufacture of Wisconsin Corliss engines. It is the purpose of the new organization to foster and to build up the existing Corliss-engine business, but the addition of new capital and new equipment is chiefly for the purpose of enabling the company to enter extensively into new lines of manufacture. Chief of these will be the Adams gas engines, which will be manufactured in sizes from 200 to 8000 horsepower in a single unit. It is stated that the company has already secured orders for upward of 10,000 horsepower of the Adams engines, and increased shop facilities and new equipments are now being installed to permit the rapid and economical production of this additional line of manufacture.

E. T. Adams, the new president of the company, has been identified with the manufacture of heavy machinery for many years, dating back to the early days of the Edward P. Ellis Company, of Milwaukee, where, under Mr. Reynolds, he was connected with the design and installation of most of the important power and pumping installations in the country. Mr. Adams was a pioneer in the heavy gas-engine business in the United States, being identified with the first large gas engine put out by the Westinghouse company and later the manager and chief engineer of the gas- and mill-engine department of the Allis-Chalmers Company. It is probable that considerably over half of the large gas engines now in operation in this country are of Mr. Adams' design, including the Allis-Chalmers engines in the plant of the Steel Corporation at Gary, Ind.

Second Monthly Meeting of Engineers' Institute

The second regular monthly meeting of the proposed Institute of Operating Engineers was held at the Engineering Societies building, New York City, on March 9. About 150 members and friends of the temporary organization were present.

Prof. W. D. Ennis, of the Brooklyn Polytechnic Institute, delivered a paper entitled "The Commercial Aspect of the Work of the Operating Engineer." An abstract of this paper will be published in a following issue, together with an abstract of the discussion which was offered by Willis Lawrence.

Cast Iron Elbow Bursts

On February 27, a cast-iron elbow in the blowoff pipe of a 135-horsepower horizontal tubular boiler in the plant of the La Porte Electric Company burst while the boiler was being fired up. A pressure of 40 pounds was on the boiler at the time. The boiler was shaken in the setting and the brickwork considerably damaged. Had the accident occurred after the boiler had been cut in the battery with the six other boilers at 125 pounds, there is not much doubt that the accident would have been more serious. The boiler had been washed out and inspected on February 10 and had not been used since that time. This is only one more reason why cast-iron fittings should not be used.

On February 17, Governor Dix sent a special message to the legislature recommending that a resolution be passed urging upon Congress careful consideration of two bills now before that body relating to the use of hydraulic power of the Niagara river and confirming a legislative grant for hydraulic development of the St. Lawrence river by the Long Sault Development Company. These measures are known respectively as the Alexander and Oliver bills.

A bill has been introduced in the Ohio State legislature providing for the formation of a State department of boiler inspection. A chief inspector at $2400 and six deputies at $1800 per annum are authorized. This department is to have supervision of all stationary boilers except those used for heating plants and very small boilers. An inspection fee of $5 is to be charged.

PERSONAL

C. W. Van Blarcom, New York representative of Noonan Brothers, of Troy, for the past fifteen years, died suddenly on March 7. Mr. Van Blarcom was 40 years of age and leaves a widow.

Moses Nelson Baker, editor of *Engineering News*, was the speaker of the evening at the charter-day exercises of the fifteenth anniversary of the Thomas S. Clarkson Memorial School of Technology, held on March 17. The topic chosen by Mr. Baker was "The Engineer and Social Service."

George Q. Palmer, formerly vice-president, has been made president of the Alberger Condenser Company and the Alberger Pump Company. Mr. Palmer is succeeded as vice-president in the Alberger Condenser Company by D. H. Chester, and in the Alberger Pump Company by W. S. Doran.

On March 18, John W. Lane, formerly an engineer of Providence and for some time editor of the *National Engineer*, the official organ of the National Association of Stationary Engineers, was tendered a reception by Rhode Island No. 1. He was greeted by a large number of friends from Rhode Island and Massachusetts.

NEW PUBLICATIONS

A bulletin describing the Moore patent automatic fuel-oil regulating system and entitled "Unnecessary Losses in Firing Fuel Oil and an Automatic System for Eliminating Them," is being issued by Charles C. Moore & Co. It can be obtained upon request from the offices of the company at San Francisco, Los Angeles, Seattle, Portland and Salt Lake City.

The system controls the supply of oil to all burners, the supply of the atomizing agent to all burners, and the supply of air for combustion, for any number of boilers, all from a central point. The results claimed are: Increased boiler-plant efficiency, the practical prevention of smoke, and the decrease in the maintenance cost of boiler equipment, due to a more uniform manner of firing. Such a system was first installed at the Redondo plant of the Pacific Light and Power Company in 1907. Here the regulating system is used to control the entire plant of 16 boilers of 600 horsepower each, and the increased economy due to the uniform rate of firing is very evident.

Qualitative Chemical Analysis. By J. I. D. Hinds. Published by the Chemical Publishing Company, Easton, Penn., 1910. Cloth; 285 pages, 5½x9 inches. Price, $2.

A textbook treating the subject of qualitative analysis from the standpoint of ions, solubilities and mass action. By this method it is hoped that the student will be better prepared to take up the study of physical chemistry. The classification of the kations is similar to that used in other textbooks, but a systematic method of separating and identifying the anions is given, which should prove helpful to the beginner. There is a complete list of the reagents and the solutions, together with the methods of preparing them to a given concentration. Among the useful tables is one giving the solubility in water of most of the substances ordinarily met with as precipitates in the course of analysis.

BOOKS RECEIVED

Steam Turbines. By Rankin Kennedy. The Macmillan Company, New York. Cloth; 101 pages, 5½x8½ inches; 62 illustrations. Indexed.

Motion Study. By Frank B. Gilbreth. D. Van Nostrand Company, New York. Cloth; 116 pages, 5x7¾ inches; 44 illustrations; indexed. Price, $2.

Industrial Plants. By Charles Day. The Engineering Magazine, New York. Cloth; 294 pages, 5x7½ inches; 48 illustrations; indexed. Price, $3.

Water Turbine Plant. By Jens Orten-Böving. Raithby, Lawrence & Co., Ltd., London, W. C., England. Cloth; 197 pages, 8½x10¾ inches; 216 illustrations.

Mathematics for the Practical Man. By George Howe. D. Van Nostrand Company, New York. Cloth; 143 pages, 4½x7½ inches; 42 illustrations; tables; indexed. Price, $1.25.

Elements of Graphic Statics. By William L. Cathcart and J. Irvin Chaffee. D. Van Nostrand Company, New York. Cloth; 304 pages, 5½x9 inches; 159 illustrations; indexed. Price, $2.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

INTERNAL COMBUSTION MOTOR. Karl Fabel, Hamburg, Germany. 985,793.

ROTARY ENGINE. William M. Hoffman, Buffalo, N. Y., assignor to the Hoffman Patents, Ltd., a Corporation of Canada. 985,804.

ELASTIC-FLUID TURBINE. Charles G. Curtis, New York, N. Y., assignor, by mesne assignments, to General Electric Company, a Corporation of New York. 985,885.

ROTARY INTERNAL COMBUSTION ENGINE. Orsemus L. R. Jones, Detroit, Mich. 985,907.

EXPLOSIVE ENGINE. Mathew B. Morgan, Lansing, Mich., assignor of one-half to Oscar M. Springer, Detroit, Mich. 985,920.

ROTARY ENGINE. Hubert I. Call, Spokane, Wash., assignor to the Hercules Rotary Engine Company, Ltd., Wetaskiwin, Canada, a Corporation. 985,974.

ELASTIC-FLUID TURBINE. Charles G. Curtis, New York, N. Y., assignor, by mesne assignments, to General Electric Company, a Corporation of New York. 985,982.

STEAM ENGINE. Christopher F. Laufer, Richmond, Cal. 986,016.

ROTARY ENGINE. Frank Wyle, St. Louis, Mo. 986,116.

TURBINE. Henry F. Schmidt, Pittsburg, Penn., assignor to the Westinghouse Machine Company, a Corporation of Pennsylvania. 986,317.

INTERNAL COMBUSTION ENGINE. Andrew Betts Brown and William Albert Hickman, London, England; said Brown assignor to said Hickman. 986,353.

ELASTIC-FLUID TURBINE. Charles G. Curtis, New York, N. Y., assignor, by mesne assignments, to General Electric Company, a Corporation of New York. 986,368.

ELASTIC-FLUID TURBINE. Charles G. Curtis, New York, N. Y., assignor, by mesne assignments, to General Electric Company, a Corporation of New York. 986,368.

BOILERS, FURNACES AND GAS PRODUCERS

FURNACE. Roy E. Ashley, Muskegon, Mich. 985,878.

OIL BURNER. Adolf Klein, Vienna, Austria-Hungary. 986,067.

WATER-TUBE BOILER. Minott W. Sewall, Roselle, N. J., assignor to the Babcock & Wilcox Company, Bayonne, N. J., a Corporation of New Jersey. 986,089.

STEAM BOILER. Minott W. Sewall, Roselle, N. J., assignor to the Babcock & Wilcox Company, Bayonne, N. J., a Corporation of New Jersey. 986,090.

POWER PLANT AUXILIARIES AND APPLIANCES

FEED-WATER HEATER. Charles Caille, Le Perreux, France. 985,778.

FEED-WATER HEATER FOR PREVENTING PITTING. John C. Parker, Philadelphia, Penn. 985,834.

BALANCED VALVE. Baxter M. Aslakson, Salem, Ohio. 985,879.

GOVERNOR. Ernest L. Nance, St. Louis, Mo. 985,022.

REDUCING VALVE. John Graham and Archibald Graham, Jr., Glasgow, and David Auld Graham, Rutherglen, Scotland. 986,165.

WATER-GLASS GUARD. George Moser, Minneapolis, Minn. 986,199.

ASH DISCHARGER. Frederick P. Palen, Newport News, and William Burlingham, Hampton, Va. 986,208.

ROTARY VALVE. Charles H. Harkins, Derby, Kan. 986,284.

CONDENSER FEED LUBRICATOR. Chas. Cheers Wakefield, London, England. 986,330.

WATER TRAP. Joseph Joy, Donora, Penn. 986,394.

ELECTRICAL INVENTIONS AND APPLICATIONS

ELECTRICAL TERMINAL CONNECTOR. Ray H. Manson, Elyria, Ohio, assignor to the Dean Electric Company, Elyria, Ohio, a Corporation of Ohio. 985,821.

INDUCTION COIL. Richard Varley, Englewood, N. J., assignor to the Autocoil Company, a Corporation of New Jersey. 986,033.

ELECTRIC BATTERY. Carl Jaeger, Seattle, Wash. 986,064.

SYSTEM OF MOTOR CONTROL. William Siebenmorgen and Samuel H. Keefer, Plainfield, N. J., assignors to Niles-Bement-Pond Company, Jersey City, N. J., a Corporation of New Jersey. 986,091.

INSULATING CAP. James C. Phelps, Springfield, Mass. 986,213.

ELECTROPLATING MACHINE. Constantine G. Miller, Chicago, Ill., assignor to the Meaker Company, a Corporation of Illinois. 986,303.

THERMAL CIRCUIT CLOSER. Fredrick C. Guptill, Elgin, Ill., assignor of one-half to William F. Lynch, Elgin, Ill. 986,382.

POWER PLANT TOOLS

CHAIN PIPE WRENCH. George Amborn, New York, N. Y., assignor to J. H. Williams & Co., Brooklyn, N. Y., a Corporation of New York. 985,766.

WIRE-TIGHTENING DEVICE. Henry F. Heitmeyer, Friendship, Ind. 986,058.

WRENCH. John C. McLean, Cleveland, Ohio. 986,192.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City. Spring meeting in Pittsburg, May 30 to June 2.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York. Next meeting in New York City, May 29 to June 2.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Commander U. T. Holmes, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., O. P. Chamberlain; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill. Meeting first Wednesday of each month.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., Walter Riddle; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Pres., R. P. Bolton; sec., W. W. Macon, 29 West Thirty-ninth street, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio, September 12-15, 1911.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June 5-10, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting at Detroit, Mich., January 15-19, 1912.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May 23-26, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

POWER

NEW YORK, MARCH 28, 1911

"THERE ain't no chance these days for a fellow to get along" is the sentiment often expressed with the degree of grammatical accuracy quoted. And for the grown man who talks that way, usually there "ain't." But, truth to tell, these are wonderful times, and there are more opportunities than ever just going abegging for lack of men to see and make use of them.

If you cannot readily believe this, we half suspect that you are one of those who sing the refrain quoted in the opening sentence. Figure over the matter for a minute.

What were the engineer's opportunities 50 years ago? Pretty small and few in a hill, weren't they? Ignorance was rife; means for self-education were totally lacking; jobs were small; the engineer had absolutely no standing, and, worst of all, there was no incentive for him to improve himself even if he had the inclination. His life was a dull, dirty, colorless monotony.

Today, there is hardly any limit to the progress that the engineer can make, the field is so broad. There are positions for men of every caliber from the two-dollar to the twenty-dollar-a-day man. There are means easily within the reach of all of fitting oneself for higher grade work; these are the correspondence schools, the engineers' periodicals, the countless good books and the associations—all can be made sure stepping stones by the man who *will*.

No one can "wish" himself well. A man must attain good health, once he has lost it, by careful diet, proper exercise and rest. So also with advancement; "wishing" that you had the other fellow's "cinch" is poor "nourishment." To reap the reward of better pay requires conscientious, hard work in increasing your ability and experience.

In steam engineering today, knowledge means ability. Professor Ennis made this quite clear by his lecture to the proposed Institute of Operating Engineers on March 9. The lecture is reproduced on page 485 herein. Many engineers have already found it to be true, and its truth is dawning on an ever increasing number as time goes on.

The men for the big jobs of the future are the men who are in training for them now. If a man is unprepared when his big chance comes, it is usually too late to start.

Knowledge will not do anyone harm, even if it is never used. But how valuable it is when there is occasion to apply it!

There is great need for educated, capable men in the steam-engineering field, and that need is constantly growing. There are opportunities, open to all, to acquire education of the kind needed. The wise ones are making use of them.

If you are not thoroughly thankful that you are alive and well and kickin' on this day of grace and exceptional opportunity, it probably is because you need to see a doctor and don't know it.

Power Plant at North Carolina College

By Francis J. Thompson

A small central plant containing a De Laval turbine unit and an engine-driven unit, supplying light and power to the various buildings and heating them with the exhaust steam.

The various buildings of the North Carolina College of Agriculture and Mechanic Arts are supplied with heat, light and power from a central service station situated on the campus. The plant, although having a capacity of only 200 kilowatts, contains many interesting features for one of its size.

Steam is furnished by two 200-horsepower Atlas boilers and two 75-horsepower Babcock & Wilcox boilers (see Fig. 1), working under a normal pressure of about 125 pounds, the pressure being controlled by a damper regulator. Natural draft of about 0.5 is furnished by a 100-foot radial brick stack. A spur track from the Seaboard Air Line railroad runs in front of the boiler room and coal is dumped from the cars into concrete pockets having a capacity of 300 tons. These are in front of the boilers and may be shut off from the boiler room by corrugated-iron drop curtains.

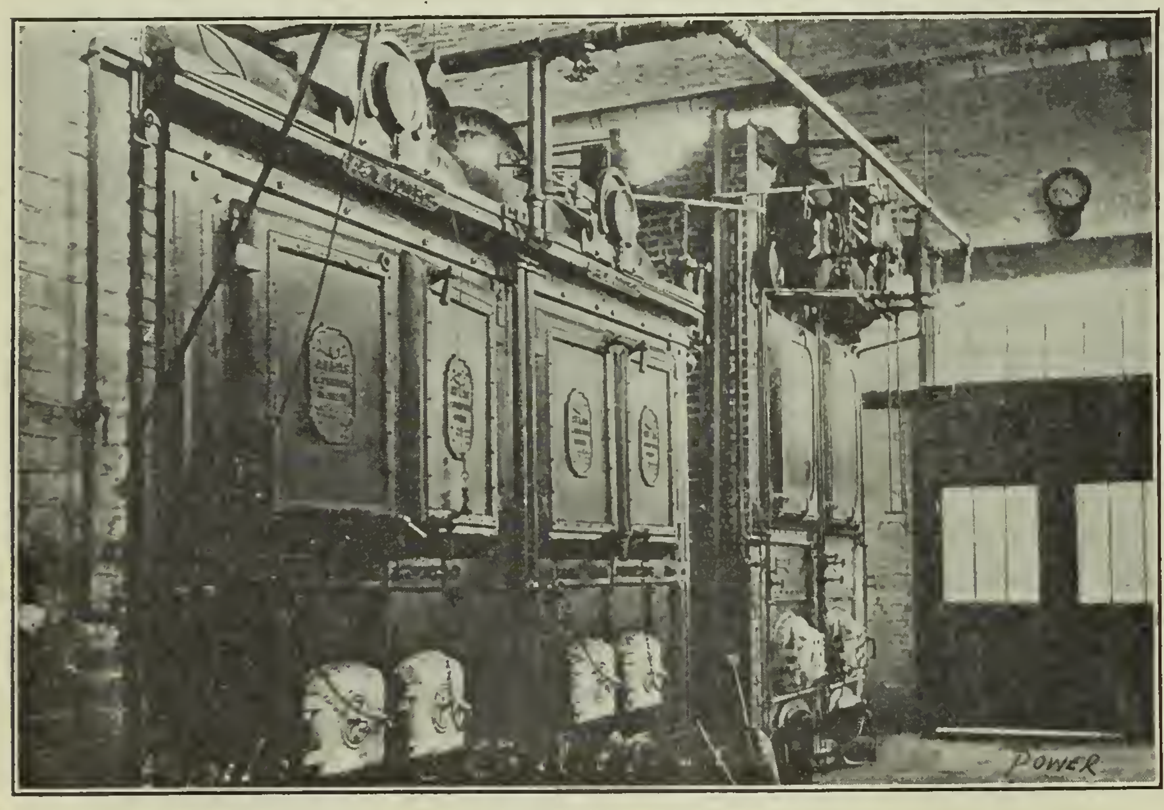


Fig. 1. Boilers

Next to the boiler room, and separated from it by a brick fire wall, is the pump room. This is several feet lower than the engine room and, on one side, is open to the latter, as may be seen from Fig. 2. A 10-inch main leads from the boilers to a header running the length of the pump room and from this header long-radius bends branch off to the steam receivers placed above the throttles of the engines. Van Stone joints are used on all high-pressure lines and a notable feature of the station piping is its accessibility.

There are two main generating units: one consisting of a 13x12-inch Skinner engine direct connected to a three-phase 60-cycle generator of 75 kilovolt-amperes capacity; the other a 150-horsepower single-stage DeLaval turbine running at 12,000 revolutions per minute and geared through 10 to 1 reduction gears, to two three-phase 60-cycle generators. Owing to the high rotative speed of a single-stage turbine the shaft must be made small in diameter, and when transmitting horsepowers of from 50 to 300 it is the practice to supply two generators for the purpose of balancing the side thrust on the turbine shaft. Mounted on the shaft of one of these generators is an exciter. Two other exciter units are provided: one a motor-generator set, and the other a direct-current generator driven by a 5x5-inch vertical engine. Either of these two exciters may be used to supply excitation to the fields of either of the main generators.

A diagram of the switchboard connections is given in Fig. 3. From this it will be seen that common practice has been departed from by supplying an ammeter for each phase. A water rheostat is also furnished for supplying the maximum load when making experimental tests in connection with the courses of instruction. The normal load comprises the motors in the machine shop, forge shop, laboratories and textile mill in addition to about 500 incandescent lamps.

The exhaust steam from the main units and auxiliaries is used to heat the various buildings on the campus through the Warren Webster system, operating at about 5 inches vacuum. This supplies approximately 40,000 square feet of radiation and the condensation is handled by two vacuum pumps delivering into a receiving tank from which the hot water flows by gravity to a Cochrane feed-water heater. Provision is made for supplying live steam to some of the buildings when the supply of exhaust steam is inadequate.

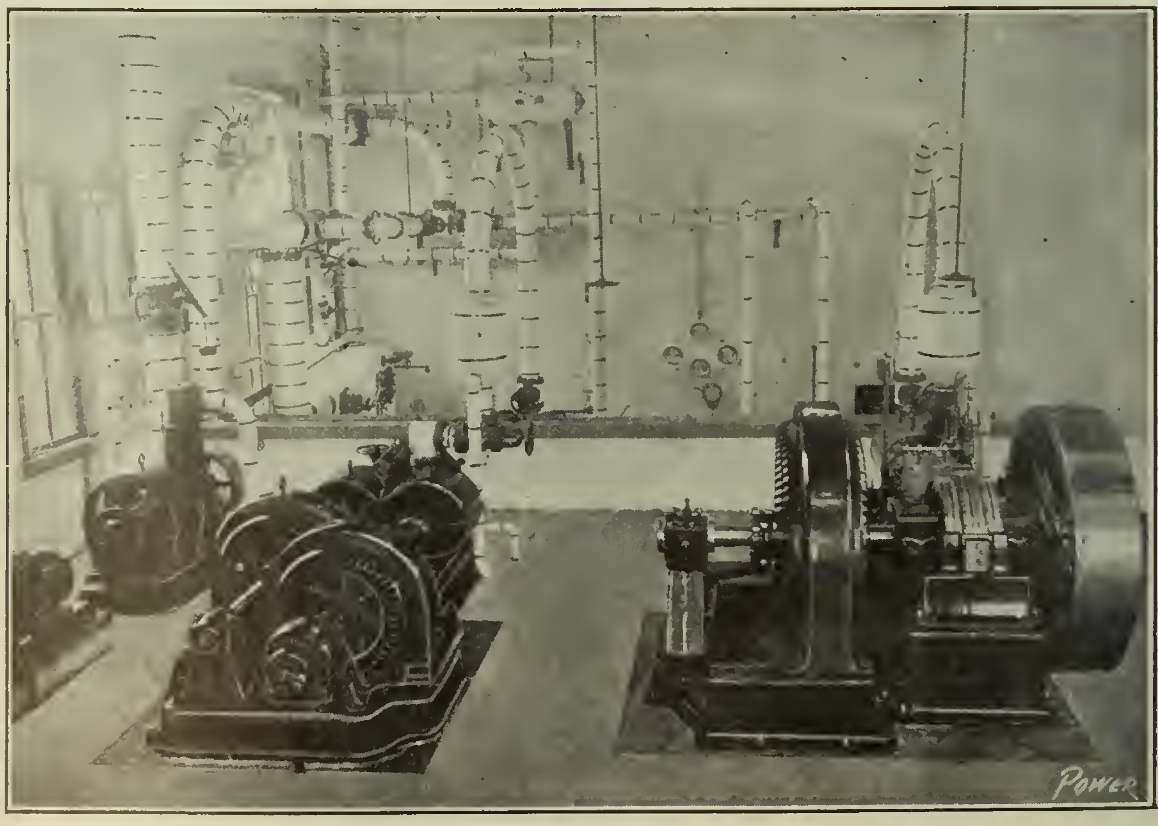


Fig. 2. Main Generating and Piping

Smoke Abatement in Glasgow and Liverpool

There are many who believe that the wisest and most hopeful method of attacking the black-smoke problem is by the education of those who have produced it, and that the further education of manufacturers and factory owners, of boiler engineers and firemen and, last but not least, of the ordinary householder is required before any real and permanent progress can be made in suppressing the black-smoke evil.

Those of our readers who accept this view will be pleased to learn that Glasgow and Liverpool have this winter followed the lead set by London three years ago, and have instituted courses of lectures for the general public and for boiler engineers and firemen upon smoke abatement.

At Glasgow the lead has been taken by the newly formed local branch of the Glasgow and West of Scotland Smoke Abatement League, and it is interesting to note that the municipality has allied itself with this body in providing two really useful and attractive courses of evening lectures; the one series intended for working boiler engineers and firemen, and the other for the general public.

The series of lectures for firemen consists of five similar courses, each of twelve lectures, delivered by the Glasgow smoke inspectors, in different centers of the working-class portions of the city, a fee of $1.25 being charged for the course. The education authorities have granted the use of suitably situated elementary schools for these lectures, and it is stated that 186 firemen and engineers have registered their names as students at one or other of the various centers, and are now attending the courses. In the majority of cases the employers have paid the fee and have urged the men to attend regularly.

The series of lectures for the general public in Glasgow is free, and is made attractive by the aid of lime-light views and experiments. The lectures are being delivered in the large hall of the technical school by several gentlemen connected with the health and medical departments of the university and city, and cover such subjects as: "The Black Smoke Problem," "The Necessity of Pure Air," "The Chemistry of Combustion," "How to Fire Steam Boilers without Smoke," etc.

In Liverpool, the school of hygiene department of the university, and the sanitary-science instruction committee of the corporation have combined to arrange a course of ten evening lectures at the school of hygiene on "The Smoke Nuisance and Its Abatement."

The course is intended primarily for working engineers and firemen but all interested in the general subject of smoke abatement are invited to attend, and, as at Glasgow, a nominal fee of $1.25 is being charged for the course.

Professor Watkinson, of the Walker Engineering Laboratories, Doctor Hawksley, of the medical offices of the health department, J. B. C. Kershaw, of the West Lancashire Laboratory, Waterloo, and Mr. McKelvy, the city smoke inspector, are delivering the various lectures of the course, which commenced on January 27 and has been continued on Friday evenings through February. It is hoped that the series now started will be the forerunner of similar lecture courses every winter in the leading seaport of the north of England.

The municipalities of Manchester, Sheffield, Birmingham, Leeds and other large inland manufacturing cities, with atmospheres certainly capable of improvement, might note the progressive action of the two northern seaports and might make arrangements for instituting similar courses of lectures in their own cities next winter.

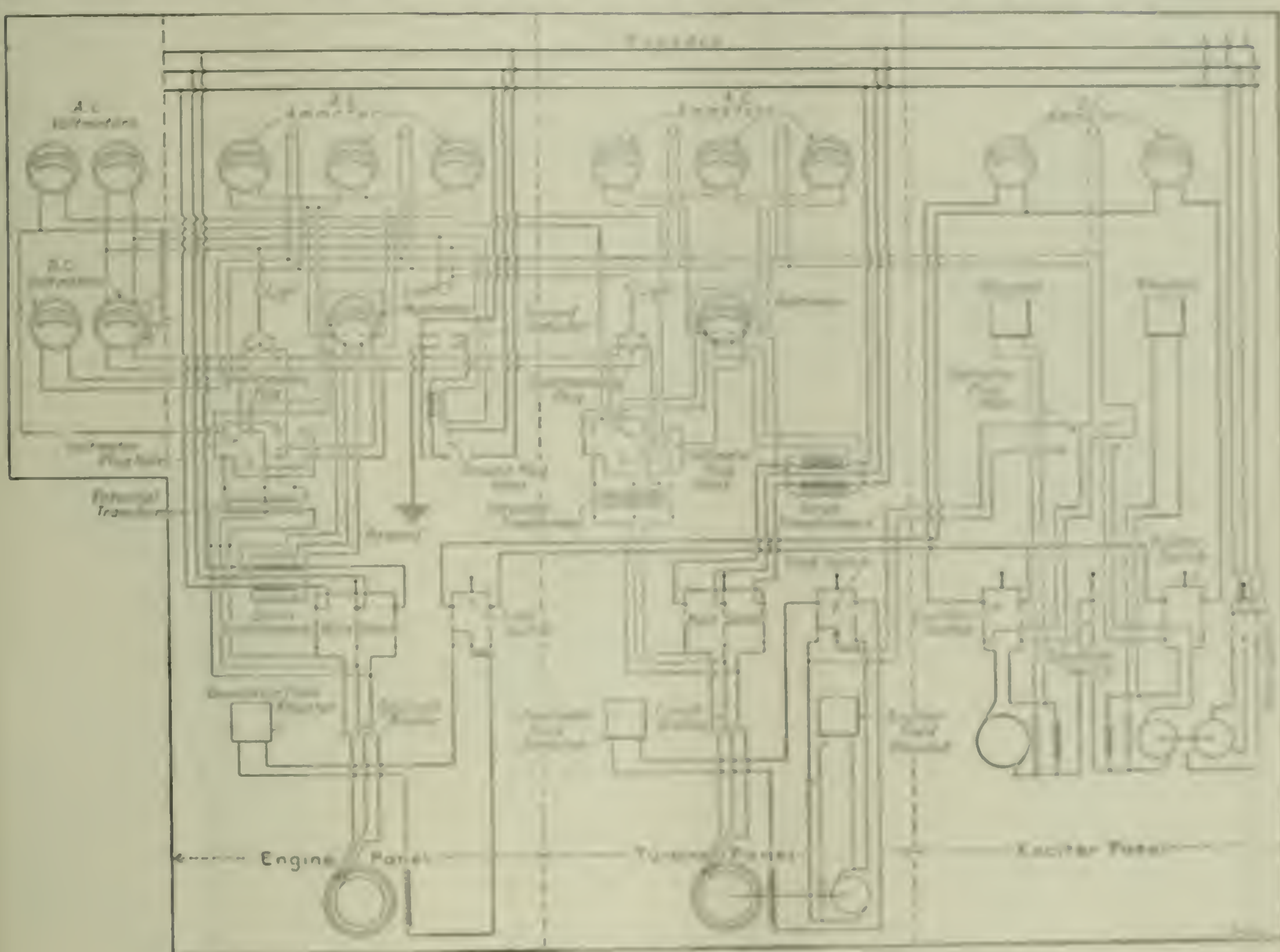


FIG. 3. DIAGRAM OF WIRING CONNECTIONS

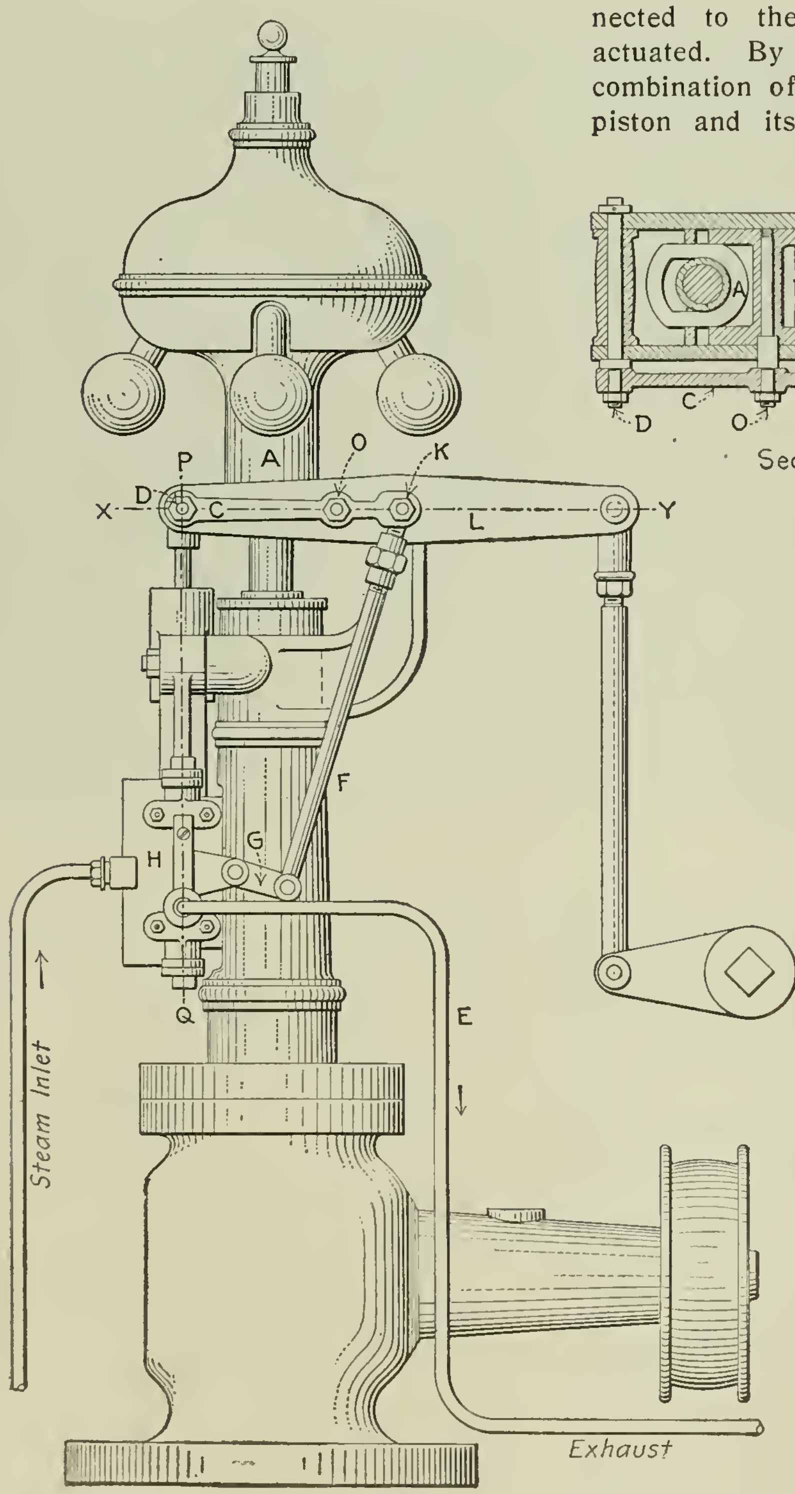
Methods of Governing Steam Engines

By John Davidson

Operation of governors controlled through relay motors, regulators or supplementary governors, safety trip gears, and crank shaft governors, representing standard English makes.

Governors Controlled through Relay Motors

Where the governor of a steam engine is required to actuate a heavy valve gear, it is difficult to obtain sufficient power, combined with sensitiveness in the governor itself, unless it be made of massive proportions; even then the friction and wear of the governor renders it an unsatisfactory piece of mechanism. Such valve gears as the Meyer and Ryder are included in this class. The gears themselves are positive, and are suitable for engines running at all speeds, but considerable force is required to move the gear to suit the variation in load.



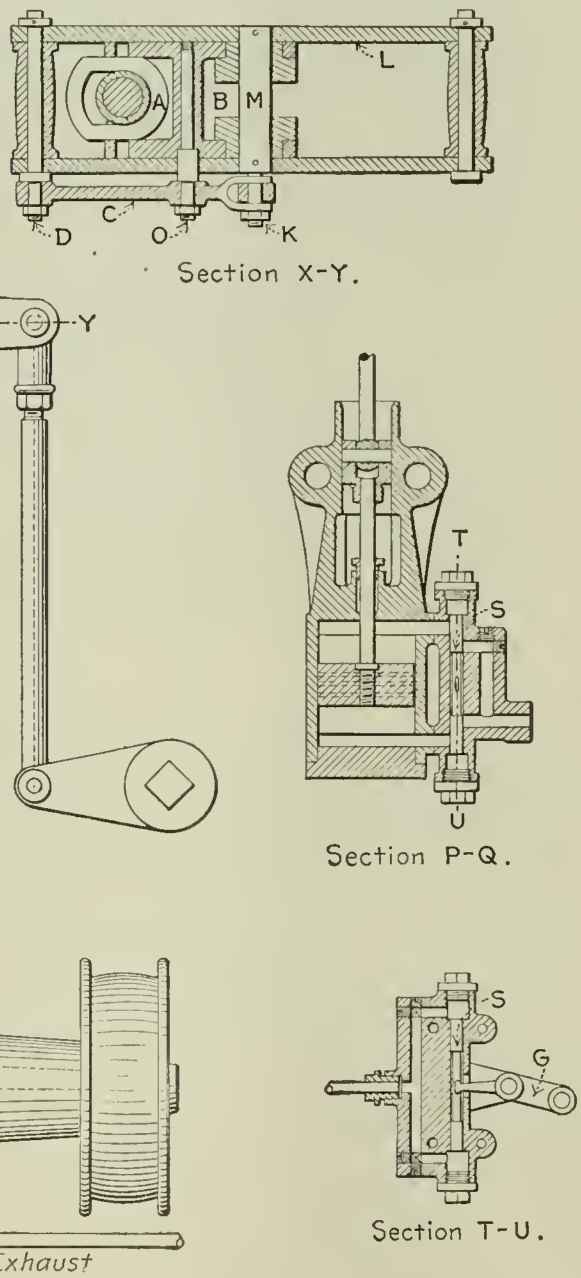


Fig. 30. Lude Relay Gear

Among the many appliances used in connection with governors as a relay gear, that invented by Lude many years ago and illustrated in Fig. 30, is perhaps the simplest in general use. With this arrangement, the only work done by the governor proper consists in controlling the piston valve of a miniature steam engine, the piston rod of which is connected to the expansion gear to be actuated. By the use of an ingenious combination of levers the motion of the piston and its connections is made to correspond with that of the governor, and, even with a very slight variation in load, the piston moves over a corresponding distance under the full steam pressure.

Referring to Fig. 30, the motion of the governor sleeve *A* is transmitted by means of the double lever *B*, to the lever *C* which is pivoted at *D* to the main lever *L*. The short arm of the lever *C* is connected by means of the rod *F* to a small lever *G* which actuates a small piston valve arranged in the casing *H* at one side of the steam cylinder. This valve controls the steam admission and exhaust ports of both ends of the cylinder. The arrangement is such that both sides of the piston are connected with the exhaust pipe when the valve occupies its central position, while a small movement of the valve in either direction will admit steam at one end of the cylinder. The resulting motion of the main piston rod and lever *L*, with its connections, causes the piston valve to return to its central position so as to again open both sides of the piston to the exhaust pipe, when the lever *L* has been turned through an angle corresponding to the movement of the governor sleeve. Normally, the center of the joint *K* corresponds with the turning axis *M* of the lever *L*. When the governor sleeve is moved the lever *C* is caused to turn about the center *D*,

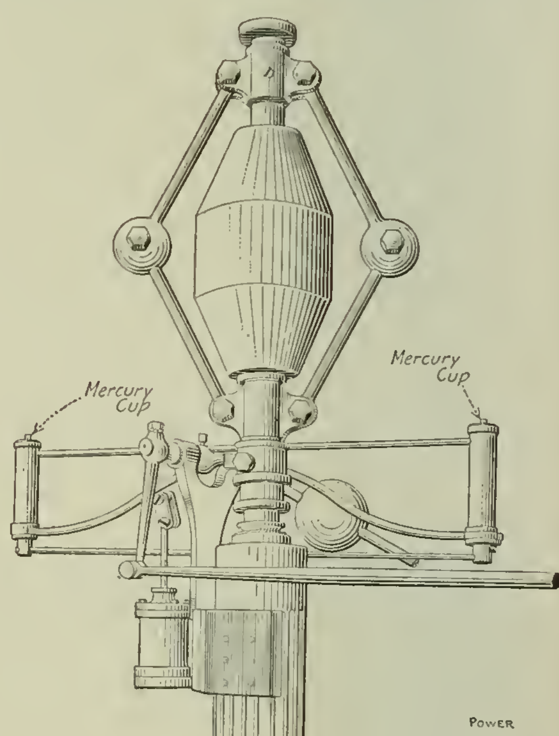


Fig. 31. Higginson Regulator

thereby raising or lowering the center *K*. The resulting movement of the lever *L* causes the lever *C* to turn about the center *O* and the center *K* is consequently returned into line with the axis *M* of the main lever *L*. As the steam flows at a high velocity the movement of the lever *L* is practically simultaneous with the movement of the governor sleeve.

Regulators or Supplementary Governors

With the ordinary type of governor it is impossible to keep the speed of the engine constant if the load or the steam pressure varies, because the governor cannot effect any change in the valve gear or pressure of the steam admitted to the engine until a change in speed has actually taken place. To obviate this defect, supplementary governors or regulators are used.

There are many designs of regulators in general use, more particularly in connection with engines driving cotton mills, etc., where it is necessary to maintain a constant speed. One of the oldest and perhaps most largely used of these is the Higginson regulator, illustrated in Fig. 31, which automatically balances the governor in whatever position it assumes to correspond to a variation in the load or steam pressure. This is effected by altering the level of mercury contained in the two cylinders at the ends of the arms which form the regulator, these being originally attached to the governor rocking ring. The mercury cups are connected by a pipe, and the weight of mercury at each end of the regulator depends upon its angular position, the cylinders being accurately proportioned to the governor. This regulator answers exceedingly well for mills where the

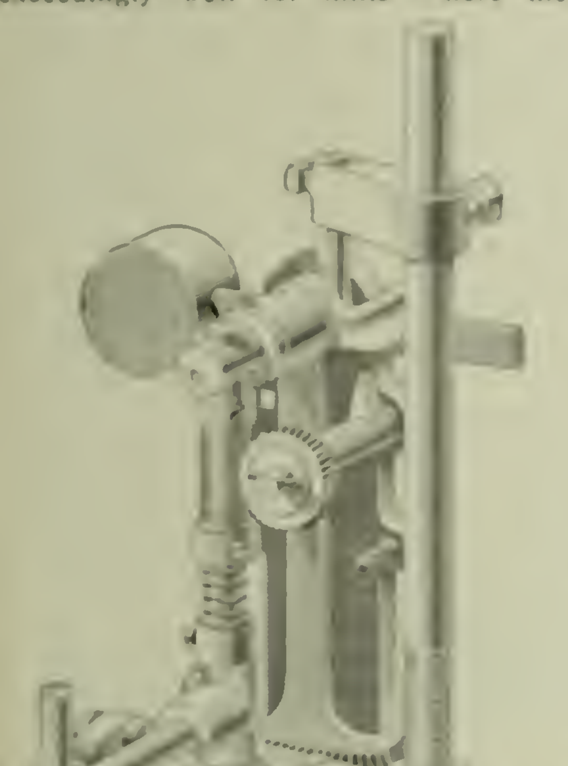


FIG. 32. REGULATOR MADE BY BRITISH METALLIC PACKING COMPANY

variation in load or steam pressure does not take place rapidly.

Another regulator, made by the British Metallic Packing Company, is shown in Fig. 32. The two parts of the governor rod, one with a right-hand thread and the other with a left-hand thread, are joined together by a sleeve. If this sleeve is revolved, the governor rod is lengthened or shortened according to the direction in which it is turned, and alters the valve motion, to give more or less steam to the engine as required. The governor-rod sleeve is rotated by means of a gear wheel, the sleeve sliding through the wheel and rising or falling in the usual manner quite independent of the wheel. The sleeve wheel meshes with another wheel which is mounted on an upright spindle, and on the top of the latter wheel is a plate which has teeth on its upper face. Over this teeth-faced wheel is a movable shield plate which has a portion cut away so as to uncover a number of teeth on the face wheel, and over the shield plate is placed a pawl carrier actuated from some suitable moving part of the engine, the pawls riding on the shield plate. At the top of the bracket is pivoted a three-armed lever,

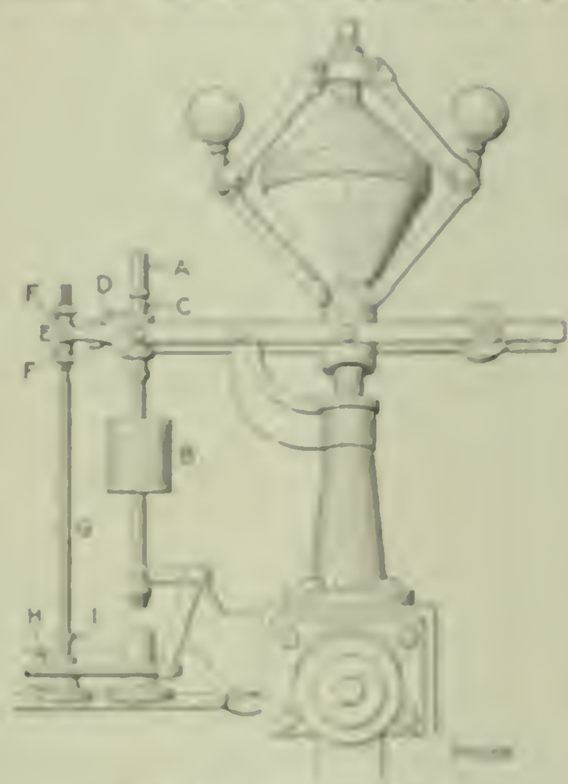


FIG. 33. SPEEDER GEAR

two of the arms being horizontal and the other vertical; the bottom end of the latter is provided with teeth which mesh into teeth formed on the shield plate. The illustration shows the pawls in the center of their travel, which ends when the pawls drop into the teeth of the face wheel.

The governor rod is shown at its normal hight, and one horizontal arm of the lever is held in firm contact with it by means of a weight on the other horizontal arm. It is evident that if the governor rises or falls the T-lever follows it and at the same time moves the shield plate and uncovers one or more teeth to be moved by the pawls. The action of the T-lever is very sensitive, about 1/10 inch rise or fall of the governor uncovering one tooth on the face wheel. The spindle revolves with the face wheel and carries a worm which meshes with a gear, automatically throwing the regulator out of action at any predetermined position.

A special feature of the regulator is that the two gear wheels can be changed, or any other wheels put on so as to obtain the exact speed of regulation suitable for the engine to which it is fixed.

SAFETY TRIP GEARS

Safety trip gears are generally fitted

FIG. 34. TATE'S ELECTRIC STOP

to all engines where the governor is driven through intermediate gearing, such as a belt or ropes. By this means, should the belt or ropes break, or should they be carried away on account of some portion of the engine itself breaking, the steam is immediately cut off. In addition to this, the engine is immediately shut down should the speed exceed any predetermined amount.

A type of speeder gear used in connection with Porter, Proell and similar types of governors controlling trip gears of Corliss and drop-valve engines is illustrated in Fig. 33. Rod A, forming the connection between the governor and the valve gear, is weighted by the pot B so as to slide in the bush C should the catch D be released. This takes place whenever the block between the ends of the pair of hook-shaped levers E comes into contact with the nuts F F on the trip rod G. These nuts are adjusted so as to come into action during about the last ½ inch of movement of the governor at both top and bottom. The tripping rod G rests on the top of the engine frame, and is prevented from lifting by the hinged quadrant H, engaging with a collar on the end of the rod. To prevent the safety trip acting every time the engine stops, it is only necessary, just before shutting off steam, to turn the quadrant H until it catches under the collar I on the trip rod, the weight of the latter preventing the quadrant from falling. This allows the trip rod to lift when the engine stops and the governor falls, instead of releasing D; but in doing this it allows the quadrant H to drop. As soon as the engine starts again and the governor lifts, the trip rod G is lowered, and its bottom collar will again engage with the quadrant, thus automatically resetting the gear to its safe position. It will be seen that the gear, if properly adjusted, will act if the governor reaches its top position through overspeed; also, if the governor falls to the bottom through the failure of its driving gear, before it tentionally prevented from doing so by the attendant propping the trip rod by means of the quadrant as described.

Another well known safety trip gear is the "Tates Electric Stop Motion," shown in Fig. 34. In this trip gear the main stop valve of the engine is closed by a powerful spring should the speed of the engine exceed any predetermined amount. In addition to this, if the engine is condensing, the vacuum is broken. Also, by means of suitable electrical connections the engine stop valve can be instantly closed from any part of the building by simply pressing a push button.

A small governor shown at C is driven by means of a belt from the engine shaft. If the engine runs at an excessive speed the tumbler at the top of the governor makes contact and the stop valve of the engine is immediately closed. If, however, the small belt driving this governor should break while the engine is running, the engine is instantly shut down.

Crank-shaft Governors

Governors of the crank shaft or drum

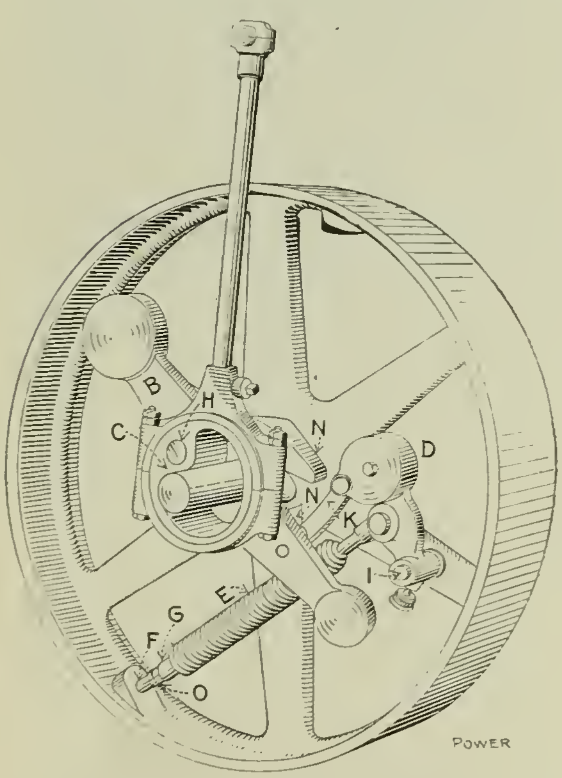


Fig. 35. Tangye Governor

type which control the speed of the engine by altering the travel and angle of the eccentric driving the valve, are not largely used in England. In the early days of high-speed engines, they were largely used and are still used by a few firms, but most makers of this class of engine have abandoned this type of governor and use the throttle type universally. For small engines, crank-shaft governors are very suitable, and a design of governor used by Messrs. Tangyes, of Birmingham, is illustrated in Fig. 35.

This governor consists of an inertia arm B, with which is cast the eccentric C, pivoted on the steel pin H, and free to swing within the limits provided by the stops $N N$. The weight box D, carried upon the pivot I, is connected to the governor arm by link K, and the spring E tends to pull the arm B against the stop N. When the direction of rotation is in a clockwise direction, the action of the governor is as follows: The weight D flies out radially when the wheel is rotated, and moves the governor arm by means of the link K. The inertia arm B lags behind, and assists the weight D

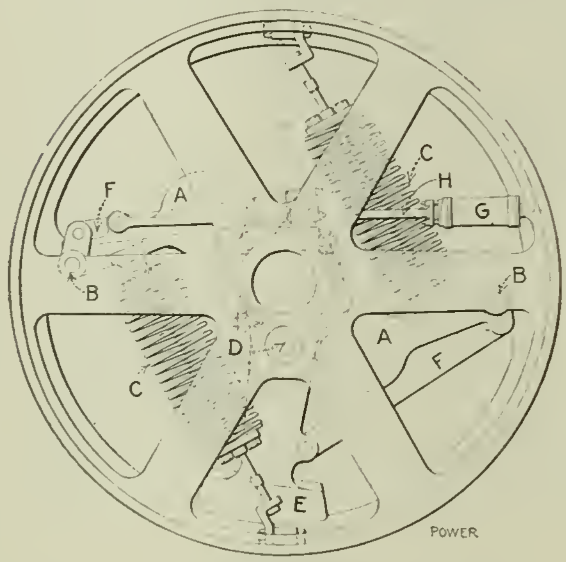


Fig. 36. Wilson-Hartnell Governor

either at an increase or a decrease of speed. This has the effect of either increasing or decreasing the travel of the eccentric and the cutoff of the equilibrium piston valve is adjusted to the required work. The eccentric in the position shown is at the maximum travel, such as when the engine is starting up. Upon the required speed being attained, the center of the eccentric moves toward the center of the shaft, and the travel of the valve is reduced. The weight box D contains loose weights secured by a cover plate and bolt; by removing one of the weights the speed of the engine is increased about five revolutions, and the entire number of weights gives a variation of about fifty revolutions. The required spring strength for best working is obtained by a plug in the spring E, which can be moved by the box spanners G. The position of this plug is secured by locknuts O.

A very powerful and at the same time sensitive type of crank-shaft governor is shown in Fig. 36, which is made by Messrs. Wilson, Hartnell & Co.

The two centrifugal weights $A A$ pivoted at $B B$ are restrained by the springs $C C$. The eccentric is pivoted at D and has a counterbalance weight fitted at E. The movement of the centrifugal weights is transmitted to the eccentric by the links F and the counterbalance for the eccentric at E makes the governor act partly as an inertia governor. A dashpot is fitted at G and is coupled to the centrifugal weight by the rod H. This is found necessary in order to resist the thrust of the eccentric.

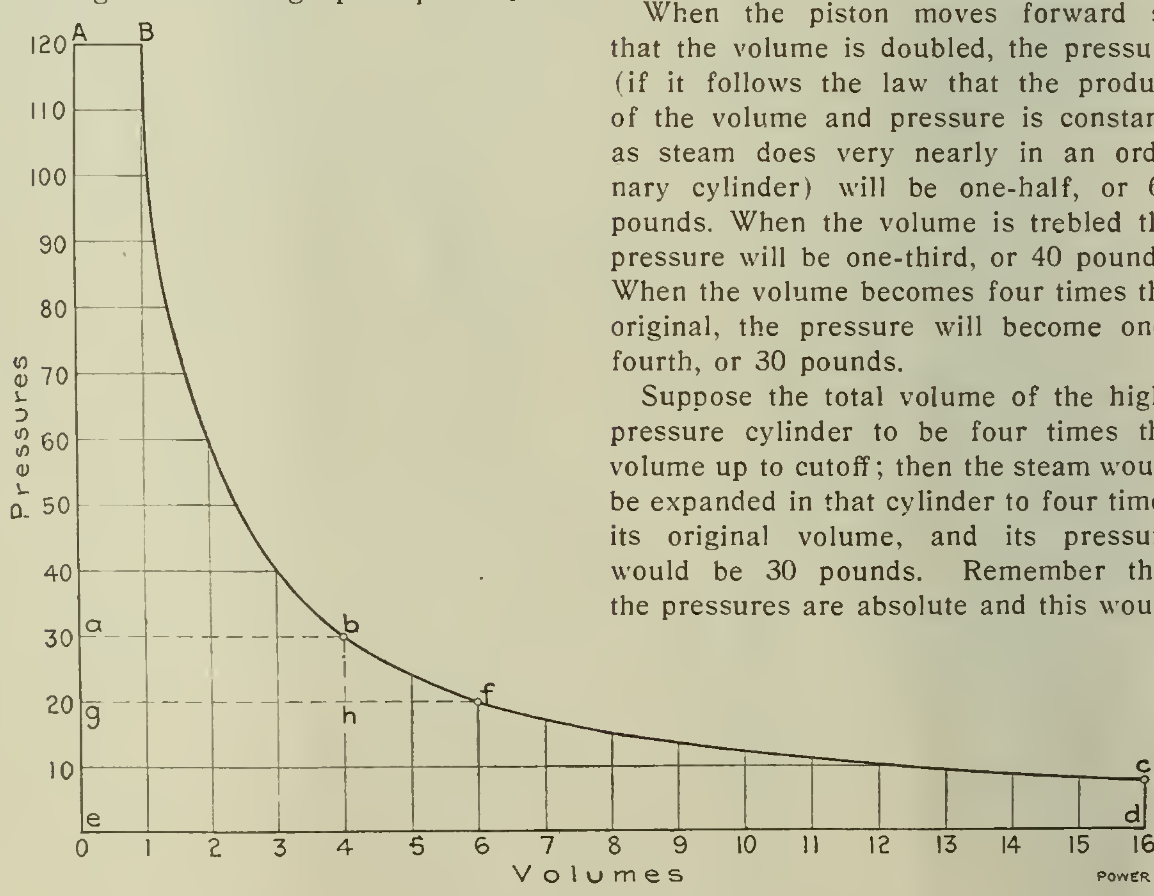
Effect of Low Pressure Cutoff on Compound Engine

A perplexed subscriber cannot understand how shortening the cutoff on the low-pressure cylinder makes that cylinder do more work.

In the diagram herewith, let the line $A B$ represent the volume of steam in the high-pressure cylinder of a compound engine at the point of cutoff and the line $A O$ represent its absolute pressure.

When the piston moves forward so that the volume is doubled, the pressure (if it follows the law that the product of the volume and pressure is constant, as steam does very nearly in an ordinary cylinder) will be one-half, or 60 pounds. When the volume is trebled the pressure will be one-third, or 40 pounds, When the volume becomes four times the original, the pressure will become one-fourth, or 30 pounds.

Suppose the total volume of the high-pressure cylinder to be four times the volume up to cutoff; then the steam would be expanded in that cylinder to four times its original volume, and its pressure would be 30 pounds. Remember that the pressures are absolute and this would be the receiver pressure, about 15 pounds by the gage.



Pressure-volume Diagram

This steam is now discharged into the low-pressure cylinder, and if the volume of the low-pressure cylinder up to cutoff is just as much as the total volume of the high-pressure cylinder, this steam, neglecting resistances, will be simply transferred from one place to the other without change of volume or pressure The line $a b$ will be the back pressure for the high-pressure and the steam line of the low-pressure diagram.

Suppose now the steam to be again expanded four times in the low-pressure cylinder. The pressure would run down the curved expansion line shown, and at the end of the stroke the steam would have 16 times its original volume. It was expanded four times in the high-pressure cylinder and then this already expanded steam is expanded four times in the low-pressure cylinder, so that the total volume of the low-pressure cylinder must be 16 times that of the high up to cutoff. The terminal pressure will then be

$$120 \div 16 = 7.5 \text{ pounds}$$

The low-pressure diagram will be *a b c d e* and the high-pressure diagram will be *A B b a*. Of course, there will be some back pressure above the absolute pressure line even with the condenser, but it is not material to the present argument.

Now suppose that the low-pressure cylinder cuts off at *f* instead of at *b*. It will take six of the original volumes out of the receiver at each stroke instead of four. But the high-pressure cylinder is delivering only four of these volumes, so that there will be a fall of pressure in the receiver to $\frac{2}{3}$ of 30 = 20 pounds.

The high-pressure diagram will now be *A B h k g*, and the low-pressure diagram *k f c d e*.

The lengthening of the low-pressure cutoff has, by reducing its initial pressure, taken the work represented by the area *a h i g* off from that cylinder, and by reducing the back pressure of the high added the work represented by the area *a h k g* to that done by that cylinder. The energy represented by the triangle *h i k* is that of the free expansion in the receiver. It is not wholly lost, as it results in some drying of the receiver steam with a slight increase of its volume or pressure.

Locomotive Boiler Explosion

By C. L. Greer

The explosion, which occurred in Texas, killed nine men and injured twelve. Probable cause was defective gage and pop safety valve screwed down to the last thread.

An awful example of the destructive force of an exploding steam boiler was recently had in the explosion of a Missouri, Kansas & Texas locomotive boiler in the little town of Smithville, on the Colorado river, in Texas.

On February 8 a switch engine was brought from the shop after being thoroughly overhauled. While steaming up preparatory to a run to another town the boiler let go in one of the most disastrous explosions ever known. The wreck was so complete that it could not be ascertained at just what point the rupture first occurred. The whole firebox end of the engine was blown to pieces and the cab to splinters. A portion of the roof sheet of the firebox was hurled a distance of three blocks, landing in the street, while smaller pieces flew twice as far. This portion is shown in Fig. 3. One large piece crashed through the roof of a business house several blocks away. At some places the rivets were sheared completely while at others the sheets, [illegible] inch thick, were torn like paper.

Fig. 1 shows a general view of the wreck. The wrecked engine before the explosion stood between the two engines indicated by the arrows. When the explosion came the tender was thrown back into the turntable pit and the front part of the boiler was shoved forward a distance of about 100 feet with the drivers plowing in the ground. The rear pair of drivers were sheared completely off

Fig. 1. Scene of Locomotive Boiler Explosion, Smithville, Texas, [illegible]

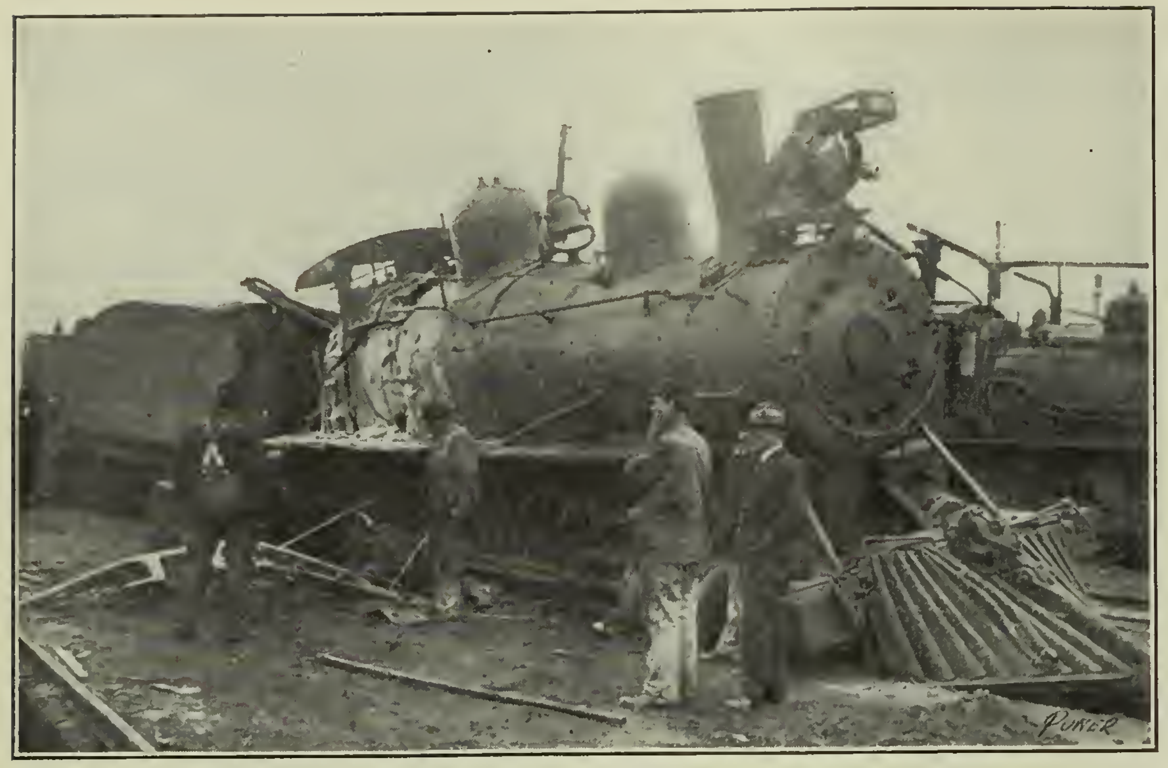


Fig. 4. This Engine Dropped into Pit Below Track

their axle, as shown in Fig. 2, and were dragged along by the connecting rods while the axle was bent to the arc of a circle. These wheels were pressed on their axle under a pressure of 90 tons. The two engines shown in Figs. 3 and 4, which stood on each side, were badly damaged, the cabs being almost entirely blown away. The engine shown in Fig. 4 was shoved off the track and dropped into the pit below while the rail on the far side was broken by the driving-wheel flange.

Fig. 5 shows how the braces and staybolts were broken and torn from the sheets. In Fig. 2 may be seen some of the sheared rivets still in the holes.

Nine men lost their lives and twelve were injured. Two men in the cab and one on top of the boiler were blown to atoms, being identified only by hands, feet and bits of clothing. A man working in the front end of the engine shown in Fig. 3 was unhurt, while one standing on the pilot of the same engine was found in the pit badly injured. Four bodies were taken from under this engine. Parts of human bodies were blown 600 feet away, rising high into the air.

It is the general opinion that the cause of the explosion was a defective steam gage. The man on the engine was setting the pop valve and it is thought the gage stuck when the pressure reached 155 pounds, as the gage stood at that point when found.

It is thought that the man screwed the pop valve down too tight and the gage failed to register the rising pressure. It is common report that when the pop safety valve was found it was screwed almost entirely down and when tested it took a pressure of 600 pounds to make it pop.

Parties who were near stated that before the explosion steam was issuing from under the jacket and apparently came from the seams, which were strained to the leaking point.

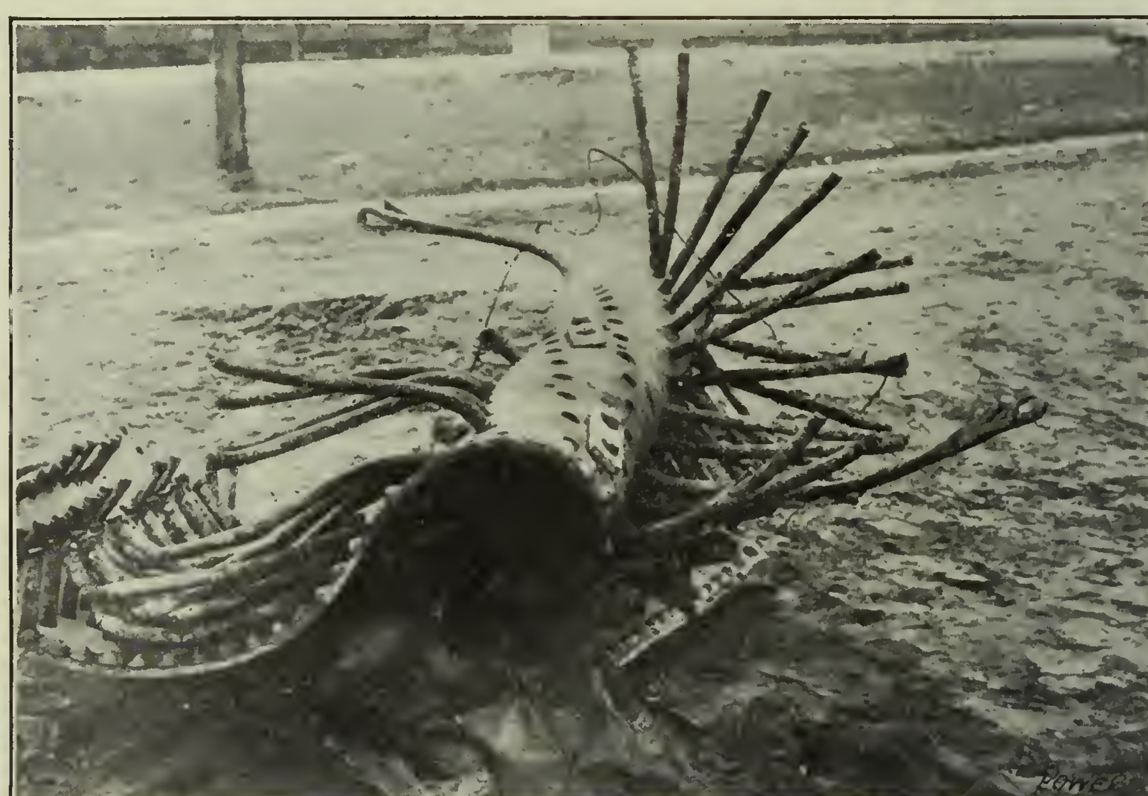


Fig. 5. An Illustration of What Explosion Did to Stays and Braces

Fig. 2. Front Part of Wrecked Engine

Fig. 3. Damage to Engine Nearby

Operating Engineer's Opportunities*

By W. D. Ennis †

> *Factors upon which economical power generation depends—the engineer's part in determining them. Education is the instrument which the operating engineer must use to further his interests.*

The wise manager endeavors to stop the big leaks first, to "hit the high spots." What are the "high spots" in power-plant engineering? It will probably be agreed that there are four fundamental considerations to be taken into account in any effort to produce cheap power. These are: first cost of the plant; the load factor; cost of the fuel, and the heat value of the fuel.

No sensible man would install stokers and economizers in a plant to be used as a water-power auxiliary for only a few hours in the year; the fixed charges on such equipment would offset any possible fuel saving. One would not expect to see the so called automatic type of engine in a pumping station running constantly at full load, because the high load factor there justifies making every reasonable effort to secure steam economy. The argument for a gas engine becomes weakened when good coal can be purchased for a dollar a ton, because the saving in fuel will not be sufficient in terms of dollars to offset the higher fixed and maintenance charges of the gas-engine plant. Power costs in western Washington are not greatly different from those in New York for the reason that, although coal there is poor in quality, it is cheap.

European engineers will scarcely build a large engine without jackets, because interest with them costs less, and fuel more than here.

It is said that the most economical rate of evaporation for a steam boiler is from 3 to 3½ pounds per hour, and perhaps it is, from a purely thermal standpoint; but if the plant has a one-hour overload of 100 per cent twice a week, it may pay better occasionally to force up the evaporation rate to 8 or 9 pounds than to install more boilers.

The operating engineer today is a business manager, and he must not be a manager of that extinct type which became fossilized a generation ago. He must not work without tools and expect people to make allowances. Tools are available and people will *not* make allowance. Executive ability is what makes cheap steam. What we need is economics as well as thermodynamics.

You can judge an engineer's work by its results. Some may think that this is a handicap for the engineer. It is a good thing, not a bad thing. You cannot frighten a good man by "keeping tabs" on him. The more "tabs" you keep, the better he likes it.

It is probably safe to say that all the power in the world is obtained from heat, and the stock of heat in the universe is not unlimited. When we burn a ton of coal—in the everyday, ordinary steam plant—we utilize the heat of about 40 pounds of that coal. The rest we throw away. We do not know how long our coal will last—it may be a couple of centuries, it may be a thousand years—but the fuel is surely going. It may be said that in the nature of things we *must* waste the greater part of the coal, and, unfortunately, that is, for the present at least, true. But few ever reduce the waste to its irreducible minimum.

The first point of attack should be perhaps the fuel itself. What is available besides coal? What coals may be used that are now not commercially available? There are wood, fuel oil, natural gas, peat, and in certain places various waste-product fuels which will never concern most of us. A wood-working establishment may produce more refuse than is necessary for the making of all of the steam that the plant can use. One principal difficulty in using slabs, edgings and shavings in such plants is the great labor involved in firing. The products of the planer and saw are also apt to burn with much smoke. In some districts where lumbering is an important industry, the best engineer is the man who burns the most, not the least, fuel. Even when he does his best, there will be a rapid accumulation of refuse which must be incinerated in open burners running night and day, at no small fire hazard. It is not easy to sell this fuel to other steam users; it is too worthless to stand much transportation, and the supply is too irregular. In one Western plant the chips and shavings from a lumber mill were blown some 900 feet through a 14-inch pipe running along the beach to a flour mill, the nearest neighbor, where they were used for boiler fuel.

To burn good wood especially cut for fuel seems like a crime. A mill plant in the West burned 100 cords a day of splendid fir for several months in 1901, paying about $3 a cord. Wood is worth too much in that district now for any such application. California oil has replaced it. Fuel oil in New York costs more than twice as much per heat unit as ordinary coal, and it is impossible to think of using it for steam making. In western Washington, California oil at one cent per 72,000 B.t.u. has driven out both wood and coal at the same price, because the oil can be fired with less labor and greater economy. In San Francisco and other cities nearer the oil-fields the price of oil is much lower. This is fortunate, because in California other fuels are high in cost and the far Western coals are mostly of poor quality.

As to natural gas, the problem is simple. Not long ago there was occasion for the writer to give advice regarding the installation of a gas engine in Pittsburg. The company owned a gas well of its own, but the pressure was irregular and the supply could not be depended upon. It was suggested that an engine be installed for natural gas—the necessary gas to be purchased—and that later on as natural gas became more expensive, the company could make its own producer gas to use in the same engine. But it was found that they could not hope to buy natural gas at a less cost, even at that time, than one cent per 80,000 B.t.u., whereas producer gas could be made at the rate of 100,000 B.t.u. for a cent. Even now, natural gas is a high-priced fuel for power purposes, and it should be. A fuel of that sort should be reserved for domestic consumption.

Engineering is constantly growing. The man who does things precedes the man who theorizes. Both types of man are useful. The steam engines of the eighteenth century were built without the help of thermodynamics, and they ran—some of them ran, some of the time—perhaps some are running yet. That wonderful engineer, James Watt—one of the most remarkable characters in engineering history—added as much theory as he could to much hard-bought experience and made the steam engine a practical machine. By the year 1800, pumping engines very nearly of the original Watt type are said to have developed a horsepower on about [illegible] pounds of coal per hour. There are pumping engines throughout the country at this moment not doing any better. The average steam engine does by no means as well. The very best engines will cheat this figure only about 50 per cent, and few of us have ever seen such engines.

That looks like a small advance to make in three-quarters of a century, but it must be remembered that in the nature of things no large advance is possible. The best engines of 1820 had an efficiency of about 45 per cent of that which

*Lecture to the proposed Institute of Operating Engineers at its second monthly meeting in New York on March 9.

†Professor of mechanical engineering in Polytechnic Institute, Brooklyn, and member of the proposed institute.

could be attained by an ideal engine; in the best engines of today this figure has been brought up to about 70 per cent. Working along present lines, we have made about all the gain that can be made. Not until 16 ounces cease to make a pound or until there are 101 cents in a dollar can more work be obtained from heat than that amount which corresponds with its drop in temperature.

Yet, the progress of the last two decades has not been negligible. There has been progress in overall efficiency rather than in engine economy, and this promises decided betterment in fuel consumption per delivered horsepower. Ideas as to plant arrangement have completely changed. Take the single matter of piping. Engineers have been closely studying power-station piping for about thirteen years. In 1898, we were using extra-heavy cast-iron fittings, screwed-flange joints, duplicate systems, ring mains, etc. The flared-over flange was brand new; cast steel was unheard of: the first special casting I ever saw used in pipe work was a gun-iron header installed in the Concord, Mass., electric-lighting plant in '99. We were just beginning to use pipe bends; there were only three (or, usually, two) places in the country where we could get them. All that has changed. The steamfitter of that day would be a cat in a strange garret if turned loose along the valve gallery of the modern station.

Thirteen years ago we were talking about magnetic clutches to connect engines and generators and the direct-driven unit was a novelty. The economizer was a matter of much interest but scarcely of immediate concern to the average man. Mechanical draft was a dangerously new invention. There were no stokers. We had just begun to talk about coal per kilowatt-hour and we did not have anything very creditable to ourselves to say. Today, we are rapidly improving some hitherto neglected details. We have been forced into the manufacture of better condensing apparatus and we are by no means through with that matter yet. We are faced with the question of superheat. We know that it pays—it increases gross earnings, so to speak—but we do not in all cases clearly know what it means finally in the year's business. Too much superheat has been installed with improper piping, valves, fittings and regulating devices. We are learning the mechanical requirements now.

It is a curious fact that the general type of apparatus adopted for some of the largest power plants has been determined by the insignificant (?) factor, cylinder oil. There is no way of thoroughly removing oil from exhaust steam under vacuum. If turbines are used, the exhaust steam is free from oil and many plants are using turbines partly on that account. If the older type of engine is used, with surface condensers, it is usually considered conservative engineering to throw away the condensed steam (although in a few plants they are filtering out the oil). Since in New York the circulating water is necessarily salt water, we must waste almost every unit of heat leaving the main-engine cylinders. With jet condensers we obtain the same result. Fresh city water might be used for condenser supply in connection with cooling towers; but it is problematical whether the very slight resulting heat economy would represent any commercial gain, and the cooling tower itself is scarcely to be regarded as standardized.

And in any case, we are face to face with the question of type of prime mover. The turbine has already shown a better everyday economy than its predecessor, although it has probably not quite equaled the latter's best record. This is from the technical, heat-unit standpoint. Commercially, the turbine plant costs less and will eventually cost very much less, so that it often has a distinct advantage. Along with this, the gas engine is looming up large, promising an efficiency well along toward double that of the best steam engines, but it is thus far handicapped by greater cost, lack of overload capacity, relatively poor efficiency at light loads and unproved reliability. Which of the three, reciprocating engine, turbine or gas engine, is to survive no one can yet say; final types have not been developed and final data are lacking as to thermal and commercial efficiency; but we may hazard the following surmises:

For direct connection to generators and other revolving machines where condensing water is available, the turbine should displace the reciprocating engine. Should its cost per pound be reduced to anything like that of the older motor, and if it can be made fairly efficient when running noncondensing, it may displace the latter in *all* applications where direct connection is possible. As to the gas engine: assuming the present rapid rate of development to continue, this form of prime mover should replace the steam plant in nearly all cases where, steam coal is high in price; the load factor is reasonably good, and there is no steam required for heating purposes. The gas engine will make more rapid progress as its underload efficiency and overload capacity are increased and its first cost is reduced.

The operating engineer's work is not confined to the engine room. Those who have to do with mill plants well know that large savings are to be made in the economical utilization of exhaust steam for heating and process work. This field is not being exploited as it should be. There are dollars to be found in the vacuum pan or steam kettle as well as in the cylinder and it is usual experience that they are somewhat easier to find in those places. You may have heard of the use of receiver steam from compound engines for process supply where steam at atmospheric pressure would not answer. You may *not* have heard of the proposal to run an engine at 20 pounds back pressure in order to supply a triple-effect evaporator. I see no objection and a certain gain. In the great majority of cases, ordinary exhaust steam is all that is necessary. Many a mill owner is superstitious about it; he thinks that exhaust steam is not hot, does not realize that with good circulation exhaust steam will warm his kettles up to 200 degrees just as quickly and reliably as live steam will. When a somewhat higher temperature is necessary, it may be better to pass the exhaust steam through a small separately fired superheater than to supplement it with a final live-steam boiling through special coils.

These are side issues, if important, to the main work of the engineer which is now more than ever centralized in the boiler room. As always, he must first of all keep things running. In the vast majority of plants this is the all-important consideration compared with which everything else is secondary. He must comply with local laws and ordinances and as far as possible avoid becoming a contributor to the smoke nuisance. A sufficiently difficult task this, with all the fuels of various grades, and it cannot be said that we have yet developed any generally applicable system of smoke prevention. Smokeless combustion is itself a matter of management, based on the coal, the equipment, the men and the load, and there is no infallible prescription for securing it. We can say, generally, that soft coal needs more air than hard coal; that the air and fuel must be thoroughly mixed to produce ignition, and that the flames must not be chilled until after combustion has been completed, that is to say, that about 10 or 12 feet of distance should be traveled by the products of combustion from the grate before they strike the boiler. These simple principles underlie the design of every "smokeless" furnace, dutch oven and soft-coal stoker in existence. We have recently developed another form of power-plant nuisance no less objectionable than smoke, namely, the discharge of fine cinders from plants burning low-grade buckwheat coal at high drafts and rates of combustion. In New York City there have been several criminal proceedings against plant operators who have offended in this way.

When we have mastered these things, in a reasonable degree, we have before us the whole field of plant economy. Here, if anywhere, a campaign of education will pay. It costs perhaps one cent in wages to shovel ten cents' worth of coal onto the grates, and I am afraid that we get good measure, that is, the willing fireman often makes it ten cents' worth of coal when it might be seven cents' worth. We should remember that in no place are brains more needed than in the *expenditures* of life, and we ought to pay enough for fire-room labor to obtain the proper degree of intelligence. The firing of coal should be made more a matter of brain than of brawn.

How is this to be brought about? One of the popular magazines which has been publishing a great deal about scientific factory management suggests that we adopt a sort of piece-work basis, paying the fireman so much per ton of coal fired. I should rather work it the other way, paying him so much for every ton he did not fire. Everyone nowadays is interested in the new "efficiency" systems of wages. These systems are claimed to have nothing in common with piece work, but they resemble piece work at least in that the more a man does the more he earns. There is no reason why such systems cannot be introduced in the fire room, but, of course, what a man "does" there is not the amount of coal he shovels but the amount of steam he gets for each pound of coal.

It is a fortunate engineer who has a poor plant—particularly in a process mill. He has the best opportunity to make great records in economy, if he can only stand the strain of keeping the plant running. Of course, there is always an element of luck that cannot be depended upon; but in the long run, as Napoleon said, the luck is on the side of the best general. Power-plant management must be judged by its results like everything else from advertising to church going. Nobody is interested in our failures and mistakes. To save is our only excuse for existing. The plant which stands still in the matter of costs is the plant that is ready to start on the down grade of efficiency. It is a fight all the time.

A word as to records. It is a fine thing for an engineer to keep statements of fuel consumption, etc., from day to day, or even, if possible, from hour to hour. Generally speaking, the more records the better. One record that should certainly always be kept is a log, recording dates of scaling and washing boilers, packing rods and the like. Data on these points are necessary and easily forgotten. I am afraid that sometimes engineers' records become literature rather than bookkeeping, interesting rather than important. This happens when a man forgets that his daily coal weights, for example, should check with the invoices and inventory month by month. If they do not, they are not worth much; if the invoice weights are wrong, the office is concerned; if the boiler-room weights are wrong, they must be made right.

If we have any cure-all, any universal medicine, in the power plant and in business generally, these days, it is system. I hope that we do not carry it farther than is profitable, but we cannot get along without it.

I sometimes think that it would be a good thing if every engineer were temporarily moved to a new plant for about four months once every two or three years. A new man will always see some new things in a plant—some disregarded opportunities for economy. The change would be good for each plant and it would teach the man some things, and when he went back to his own boiler room he would approach it with a more or less fresh view. I once looked into a mill which had a small closed feed-water heater supplied with exhaust steam from the auxiliaries. It was so overloaded that, although there was an ample supply of steam, the water could not be made hotter than 180 degrees Fahrenheit. When a condensing engine was installed later on, a large heater was placed between the engine and the condenser, and the feed water after passing through the old small auxiliary heater was put through the new large heater. It seems incredible that among all the people concerned there was no one who knew that steam at any vacuum, however poor, is colder than 180 degrees; at any rate, that was the arrangement when I saw it, and we had to buy two thermometers in order to prove to the superintendent that this heater was literally a *feed-water cooler*.

It is unfortunate that in engineering, as in everything else, we are all more or less apt to adopt fads. There was a time when everyone who preached power economy used boiler scale as a text, and we thought that we knew with mathematical accuracy just how much loss would follow the presence of so many sixteenths of an inch of scale. Our methods of treating scale were cure-all methods, and the idea of "making the punishment fit the crime"—of choosing a treatment adapted to the water and type of boiler—was scarcely heard of. I suppose that a critic might say that today the chief fad is air supply and CO_2. Perhaps this subject has become a fad in some places; we "know" a great many things about it that are not so; the facts of the matter are outnumbered by the fancies. Yet, disregarding all questions of measurement methods, recording apparatus and exactness of deductions therefrom, the incontestable facts remain that in the average plant an excess of air is admitted to the furnace; that this, by diluting the products of combustion causes the most serious preventable loss in the whole plant; that improvement in this direction is to be accomplished, not by the installation of expensive new equipment but by intelligent control of the ashpit door and the damper. Between the plant where the air supply is right and that where it is badly wrong the difference may amount to half of the coal that burned. Hard coal needs high draft but not a great amount of air. Until we learn that air pressure is one thing and air quantity another we shall not get very far. We want to get about as intelligent as the engineer I once met in the West who knew no such thing as a pound of steam other than the "pound" registered on the steam gage. Men who have plants close to New York and are not interested in oil fuel, producer gas, or water power—here is a subject which concerns you and demands the best that is in you.

One of the chief needs in power-plant economy today is a better method for the purchase of fuel. When we buy anything else, we intend and aim to get what we pay for. Too many of us, in buying coal, take what we get. Every man who contracts to sell something is supposed to state what and how much he sells. It is very difficult to get sellers of coal to do this. Nobody seems to know less about coal than those who have it to sell. And we who have to buy it take it as it comes—more or less; there are some exceptions—although it is the largest single item of power cost.

Coal should be sold on the basis of its heat value and analysis and a pound paid for should weigh 16 ounces. Perhaps we need a National "pure-coal law" to protect us in this respect.

The value of coal to the user depends on its quality and whenever a contract is made it is based on the supposed analysis of some sample or standard. If the quality descends, the coal is not worth the contract price and should not be paid for at such price. No matter whether the decrease in quality is ascertained by actual experience with the coal in the fire room or by analysis, the fuel should be condemned. It is cheaper and quicker to determine heat value and composition in the laboratory than in the furnace, the results are more accurate and less affected by variable conditions (a 500-horsepower boiler is a poor piece of experimental apparatus) and the only failures of analysis to give the same results as practice have been due to insufficient or improper analysis or an unintelligent interpretation of the results of analysis. This is one of those cases where trouble arises not from "too much theory" but from too little theory.

We should not be called on to accept coal high in sulphur. We should not be handicapped with excessive percentages of moisture and ash; three dollars a ton is too much to pay for these things. If the volatile matter in the coal runs up to 50 per cent. and black smoke is produced, the coal man should be arrested, not the engineer. We are entitled to what we pay for. By purchase regulations or in some way, we pay for coal of defined properties. If we do not get such coal, within a reasonable limit of variation, we are not getting what we pay for. The coal dealer may say he has no control over these details, but somebody has, and we must reach that somebody through the man who gets our money. Take the matter of sizes, I have met men who did not know that No. 1 buckwheat meant a certain range of size. If we buy No. 1 and pay for No. 1, why do we not see that we get No. 1?

And then, there is the commercial problem of delivery. Those of us who operated plants in New York in the winter of 1903-04 know what happened to costs per kilowatt-hour during that time. Why? Because nearly every dealer defaulted on his contracts. We would not tolerate such a thing on the part of anyone else; why should we tolerate it when perpetrated by the coal men?

To city engineers with office-building plants, the prospect of coal shortage is serious enough, but to the mill engineer out in the suburbs it involves some additional troublesome problems. He must store coal at the beginning of the winter if he wishes to keep running in spite of strikes or railroad delays. Storage of coal is one of the most serious items of cost. We say nothing about the money tied up in the coal pile; the expense of handling and rehandling is alone rather staggering in a plant of any size. And then, there is shrinkage, in quality as well as in quantity. The hazard of fire is extremely serious, at least with soft coal, and fires in a coal pile are hard to put out.

These are some of the commercial aspects of a few of the problems entrusted to the operating engineer. This Institute of Operating Engineers is going to help us solve them. I believe the institute will succeed because it recognizes in its foundation two broad principles which accompany all great work and which are always associated with success: the principle of education and the principle of helping the other man—especially the younger man. We all need education, all we can get of it, and we need it before anything else. Our troubles come from too little, not from too much education. Therefore, it was wisdom to make education one of the institute's first aims. Just what kind of education operating engineers need and what shall be the program of getting it, will be gradually determined as time goes on. Let us merely aim high and then let matters shape themselves. It was most wisely said by the editor of POWER that the worth of your certificate of membership will be determined by the first one hundred holders of it. Be sure of your first hundred and you will be bound to grow in the right direction.

We sometimes forget what the word *engineer* means. In its derivation, it has no reference to engines. The engineer means the man who is ingenious, inventive, of wide-awake and active mind and who can meet and master situations with science and skill. If we remember that derivation, we will all agree that the word describes the highest and best type of engineer, the type we ourselves aim to be. Our work does not begin with the throttle and end with the flywheel; it does not even begin with the coal pile and end with a salary check; it is a part of the great work of efficient men all over the world making two blades of grass grow where one grew before.

Flywheel Explosion at Greensburg Ind.

Failure of the governor to shut down the engine after the breaking of the governor belt, was responsible for the wrecking of a flywheel at the works of the Bromwell Brush and Wire Company, Greensburg, Ind., at 7:30 a.m. on March 2.

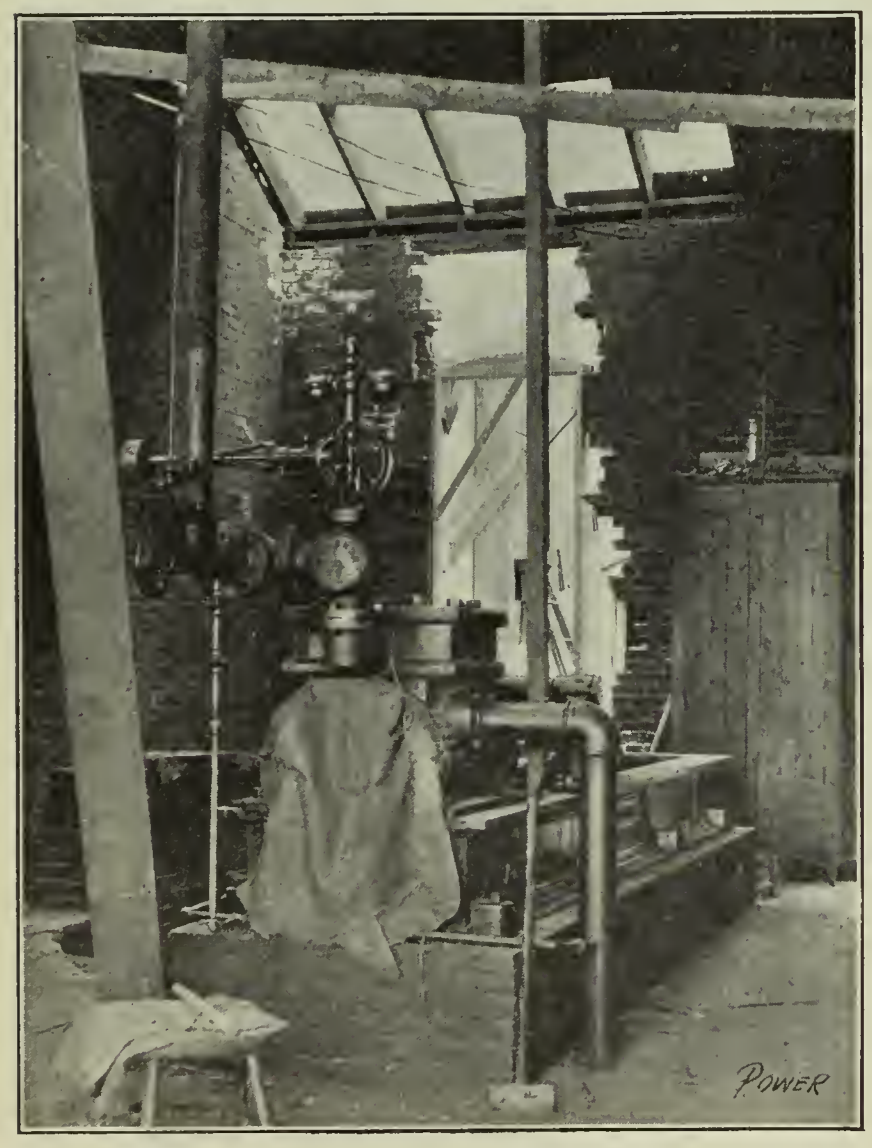


FIG. 1. ENGINE ROOM AFTER THE ACCIDENT

FIG. 2. PART OF RIM OF THE BROKEN FLYWHEEL MID RURAL SURROUNDINGS

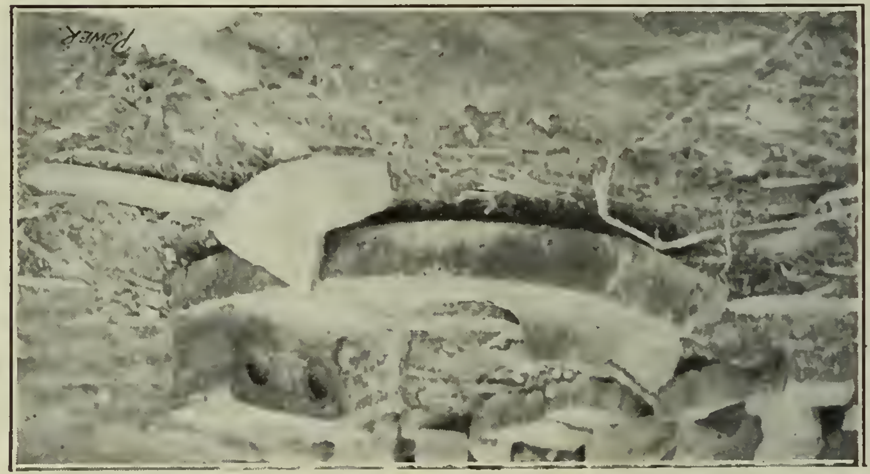


FIG. 3. ANOTHER PIECE OF THE RIM

The engine was of the old slide-valve throttling type, with a 14x24-inch cylinder and a 10-foot cast-iron flywheel made in two pieces. The rim was 10 inches wide and 2½ inches thick and was held together at the circumference by lugs, each containing two 1⅞-inch steel bolts. The normal speed of the engine was 110 revolutions per minute.

The engineer had left the engine room a few minutes before the accident to get a piece of 2-inch pipe from the storeroom. On his way back he noticed that the machinery was speeding up and hastening to the engine-room door he found the engine running at a dangerous rate of speed. As the throttle valve was directly in line with the flywheel and wide open, he saw that it would be impossible to screw the valve to its seat before an explosion would occur, so turned and ran from the room. He had gone but a few feet when the wheel let go, a number of pieces tearing through the roof and side of the building, as shown in the accompanying photographs, wrenching the main shaft from its journals and breaking the frame of the engine. Pieces of the flywheel weighing from one to two hundred pounds were scattered all over the neighborhood, one of them landing in a corn

Fig. 4. Part of Bandwheel with Piece of Flywheel in Background

field several hundred feet away, another crashing up through the floor of the main building and coming to rest in the attic.

No one was injured, owing principally to the fact that when the speed of the machines in the factory began to increase, all the operatives left their stations and made for the exits furthest removed from the power plant.

The flyball governor was equipped with a safety device designed to shut down the engine in such an emergency. This consisted of a ball-weighted lever, held up by the tension of the belt, causing the belt-wheel shaft, which was pivoted to swing loosely, to bear against a lug on the weighted lever, the idea being that should the belt break, the tension would be removed and the weight would close the valve and shut off steam.

After the accident this weighted lever was found in its upper position, and consequently the throttle valve was held wide open.

Fig. 5. Parts of Flywheel and Main Journal

Engineer Bungle Repairs an Engine

"Blank the blackety blank double blank blank luck. Blank * * ! * * * * ! * * * !"

The above is but a faint imitation of the sounds that came out through the open windows of a small country engine room. Waiting until I concluded it was safe, I ventured in where the commotion had occurred.

There I found a small slide-valve engine and a big, fat engineer with about as much expression as a half decayed potato.

The engine had been stopped and the reason was apparent from the broken valve-stem guide lying on the floor. The blacksmith's helper in trying to juggle a sledge hammer while passing through the engine room had accidentally hit the guide with the hammer and broken it. The profanity had come from the proprietor of the sawmill, but he had departed to telegraph for a new part.

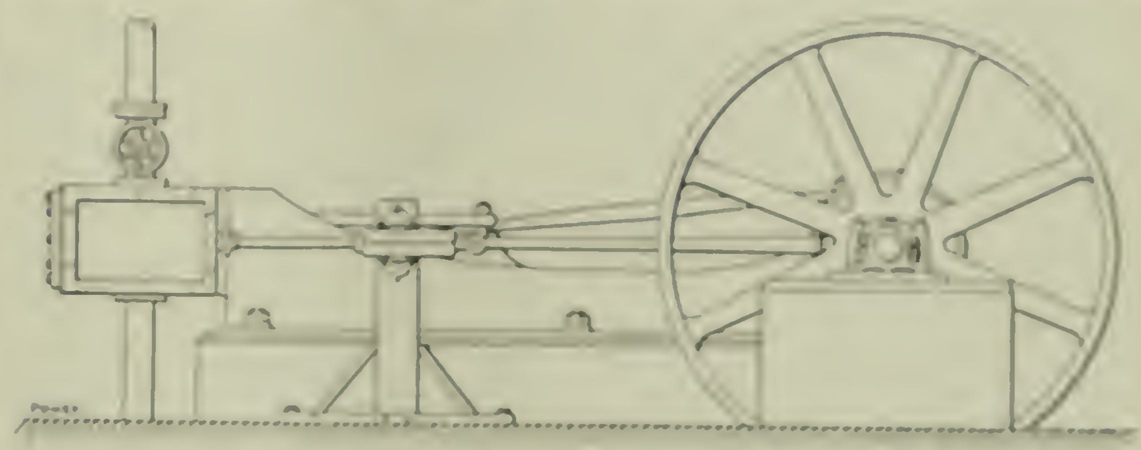
"In trouble?" I asked of the engineer.

"Yep," he replied, which was half a groan.

"Why don't you surprise the boss and fix the engine so it will run?" I asked.

"Dunno how," was the answer.

After some more talk, I decided that the engine could be fixed up temporarily and run until the new part arrived. A stand was made of wood, the upright piece being braced as shown in the illustration. To the upright piece two window-cord pulleys were secured by hook bolts and nuts, after placing the frame back of the valve-stem guide in such a position that the two pulleys, which se-



How the Engine Was Repaired

cured in place, formed a guide for the valve-stem end. The grooved pulleys served to prevent side play of the rod and were sufficiently strong to resist the thrust of the eccentric rod. The illustration shows the makeshift guide.

When all was ready, the engineer started up with fear and trembling, but soon had the engine up to speed.

Just then there was a shout and a clatter of horses' hoofs and wagon wheels, as the boss, on his return, seeing exhaust steam issuing from the exhaust pipe, hurried to find out what it all meant.

Not wishing to have any possible trouble with the proprietor, I stepped into the boiler room and, as I made my way past the engine-room windows, I heard him exclaim:

"Well, I'll be ——. Bungle, I didn't know you had half enough brains to do a job like that!"

"Huh, is that so? Well, you ain't the only man as what knows a steam engine from a cobble stone."

The lignite coals of Texas are excellent fuel for stationary, power and domestic purposes. The coal mining industry in Texas at present is not extensive, but the time is not far distant when the State will rank as an important coal producer. There are thousands of acres of lignite coal in several counties of Texas. The coal veins from 4 to 10 feet in thickness, ranging from 20 to 80 feet under the surface. At different places in the same section coal is found at a depth of 125 feet. The mines have no gas or firedamp, and the lignite is easily mined.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Hydroelectric Developments in Georgia

By R. C. Turner

On February 8, the 24,000-horsepower plant of the Central Georgia Power Company, located on the Ocmulgee river at Jackson, Ga., was put into commission. The first line connecting out will be the line for Macon, supplying current for operating the street-car system and electric lighting. At present only 6000 horsepower is being used, but as soon as the connections are completed to several large manufacturing concerns near the city the load on this line will be increased to 16,000 horsepower. The lines into Macon will operate at 50,000 volts and are about 25 miles long. The lines leading to Atlanta, 75 miles long, will be operated at 100,000 volts. Branch lines from this feeder will extend to Griffin, Forsyth and Monticello. The current is generated at 6000 volts and stepped up for transmission.

The plant at Jackson is the first of the three which will be developed by the company; when the other two are completed the three will be capable of delivering 100,000 horsepower. The water rights for the other two plants have been secured and will be developed as speedily as possible.

The Georgia Power Company, which controls the rights for 200,000 horsepower in the State, is rushing the work on the development at Tallulah Falls, which will be largest single development south of Niagara Falls. The water from the head level will be conducted through flumes to the power house a mile away, and will have 600 feet fall. It is estimated by the engineers in charge of the development that this plant alone will be able to deliver 100,000 horsepower. Two three-phase lines will be operated at 100,000 volts pressure and will terminate at Atlanta, 90 miles south of the falls.

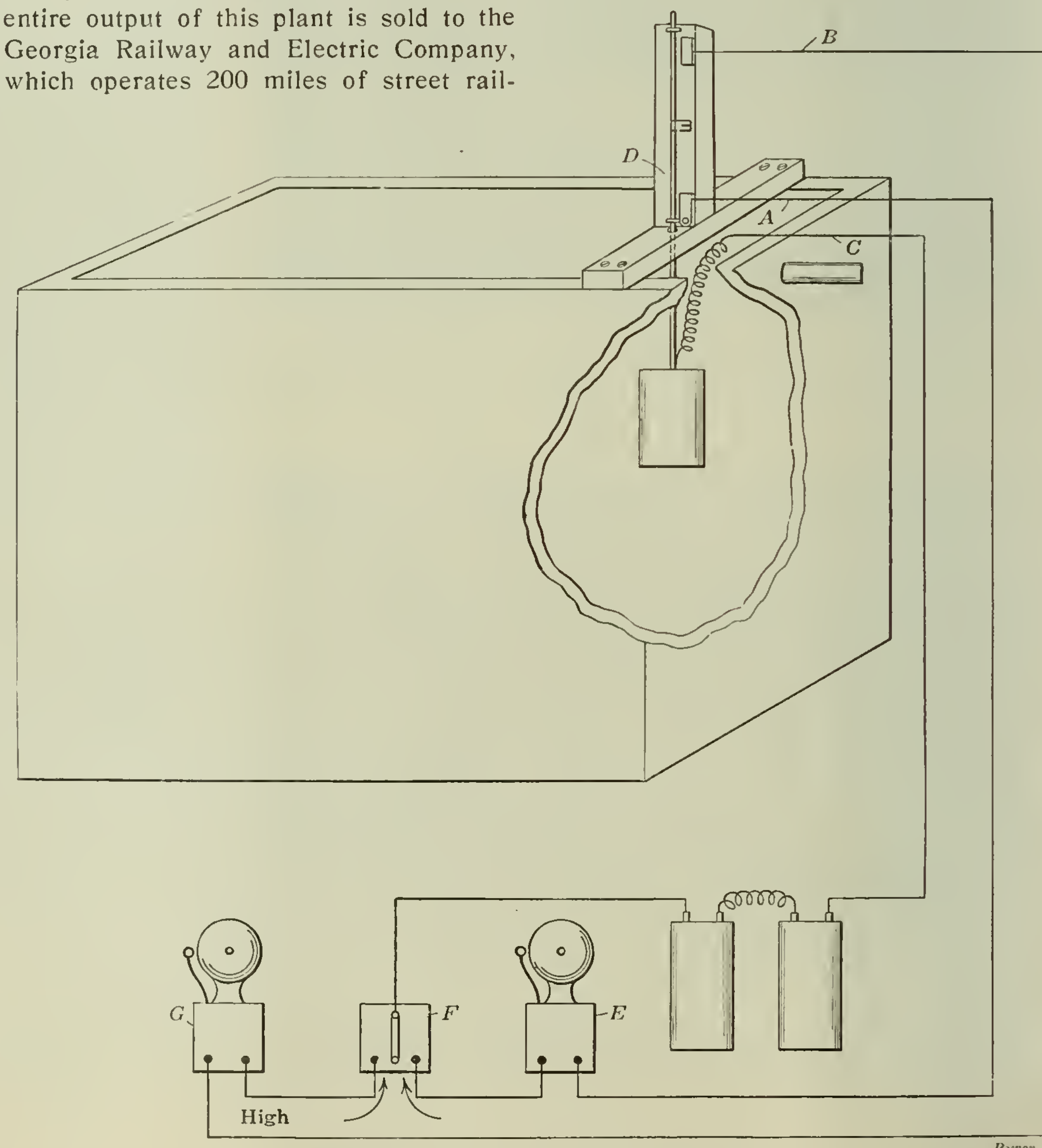
The 15,000-horsepower development of this company at Gainesville, on the Chattahoochee river, known as the Dean plant, has been completed and is supplying current to Gainesville, Buford and Norcross. A 50,000-volt line also is operated from this plant to Atlanta, 55 miles south of Gainesville. At the city limits the current is stepped down to 11,000 volts and delivered at this pressure to manufacturing establishments on the edges of the city. At Morgan's falls, 18 miles north of Atlanta, the company has in operation another plant, which has a capacity of 17,000 horsepower. Two three-phase lines terminating at Atlanta are operated at 22,000 volts pressure. The entire output of this plant is sold to the Georgia Railway and Electric Company, which operates 200 miles of street railway and a 20-mile interurban line to Marietta and also supplies current for electric lighting in Atlanta.

All the plants of the Georgia Power Company will be tied together so that a breakdown at one plant will not cause a dead shutdown. The properties of the company when fully developed will represent an expenditure of ten millions of dollars and will supply to Atlanta and vicinity 200,000 horsepower of electrical energy.

Water Tank Signal System

Most tank-signal alarms are equipped with an electric bell that rings until a switch is thrown, the signal being only for high water; but, in some instances, it is just as important to have a low-water alarm.

An alarm system for both high and low water in a tank is shown in the accompanying illustration. Two bells, a switch



Alarm System for Water Tank

and two primary cells are used. The tank is square and has a cross piece reaching from one side to the other. This piece supports a wooden upright acting as a guide to the float rod, which slides through eye screws turned into the riser. A contact spring is attached to the float rod and comes in contact with the terminal blocks of the wires *A* and *B*. A third wire

C is connected to the float rod at one end and to the batteries at the other end.

The operation is as follows: When the water is low the contact spring *D* engages with the terminal *A*. This closes the circuit through the bell *E* and the battery when the lever of the switch *F* is thrown to the right contact head.

When the water is high the contact spring *D* engages with the terminal block *B*, closes the circuit through the bell *G* and the battery when the switch *F* is thrown to the left-hand contact head.

This arrangement permits the contact spring *D* to be engaged with either *A* or *B* for any length of time, as the switch *F* can be thrown on the central contact head. This arrangement is desirable in cases where the water level remains practically stationary for several days at a time, the switch allowing the engineer to test for the hight of the water at intervals.

Brush Setting for Interpole Motors

By R. W. Wilbraham

It is a well known fact that the good performance of an interpole motor is dependent upon exactness of brush setting far more than the common shunt-wound or compound-wound motor. Some trouble lately encountered with a number of small interpole motors brings this out remarkably well. The motors were all of the same type, rated at 1 horsepower, and designed for variable speed; they were compound-wound machines direct connected to the headstocks of wood-turning lathes. The speed range was from 800 to 2800 revolutions per minute, the first part of the range being controlled by armature resistance and the latter part by field resistance.

The motors were started up by a starting box which left them running at 800 revolutions per minute. As they were speeded up, some of them upon reaching 1600 revolutions per minute would stop and reverse, running at approximately the same speed in the other direction; others would do the same thing when passing from 2000 to 2800 revolutions per minute. It was then found that the motors that reversed at the 1600 point would not reverse until they reached 2000 revolutions per minute if they were speeded up very slowly. These particular motors, it was discovered, had no oil in the bearings. Upon being oiled, they could be rapidly speeded up to the 2000 point where, like all the rest, they would reverse. After making a number of tests, the conclusion was reached that the brush position was wrong. This proved to be the case and after setting the brushes backward (opposite to rotation) about one bar the trouble was entirely remedied.

The internal magnetic actions that take place are very interesting and are as follows:

In any motor when the brushes are ahead of the neutral point, as they were at first on the motors just mentioned, the armature reactions are less than normal and, consequently, the resultant magnetic field is stronger than usual. The result is that at each successive point in the speed range the armature falls more and more below the designed speed. As the counter e.m.f. of an armature is directly proportional to the speed, there is a proportional decrease in counter e.m.f. and a proportional increase in armature current, which results in a very strong armature field the strength of which is relatively greater than the proportional increase of armature current.

In the case described, the higher speeds being obtained by field control, at the last point the field due to the field-magnet winding was very weak and the armature field very strong. The consequence was that the magnet poles were first demagnetized and then magnetized with opposite polarity, causing the motor to reverse. This reversing, as would be expected, was accompanied by sparking at the brushes due to the interpole polarity being wrong for the reversed rotation.

CORRESPONDENCE

Mr. Blue's Induction Motor Trouble

I have had the same experience with induction motors that Mr. Blue described in the issue of February 14, and I believe that his trouble can be cured by removing all the rotor conductors, thoroughly cleaning the ends of the bars and the short-circuiting rings and reassembling the structure carefully with a view to making the joints as nearly perfect as possible. The ends of the bars should be bolted to the short-circuiting rings for mechanical security and then thoroughly soldered to them to get good electrical joints. It might be well also to reinsulate the rotor bars with heavy manila paper wherever the original insulation has become worn. This will improve the torque.

J. E. Danforth.

Harrison, N. J.

In response to Mr. Blue's request in the issue of February 14 for suggestions regarding a "cranky" induction motor, I offer the following:

The facts that the motor starts in one direction on the second controller point and in the other direction only on full-line voltage indicate clearly that the trouble is in the starter. Wrong connections or, more likely, imperfect contacts should be looked for. On the day that the motor started all right but refused to take its load the starter probably failed to make contact on one phase in the running position. If it got current on both phases in the starting position it would have started and run near enough up to speed for one phase to keep it going when the lever was thrown into the running position. One phase being out and the airgap not uniform would account for its refusing to carry the load.

If the stator windings had been open-circuited it would have refused to start at all, and if they had been short-circuited the fuses would have blown.

In some instances the rotor bars become loosened from their connecting rings; in such a case the motor will refuse to carry full load. This may have been a contributing cause in this case but cannot have been the whole trouble as it does not account for the motor's behavior in starting; moreover, this trouble usually comes on gradually.

G. E. Miles.

Salida, Colo.

Melville-Macalpine Gear for Direct Current Generators

The letter of Mr. Malcolm, in the February 14 issue, pertaining to Mr. MacMurchie's discussion of large gear-coupled direct-current turbo-generator sets, is unfortunately not well founded. Mysteriously the salient fact has been overlooked that the use of the Melville gear permits the most efficient turbine and generator, respectively, to be employed, obviating the compromise necessary with the two different elements on a common shaft. The deductions in the second table are manifestly illogical. Turbine kinetic efficiencies were arbitrarily assumed by Mr. Malcolm. Had a value of 50 per cent. been taken also, for illustration, it could have been shown that the geared generator would have had to possess an efficiency exceeding 100 per cent. On the other hand, a higher turbine efficiency, say 70 per cent., which is feasible, would prove the direct-driven generator to be unreasonably low in efficiency.

I infer from the conclusion reached by Mr. Malcolm that he understands that the benefit resulting from the use of the gear would indicate an improvement chiefly in the generator, while, in fact, the greatest gain in economy occurs in the turbine, and very much so in small sizes. From a commercial standpoint, however, the geared generator has the advantage of more desirable commutation speeds.

On determining the Rankine-cycle efficiency, Mr. Malcolm applied an actual water rate for saturated steam against the ideal steam consumption for 100 degrees of superheat and identical pressure conditions. The efficiencies derived are, therefore, lower than they should be, accordingly affecting the values in the second table. Furthermore, the comparison with a turbo-alternator and rotary combination has, in the estimate, several omissions, which is immediately refuted by the fact that such combinations have been installed for the express purpose of obtaining direct current immediately at the point of generation, before the large gear had been completely developed and which system was given preference over the large direct-coupled continuous-current turbo-generating unit. To my knowledge four such plants have been installed.

In looking at the first cost of the geared set disparagingly, Mr. Malcolm loses sight of the facts that standard turbines and generators may be used while for direct coupling the designs must be special.

Mr. MacMurchie's presentation of the comparison, in my mind, is entirely equitable, and is in conformity with the actual performance of the different elements.

EDWIN D. DREYFUS.

East Pittsburg, Penn.

Mr. Dreyfus' comment on my article relating to Mr. MacMurchie's paper is in error in at least one point: I did not assume any turbine efficiency in preparing the table accompanying my article; I simply took Mr. MacMurchie's figures for steam economy and worked back from them to see what would be the probable distribution of the overall efficiency between the turbine and the generator on the basis of 97 per cent. efficiency for the gear.

My assumption of 100 degrees of superheat for the turbine was based on the fact that this is commonly assumed in discussing turbine plants. If Mr. Dreyfus prefers a comparison based on saturated steam at the turbine throttle he will find it in the accompanying tables. The theoretically available energy in a pound of steam expanded adiabatically from 150 pounds pressure to the condenser pressure corresponding to 28 inches of vacuum is 319½ heat units. According to Mr. MacMurchie's figures the direct-connected unit would require 20.6 pounds and the gear-driven unit 19.3 pounds of steam per kilowatt-hour, showing overall heat efficiencies of 51.85 and 55.34 per cent. respectively. If the Melville-Macalpine gear has 97 per cent. efficiency, the geared turbine and generator must have a combined efficiency of

$$\frac{55.34}{0.97} = 57.05$$

per cent., as compared with 51.85 per cent. for the direct-connected turbine and generator.

Not knowing what Mr. MacMurchie allowed for turbine and generator efficiencies separately under the two sets of conditions I have simply presented in Table 1 a list of possible turbine efficiencies and given opposite each the generator efficiencies necessary to fit the stated overall efficiencies; in Table 2, the generator efficiency is the starting point.

Mr. Dreyfus seems surprised that I should construe Mr. MacMurchie's paper to mean that the use of the gear would permit the use of electric generators of higher efficiency. As Mr. MacMurchie's paper contained that specific statement I do not see how I could "construe" it otherwise. However, assuming that facility of commutation is the only generator advantage and that the turbine gets all of the increase in efficiency, Table 2 gives the direct comparison.

TABLE 1.

Turbine Efficiency.	Corresponding Generator Efficiencies.	
	Direct Driven.	Gear Driven.*
54	96.02	.....
56	92.59	.....
58	89.40	98.37
60	86.42	95.09
62	.....	95.02
64	.....	89.15

TABLE 2.

Generator Efficiency.	Corresponding Turbine Efficiencies.	
	Direct Drive.	Gear Drive.*
86	60.3	64.4
88	58.9	62.9
90	57.6	61.5
92	56.4	60.2
94	55.2	58.9
96	54.0	57.7

*Assuming 97 per cent. efficiency for the gear.

It is conceivable that a large turbine running at a favorable speed will show an increase of 3½ to 4 per cent. in efficiency, as indicated by the table, when compared with its performance at a lower speed. But it is also quite reasonable to suppose that the generator efficiency would suffer somewhat by a reduction in speed. I cannot imagine a turbine (other than the De Laval) of 1500 horsepower that would require such a high rate of speed for maximum efficiency as to carry the generator beyond its maximum-efficiency rate of speed.

However, that phase of the question is scarcely worth haggling over; it is within the reach of imagination that in relatively small units the use of the gear might effect some improvement in overall efficiency and an appreciable reduction in the cost of the turbine, but I believe the cost of the gear would more than eat up the gains.

The bald truth is that increased facility of commutation is the only real excuse for using anything except a direct coupling between a turbine and a direct-current generator. Whether or not that justifies the expense I am not sure; only a practical demonstration would convince me.

GEO. W. MALCOLM.

Brooklyn, N. Y.

Would It Have Been Serious?

Under the title "The Light That Failed," in POWER for January 31, Howard H. Bliss tells of a retiring operator who, through spite, filed a brass connection thin, with the idea that it would melt as a fuse when the synchronizing lamps were at full candlepower and thus extinguish them and cause the new operator to close the switch and throw two machines together when they were farthest out of phase.

I believe, however, that the probabilities of success for the scheme are very remote. In the first place it would have required very fine calculation to have enabled the man to file the brass so it would melt just when the lamps were at full candlepower. The chances are that it would either have melted too soon or not at all. In the second place it is not likely that anyone would have thrown the machines together the first time that the lamps went dark, and the fact that they stayed dark would or should have aroused suspicion and led to investigation. In the third place, had the brass melted just when the lamps were at full candlepower, they would have gone out suddenly and not gradually, as is the case when machines are near enough the same speed to be thrown together. This would or should have caused the operator to hesitate. He would have expected the lamps to light up again just as suddenly and would not have risked closing the switch. Their failing to light again would have started him looking for trouble.

I do not mean to say that it *could* not have happened as planned, but I hope that if ever anyone tries to make synchronizing trouble for me he will choose as uncertain a way as the one described; I believe that in the majority of cases, cold snap or no cold snap, that plan will result in nothing more serious than the trouble of running down an open circuit.

Salida, Colo. G. E. MILES.

John T. Nicholson, of high-speed boiler fame, in a letter to *The Engineer*, of London, upon the comparative merits of the cut-and-try method and mathematical investigation, says: "Mechanical engineering is not only an art or a craft, but it largely consists also in the application of mathematical and physical principles. Men who do not possess a good knowledge of these principles are incapable of foreseeing in what way a new apparatus will behave. They can in fact only repeat with slight and timid modifications what other engineers have done before, and as Professor Perry has said, 'By dint of expensive trial and failure they sometimes arrive at results which they might have arrived at very inexpensively if they had been better educated.'"

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Notes from the Gas Power Plant at Gary

Some of the engines in the mammoth power house of the Indiana Steel Company at Gary, Ind., have now been in operation over three years and it is interesting to note the experiences encountered. During the first few months there were slight difficulties, due mainly to the inexperience of the operators. One or two cylinders were cracked (but are still in operation) and some troubles from back firing and preignition occurred. It did not take long, however, for the operating engineers to become familiar with the engines and now everything is said to be running as smoothly as could be desired. The alternating-current generators have a nominal rating of 2000 kilowatts each at 80 per cent. power factor but regularly carry from 2500 to 2800 kilowatts. Units are cut in or out so as to maintain this high unit load as nearly constant as possible.

As the power is largely used in the rolling mills the load is subject to frequent variations and it may happen that an engine will be started and stopped a dozen times during the day. This is done with much facility now; it is not usually over one minute from the time an engine is ordered into service until it is on the line in parallel with the other machines. The shortest time in which this has been done is 37 seconds.

The engines operate on the waste gases from the blast furnaces and as there is available more power than is needed at the plant electricity is regularly supplied for lighting the city of Gary, for operating the water works and for private uses. In addition to this, some power is delivered to the plant of the Universal Portland Cement Company at Buffington, Ind.

The Gary power house operates in parallel with the power house of the Illinois Steel Company at South Chicago, where gas engines, steam engines and steam turbines are in operation. The junction point of the lines is at Buffington. This arrangement enables either plant to supply power to the other in case of necessity, or both can supply the cement plant.

The Boott mills, Lowell, Mass., are gradually going over to electric power, which is being bought from the Lowell Electric Light Company. The company, however, soon expects to furnish its own power.

LETTERS

Mr. Rushmore's Freak Diagrams

In the February 28 issue, Mr. Rushmore shows two "freak" indicator diagrams taken from a single-cylinder producer-gas engine. If the diagram illus-

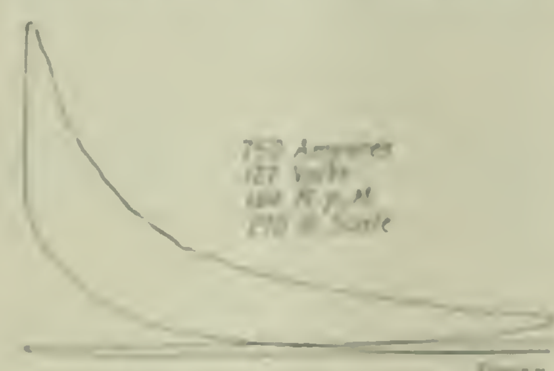


FIG. 1. NORMAL DIAGRAM

trated as "first freak" had been properly taken, the work diagram outline would have extended farther to the left, as it did in the "second freak." It is impossible for an indicator to produce a card of that kind if the external connections, springs, etc., are in good working order, unless the direction of rotation

FIG. 2. FIRST FREAK

of the flywheel is reversed, and it appears that this did not occur in Mr. Rushmore's test. I attribute the first freak to a faulty external connection, catching of the indicator cord, or sticking of the drum spring. I cannot understand why compression did not begin sooner, because by laying a tracing of Mr. Rushmore's normal diagram over the expansion curve of the first freak diagram I find they coincide almost exactly,

FIG. 3. SECOND FREAK

which means that practically the same quantity of gas and the same number of heat units were taken into the cylinder and ignited. Fig. 4 shows Mr. Rushmore's first and second diagrams superimposed; from this it can be seen how nearly the curves coincide, the dotted curve being taken from Fig. 1, his normal diagram.

I would call his second freak a case

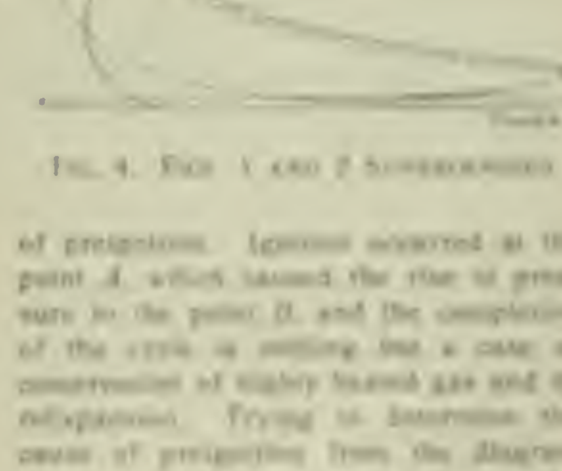


FIG. 4. FIGS. 1 AND 2 SUPERIMPOSED

of preignition. Ignition occurred at the point A, which caused the rise of pressure to the point B, and the completion of the cycle is nothing but a case of compression of highly heated gas and its reëxpansion. Trying to determine the cause of preignition from the diagram alone would be mere speculation on the part of anyone not acquainted with the engine.

W. F. SCHAPHORST.

Agricultural College, N. M.

There is no mystery about Mr. Rushmore's diagrams. Compare the length of the diagram labeled "first freak" with that of the normal diagram. It is considerably shorter, indicating that a knot or joint in the indicator cord slipped near the head end of the stroke. The diagram is not complete; the compression line is not indicated until near the end of the compression stroke and at this point the indicator cock was thrown open.

The second freak was caused by preignition due to overload. The high peak is a sign of full or overload in using a throttling governor. Ignition took place slightly before the piston reached the middle of the compression stroke and the momentum of the flywheel carried the piston against the explosive pressure, as indicated by the rising compression line. The expansion line falls below the compression line because of the loss of heat through the cylinder walls.

HAROLD DOOLITTLE.

Birmingham, Ala.

The Diesel Engine and Engineers

I read in the February 21 issue the article by Edward B. Pollister on "The Diesel Engine in Service," and I share Mr. Pollister's good opinion of the Diesel engine.

About five years ago I took charge of a large power plant in central Europe containing a 1000-horsepower horizontal cross-compound steam engine and a four-cylinder Mirrlees-Diesel engine of 225 brake horsepower direct-coupled to a 150-kilowatt generator. The Diesel engine was five years old, but it carried its load successfully with great economy, running only at night for lighting service. During my two years of service the biggest repair was a new piston for the air compressor, but I spent about ten hours every two weeks in inspecting and taking up connections and various other parts, and had the men blow out all piping and wash out all other parts with kerosene. I did not take the pistons out every time, but turned the crank over and cleaned out deposits in the cylinders with sponges and kerosene, working through the suction and exhaust-valve ports. The engine ran satisfactorily and never scored the cylinders.

I presume that Mr. Pollister understands that the Diesel engine is successful only when operated by skilled engineers who have had proper training; an internal-combustion engine, whether using gasolene, gas or crude oil, will not run with the exhaust valves opening 4 inches late or with the eccentric set 5½ inches of the stroke late, as will some Corliss engines.

I do not say that there are not skilled men in plenty; there are well trained, capable men in the United States and Canada, but plant owners cannot expect to get a well educated and skilled engineer for $70 to $75 a month to work 66 and more hours a week and be ready to respond cheerfully whenever the night engineer calls him out of bed to clear up trouble in the water or steam line, or to fix up a balky ignition system or a cranky mixing valve. Under such conditions there need be no wonder that 90 per cent. of the capable men are working at manufacturing trades instead of running power plants.

In the hands of the right sort of engineers, the Diesel engine is the most economical prime mover known.

J. G. KOPPEL.

Montreal, Can.

Generator Linings

The method of lining a gas generator described by C. R. McGahey in the February 7 issue is interesting, but I think it would be unnecessarily expensive. We set the firebrick in 8 inches from the shell and fill in behind the lining with sand. As we have no trouble, we believe the method is all right. I think, also, that this is the way it is generally done in this part of the country.

J. O. BENEFIEL.

Anderson, Ind.

Mr. Barker's Engine Speed

In the issue of February 28, Mr. Barker asks if a speed of 300 revolutions per minute is practical for a vertical gas engine of 9½ inches bore and 12 inches stroke with a connecting rod 30 inches long.

In my opinion this speed is practical. I have one 11x12-inch gas engine running at 300 revolutions per minute with connecting rods 36 inches long; also, a 12x12-inch engine running at 275 revolutions per minute with connecting rods 36 inches long. Both engines are three-cylinder verticals with long trunk pistons lubricated by splash from the crank case, and both run 12 hours per day, under about the same conditions. The crank-pin and piston-pin brasses of the 12x12-inch engine need adjusting every two days but the brasses of the 11x12-inch engine need adjusting only about once a month. The pistons and cylinders show very little wear and have been in service over eighteen months.

M. W. UTZ.

Minster, O.

The piston speed of a 9½x12-inch engine at 300 revolutions per minute is not too high, but the flywheels should not be more than four feet in diameter because at 300 revolutions per minute the rim speed of a 4-foot flywheel would be 3600 feet per minute. The safe working speed being about a mile a minute, this would leave enough margin for safety in case the engine should run away.

It is very seldom that the flywheel of a gas engine breaks from excessive speed; more often the connecting rod breaks, due to the piston being heavy and being cushioned only at one end of the stroke every other revolution.

N. E. WOOLMAN.

Danbury, Iowa.

An Inconsistent Engine

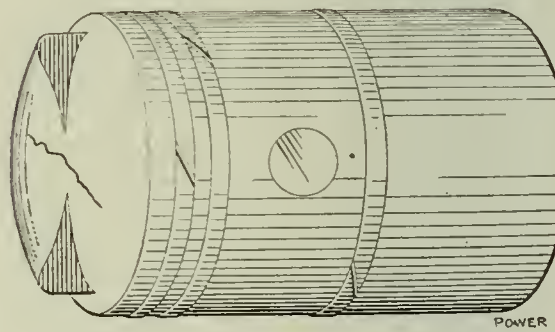
A small four-cylinder vertical gasolene engine which seems to be in first-class condition runs faster when the pet cock on cylinder No. 3 is open than when it is closed. Can anyone explain why?

FRED HALL.

Dexter, Mo.

Cracked Piston Faces

I have taken several pistons from gasolene engines that were cracked through the top, as shown in the sketch. I should like to have expressions of opinion from



PISTON WITH CRACK IN FACE

other readers as to what makes them crack in the top and the best method of repairing them. Can they be brazed or closed up with Smooth-on cement or patched with soft patches?

JNO. G. KOHNSBERG.

Hathaway, Tenn.

Petroleum in Turkey

According to Consul George Horton, the importation of Russian petroleum into the Saloniki district is increasing despite Hungarian competition, which is handicapped by higher freights. As nearly as can be ascertained the imports of petroleum into this district in 1909 were as follows, in cases: Russian, 370,000; Hungarian, 50,000. The figures for 1910 will show a decided increase.

American petroleum is imported in small quantities, but on account of the higher price the demand is not important, despite its acknowledged better qualities, viz., less odor and clearer light. Before the opening of the Batum wells petroleum was exclusively imported from the United States, and the market was lost through the inactivity of the American producers; but it can be regained, and steps to this end have been taken by the purchase by an American company of a site here for tanks and a factory. This real-estate transaction has caused considerable interest here as the company was forced to pay an exorbitant price for the land. A Hungarian company had already purchased a site, but it is now rumored that it is ready to sell it and retire from the contest.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Constant Receiver Pressure

Recently I visited a power station in which there were one 24 and 48 by 48-inch and one 26 and 50 by 60-inch cross-compound condensing engine. The large engine was running with a receiver pressure of 12 pounds; in a short time they shut down this engine and started the small one and carried a receiver pressure of but 6½ pounds.

I asked the engineer why he carried 12 pounds receiver pressure on one engine and but 6½ pounds on the other. He replied that the engine with the low receiver pressure had just been repaired and that it did not require any more, but that the engine carrying 12 pounds receiver pressure was old and required repairs, so he had to carry a higher receiver pressure to make it do its work.

The engineer said that the engines had not been indicated since he had been there, some nine years, and that he guessed the engine cylinders balanced.

I told him that he ought to indicate his engines, adjust the valves, equalize the cutoffs and then work out his cards to see which cylinder was doing the most work, and, if the low-pressure side was not doing the same amount as the high-presuere side was, to shorten the cutoff on the low-pressure side and raise the receiver pressure until both cylinders were doing the same amount of work.

I have also noted that the receiver pressure of many cross-compound engines varies as much as 20 pounds. With some engines the pressure goes up when the load goes off; with others it goes up when the load comes on. I contend that if an engine is properly constructed, valves properly set and the load balanced between the two cylinders, it should maintain the same receiver pressure at no load that it does at full load, providing that the governor controls the cutoff on the low-pressure cylinder as well as on the high-pressure cylinder. If the governor controls the high-pressure side only, this is not possible, as the low-pressure side has a fixed cutoff.

When a large engine is running with a variable load and the receiver pressure varies from low pressure at no load to a high pressure at full load, the high-pressure cylinder will do most of the work until the receiver pressure is built up. With a constant receiver pressure, the instant the load is thrown on, the low-pressure cylinder is ready to do its share of the work without waiting for the pressure to be built up in the receiver.

When the load is suddenly thrown off, steam to the high-pressure cylinder is cut off shorter, less steam is taken, and the low-pressure cylinder likewise cuts off steam shorter at the same instant, keeping a constant receiver pressure. The low-pressure cylinder is ready when the load is again suddenly thrown on to do its share of work at the same instant the high-pressure cylinder takes its load.

W. R. BEARD.

Cleveland, O.

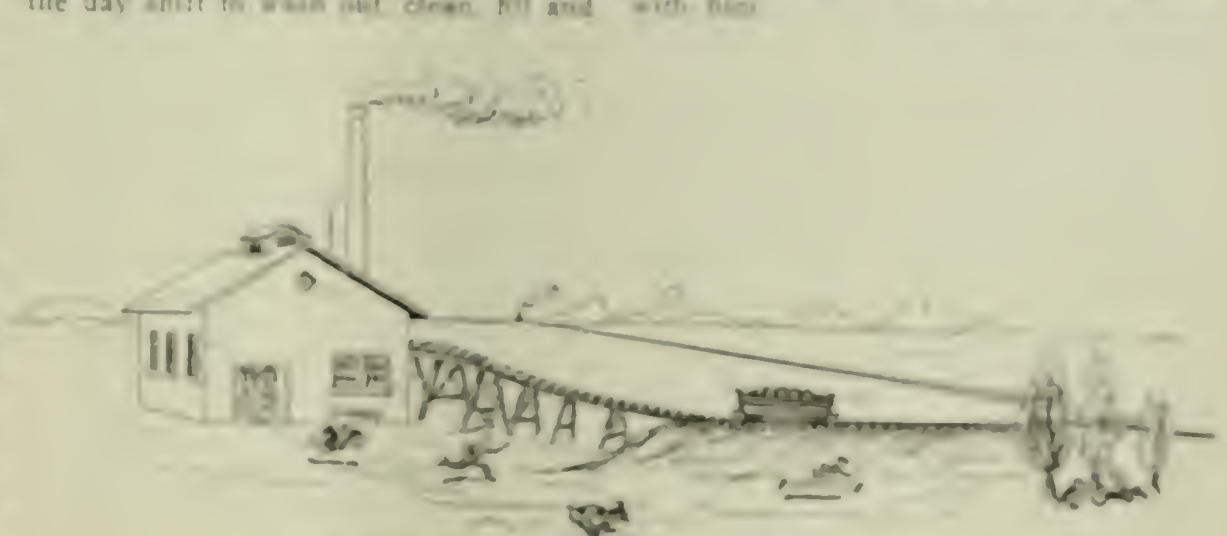
White Hot Boiler Stampeded the Firemen

In a steam plant containing 12 return-tubular boilers it is the custom for the day shift to wash out, clean, fill and prime six of the battery every Sunday; the night shift fires them up and has steam ready by six o'clock Monday morning.

Not long ago this same routine was gone through with as usual. The night shift fired up and everything went along smoothly until about 5 a.m.

These boilers are fed by mechanical stokers and each fireman feeds four stokers and attends to the feed water. The fireman at No. 7 boiler had an empty stoker and was about to refill it when he thought he would have a look at his fire. He opened the little door on the side of the stoker through which a slice bar is usually thrust and what he saw almost threw him into a fit; but he did not take time to indulge in one. With white face and standing hair he raced down the boiler room, shouting as he ran "Biler g'wine bust." The other firemen, coal and ash wheelers, seeing his white face and wild actions, surmised something was wrong, and without stopping for orders started after the leader until seven men were doing a "marathon" up the coal trestle and down the railroad track. About 1000 feet from the plant they came to a stop behind piles of railroad ties, trees and other objects and then asked the panic maker for an explanation.

What that fireman saw in that momentary glance into the peek hole was enough to "frazzle" the nerves of the most reckless shovel mechanic who ever held a scoop. The first fire sheet was hanging down to the grate bars and was white hot all over. While the fireman was informing his fellow workers of how the boiler looked, he ducked at every second word as if the expected crash was coming, and the rest would duck in unison with him.



THE FIREMEN DID NOT STOP TO ASK QUESTIONS

After about half an hour's breathless waiting for the blast that did not come, one of the firemen, braver than the rest, started back. He got to the boiler house and found the master mechanic on the job.

The boiler that had caused the scare had cooled off, for, as there was no more coal in the hopper, the grate had gradually burned bare. The boiler was at once cut out from the others and an investigation disclosed the trouble. There were two gages of water in the glass, but both gage cocks were closed. The try-pairs consisted of a new sheet and a full set of tubes.

The firemen and coal and ash wheelers came back, but the fireman who caused the stampede did not even return for his hat and coat.

A. R. Hilbert.

East Rutherford, N. J.

What Is Wrong with the Valve?

The automatic cutoff engine, from which the diagrams shown in Fig. 1 were taken, was apparently running satisfac-

Fig. 1

torily at a speed of 215 revolutions per minute. The governor was keyed to the shaft and there was no way to shorten the valve rod except to heat it. After taking the diagram shown in Fig. 1, I

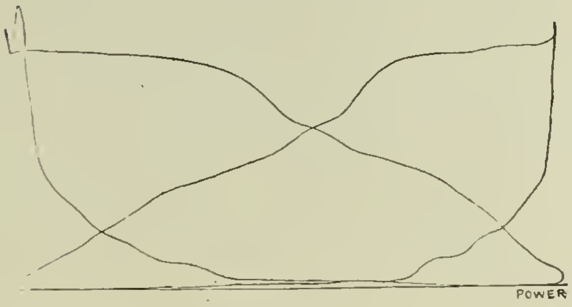


Fig. 2

shortened the rod ¼ inch and took those shown in Fig. 2.

Upon removing the valve-chest cover all that could be seen was a square piece of cast iron. I came to the conclusion

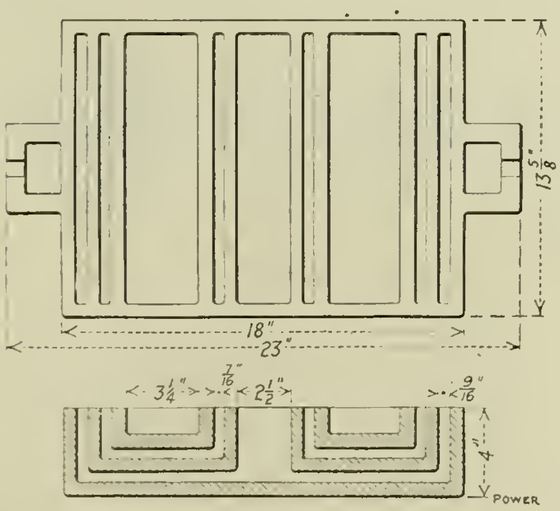


Fig. 3

that the man who invented the proposition never intended to run it. Fig. 3 shows the face of the valve. Who ever saw one like it?

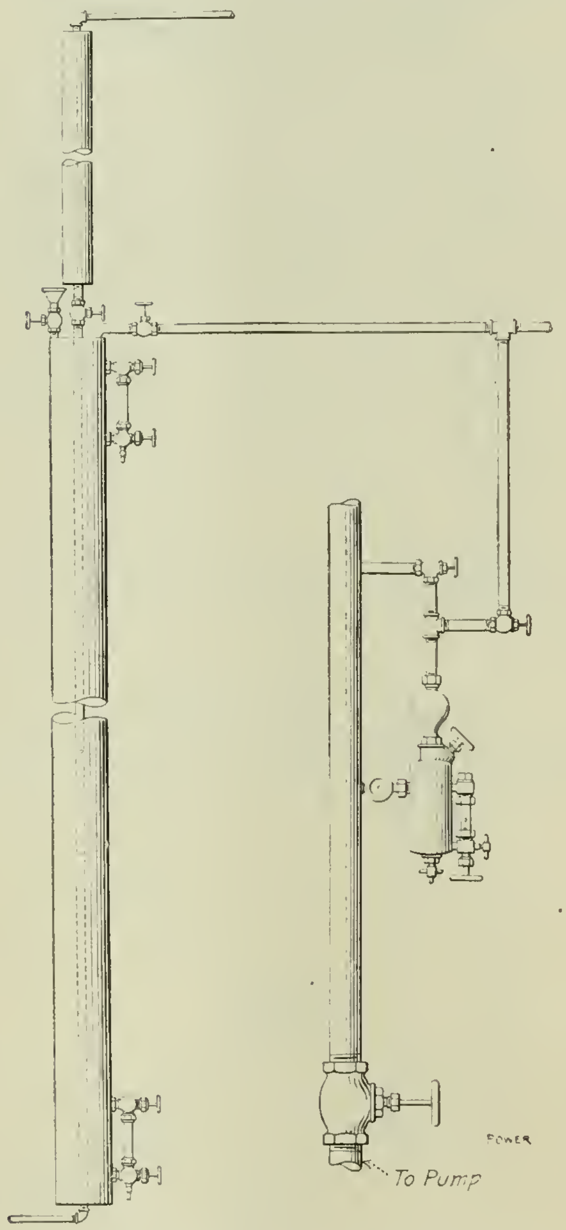
Allen J. Stocks.

Seattle, Wash.

Lubricator Connections

Some time ago I took charge of a water, light and power plant in which there were ten sight-feed lubricators. The oilers always filled them to overflowing, which caused a waste of oil at each filling, amounting to about ½ pint per day. Then there were the time and waste necessary to use in cleaning up the lubricator and floor.

This loss and annoyance were overcome by using a piece of 4-inch gas pipe, 10 feet long and capped at each end to form an oil chamber. A ¼-inch hole was tapped in the lower cap for a drain pipe and a ½-inch hole drilled in the center of the upper cap. A ½-inch pipe, 9 feet



Oil Reservoir and Lubricator Connections

10 inches long, was screwed inside of the 4-inch pipe, through the upper cap. A valve was put on the upper end of the ½-inch pipe just outside of the 4-inch cap. Then 3 feet of 2-inch pipe was placed above the ½-inch valve to serve as a condensing chamber and was connected at the top to a steam header.

I also connected a ½-inch pipe in the 4-inch cap and extended it to the individual lubricators. A gage glass was placed near the top and bottom of the oil chamber to indicate the hight of oil. The main feed line is attached to each individual lubricator just above the condenser bulb by means of a tee and valve as shown.

C. J. Beach.

Iola, Kan.

A Makeshift Gin Pole

I was recently sent to erect a boiler and engine on a rice farm. Work went along smoothly until I was ready for the 40-foot gin pole, but none was to be found. Two 20-foot sections of 3-inch gas pipe were finally obtained and coupled together. A piece of wood was driven into one end of the pipe, to which a short crossarm was nailed to support the guy lines and hoisting ropes. As there was a derrick over a well the raising of the gin pole and stack was an easy matter.

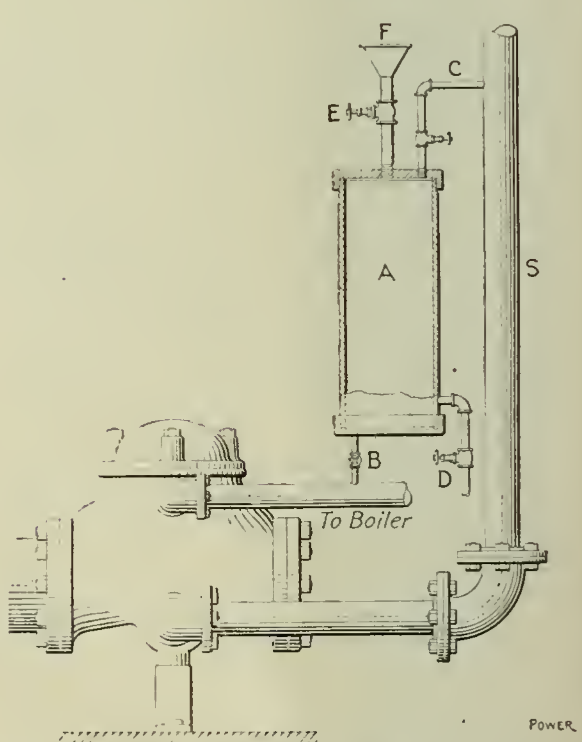
Ernest Beck.

Marianna, Ark.

Compound Feeder

In the accompanying sketch is shown a convenient method of feeding boiler compound, where the pump receives water under pressure, as from an overhead tank.

A cylinder, which may be made from



Compound Feeder

a piece of 12-inch pipe, capped on each end, is shown at *A*. A ¼-inch pipe *B* and valve runs from the discharge of the pump to the bottom of the cylinder. *C* is a ¼-inch pipe leading from the top of the cylinder to the suction pipe *S*.

A ½-inch drain pipe *D* leads from a point near the bottom of the cylinder. *E* is a 1½-inch pipe and gate valve through which the cylinder is supplied with boiler compound.

To refill the cylinder with compound, close the valves *B* and *C* and open the valves *D* and *E*. The cylinder will drain through the valve *D*, which is then closed and the cylinder fills through the valve *E*, which is then closed and the valves *B* and *C* opened, when the apparatus is at work.

This is a particularly good arrangement for feeding soda ash as there is no possible chance for the pipe to become clogged and the force of the entering water is a great aid in dissolving the soda ash.

J. D. Chambers.

Tacoma, Wash.

Engine Needed Indicating

The accompanying diagrams are from a 16x42-inch Corliss engine running at 100 revolutions per minute. The diagrams

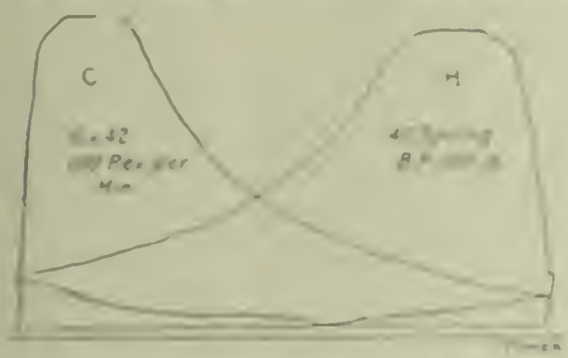


Fig. 1. Before Setting the Valves

shown in Fig. 1 were taken from the engine as I found it, and those in Fig. 2 as I left it.

I would like to have some of the indicator men figure the saving made. They

Fig. 2. After Setting the Valves

had two boilers in operation before the change and could run with one afterward. It required but 20 minutes to make the adjustments.

H. T. Fryant.

Memphis, Tenn.

Pressure on Pump Plunger

If, in a single-acting triplex power pump, with the cranks set at an angle of 120 degrees, and the space below each plunger be connected with a suitable pipe, and, if this space is filled with water, can the crank shaft be turned around one complete revolution without the pressure on the water being raised, and indicated by a gage attached to the pipe? Or, in other words, will there be a constant volume during all parts of the revolution?

This problem came to me while trying to locate the cause of a breakdown on a triplex pump, which was of the piston type, but was single acting, and discharging only when the plungers were descending. The top ends of the plunger cylinders were all connected beneath the stuffing boxes, with a suitable sized port. This port was supposed to connect with the suction also, but had become stopped up.

Now the question is, if the plungers did not leak, would there be excessive pressure on top of the plunger when the pump was in operation?

B. U. Potter.

Holyoke, Mass.

A Governor Problem

Recently a governor problem came up, a discussion of which may be of interest. It is as follows:

A diagrammatic sketch of an inertia shaft governor is shown herewith, in which *A* is the engine shaft, *B* the eccentric, *C* the point of suspension of the weight arm, *D* one of the two weights attached to one end of a weight arm, the weight having a pocket so that shot may be added. *E* is the other weight, which is made up of removable plates, and *F* is the weight connected to the weight arm. The hollow part of the weight *D* was filled with shot, all of the plates were removed from the weight *E*, and 20 pounds of lead were added to the weight *F*, as shown at *G*. Why were these changes made, and what effect did they have on the speed of the engine?

After carefully analyzing the sketch it seems to me that the aim in making the change was to change the center of gravity of the weight arm so as to increase the centrifugal force and at the same time keep the inertia effect practically the same. By removing the plates from *E* and adding shot to the weight *D*, the center of gravity of the weight arm is shifted toward the weight *D*. Since the weight *E* is made lighter and the weight *D* is made heavier there is less tendency for these weights to balance each other and, consequently, the inertia effect of the weight arm is decreased and the centrifugal force is increased because the weight *D* is increased and its distance from the center *C* remains the same. Since the weight *E* was lightened the inertia effect of the weight arm was decreased and in order to make up for this inertia 20 pounds of lead were added to the weight *F*, as shown at *G*. Now the weight *F* has practically no effect on the centrifugal force of the governor because the center of the shaft, the center of the pivot *C* of the weight arm and the center of gravity of the weight *F* are very nearly in a straight line. The effect of the weights *F* and *G* is almost entirely that due to inertia; therefore, by adding the weight *G* to the weight *F* the inertia of the governor was maintained and, consequently, the sensitiveness of the governor was not lost, but by increasing the centrifugal force by shifting the center of gravity of the weight arm the power of the governor was increased.

The centrifugal force of the governor being increased, the speed of the engine

Showing Weights on Governor Arm

will be decreased because the governor will respond at a lower speed.

T. W. Holloway.

Scranton, Penn.

Operating a Dangerous Boiler

An old boiler, located in the oilfield of Ohio, is used to steam and pump oil about two hours in four weeks. It remains idle the rest of the time, but a small flame from a gas jet keeps the water from freezing.

One morning the boiler was fired up to steam a tank of oil preparatory to pumping it into the line. When the steam gage registered 100 pounds pressure the front head sprung a leak around the handhole plate, which promised to drain the boiler in short order.

The fireman started the injector, but seeing that the water was dropping about an inch a minute he drew the fire and, after the boiler had cooled down, an examination showed that the front head was so wasted away around the handhole that two holes were visible and the head could be punctured with a light tap with a hammer. The rivet heads of the rivets joining the head to the shell had entirely wasted away. The front head was originally [illegible] inch thick, but up to the third row of tubes showed a thickness of [illegible] inch.

This boiler is of the firebox type and of about 25 horsepower. It does not come under the license law of the State, and is fitted with an old ball and lever valve set to operate at 100 pounds pressure. It is 15 years old and has been almost continually exposed to the weather. That the boiler did not explode is a mystery, but it will have another chance, for it was patched up again and put in service at 100 pounds pressure and is doing business at the old stand.

M. W. [illegible]

[illegible], O.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Indicator Cord Hook

A hook for connecting the cord from a reducing wheel to the rod on an engine crosshead was described in the February 7 issue. I have used this form of hook and, although it serves the purpose admirably, have found that the one shown in Fig. 1 is more convenient to connect. The distance between points *A* and *B* is a trifle larger than the diameter of the rod on the crosshead. The hook is held at the head end of the engine stroke and tilted as shown so that the rod will pass between *A* and *B*, whereupon it will readily connect.

This hook cannot be used satisfactorily with high-speed engines when the reducing motion is obtained by link work. For this purpose I have used the connector shown in Fig. 2, which is made of moderately stiff wire, a little longer than the stroke of the pin prepared for cord attachment, that is, about 3 or 4 inches. To use this connector, the indicator drum is drawn to the end of its stroke by pulling on the cord *C*. The wire is then slipped over the end of the reciprocating pin so as to take the position shown in Fig. 2—the dotted circles representing the end-stroke positions of the pin. Now, by allowing the indicator-drum spring to draw the wire to the right until the pin strikes it at the end of its stroke to the left, the "hooking up" is very easily accomplished. The end of the cord *C* should then be attached to some convenient point so that it will not swing around the link motion. When disengaging the indicator, this cord *C* is used, the wire connector being pulled with it until free of the pin.

FIG. 1. CONVENIENT CONNECTOR FOR ENGINES OF MODERATE SPEEDS

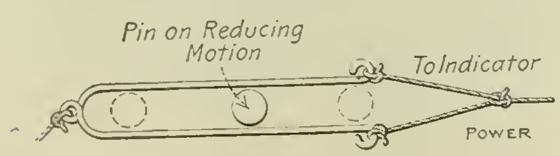


FIG. 2. CONNECTOR FOR HIGH-SPEED ENGINES

If it is found at all difficult to slip the wire in place on account of its ends being drawn together, the form shown in Fig. 3 may be used. In this case the wire is bent so that its legs have a slight spring outward which is taken up as soon as the indicator cord becomes taut. The right hand is used only to slip the wire over the pin; after this is done, the hooking up is as before.

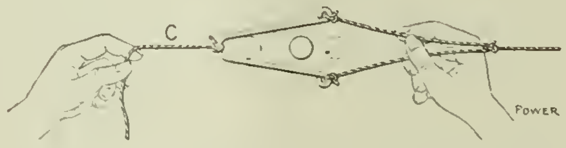


FIG. 3. ANOTHER FORM OF CONNECTOR FOR HIGH-SPEED ENGINES

JULIAN C. SMALLWOOD.

Syracuse, N. Y.

See Your Plant as Others See It

Referring to the first-page editorial in the March 7 issue, it is a good plan for a chief engineer to get away from his plant occasionally and do some visiting around among the other plants. It tends to broaden him and gives him a better knowledge of engineering matters in general. It also enables him to get many valuable ideas which he can apply in his own plant to his own and his firm's advantage. Ideas gained in this way make a lasting impression and cannot be obtained in any other manner.

Most engineers are confined so much to their own plants that they are more than likely to get into a rut and overlook many things about it which might easily be changed in a way to give better economy. As long as they do not have an opportunity to see how the engineers of other similar plants are handling them and overcoming their troubles, they are likely to continue in the same old rut to the detriment of both themselves and their employers.

When an engineer visits other plants he frequently notices things which he knows could be changed in a way to produce better results and when he returns to his own plant he is likely to find that he has the same set of conditions or a worse set. The reason why he had not noticed it before was that he had became so accustomed to it that it escaped his attention until he had traveled around visiting the other plants and got jarred out of his rut.

I believe that the best investment that a firm can make is to give its chief engineer a couple of weeks off each year with full pay and expenses and have him spend the time visiting other plants in order that he may keep uptodate.

If the engineers who are unable to get away from their plants would make it a point to ask questions of all of the traveling men who call on them, they would probably be surprised by the amount of information that they can gain in this way. A great many of the traveling men today are well posted on engineering practice, many of them having had years of practical experience in the engine room and, as they are constantly visiting plants of various kinds, they are always able to give an engineer much valuable information. In addition to getting all of the information possible by discussions with others an engineer should read as many journals and books on the subject as possible.

S. KIRLIN.

New York City.

Slipping Latch Blocks

In the February 28 issue, I read C. L. Greer's reference to slipping latch blocks of Corliss engines. Of course, the steel plates should not be allowed to become so worn that slipping off is liable to occur. It is to prevent this that daily inspection of the plates is a regular rule in some power plants, particularly in large power and lighting stations. Whenever the edges begin to get "rounded," as they call it, the plate is to be turned so that a new and square edge is presented for wear. Sometimes, though, an engineer thinks that a certain plate will last through just one more run and he allows it to remain. After running for, perhaps, three-quarters of the watch, slipping begins, much to the annoyance and disgust of those concerned. It is not desirable to shut down to effect a repair, especially as the watch is almost up, and so various things are tried to keep the engine going until it is cut out of service at the proper time.

It is better to prevent the possibility of such slipping off, but if caught during a run, try the following: Squirt kerosene oil on the plates, and the slipping will stop, or the slips will not be so frequent. Turpentine is better still and seems to have the same effect as roughening the surfaces with a smooth file. Still another expedient that I have tried is to wipe off all the oil or grease and chalk the edges of the contact plates.

CHARLES J. MASON.

Scranton, Penn.

The Pabst Verdict

In regard to the damage suit growing out of the recent boiler explosion at the Pabst brewery, I am unable to agree with the opinion of B. J. Morrison, as reported in the February 21 issue, that the initial rupture came in the main steam line and that, as a result, the water in the boiler flashed into steam, causing an overpressure and the resultant explosion. I should expect a sudden escape of steam to produce a reduction of pressure in the boiler.

Professor Breckenridge's belief that the reinforcing plates prevented the drums from conforming to a true circle seems far fetched, as his belief must be equally applicable to the reinforcing strip at the butt joint.

The lack of information regarding the general layout of the plant and the position of the points of supposed initial rupture in relation to surrounding objects precludes any reasonable judgment being formed regarding the primary cause of the disaster. The appearance and location of the several parts subsequent to the explosion tell very little of value in founding just judgment regarding the cause or source.

JOHN W. PAYLER.

Detroit, Mich.

I have just read the report in the February 21 issue of the verdict in the Pabst boiler-explosion damage suit. I was at the scene of the explosion on the morning after it occurred and examined the wrecked boilers as best I could.

If the boiler tubes had been connected into the sides of the drums instead of into the bottoms, the disaster might not have occurred. The expansion and contraction of the straight tubes caused the excessive "breathing" action and the weakening of the plates.

The theory that the steam line let go first has no substantiation in my opinion. An accident occurred to a tug-boat boiler here recently and I had a chance to observe the effects. A bridge swung around and broke off the main stop valve. The boiler did not explode, although it was rather badly distorted, and the staybolts were pulled away from the sheets.

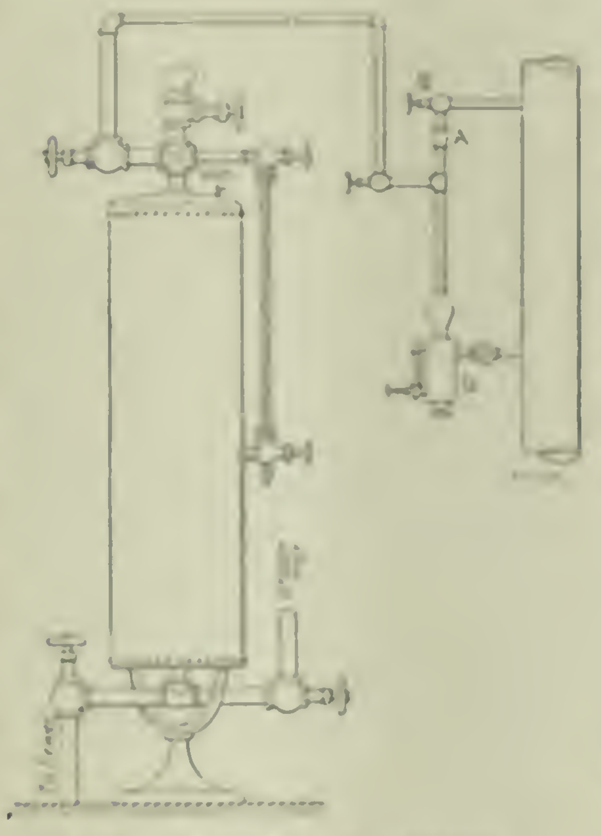
JOHN DOE.

Milwaukee, Wis.

Oil Reservoir Layout

In response to Mr. Pierce in the February 21 issue, I submit the following on a "central-station" lubricating system which I installed in a hotel. A 30-gallon tank was procured and set up as shown in the accompanying figure. The figure is self-explanatory.

Some engineers might prefer a simple sight feed instead of a complete lubricator at *G*, but I prefer using the lubricator as then the outfit is "hooked up" double. If for any reason the "central station" is out of commission, the lubri-



ARRANGEMENT OF OIL RESERVOIR

cator can be filled in the old way from "Grannie's" teapot and used as originally intended until such time as the system is in commission again. I would advise anyone who installs a system of this kind not to forget the vertical check *A*, as I have found by actual experience that valve *B* can be opened mysteriously.

CHARLES P. WEAVER.

Buffalo, N. Y.

Size of Air Chamber

In the issue of February 21, F. A. Dew wants to know about the air chamber on a power pump. I think all of the trouble is in the suction pipe and the knock or pound of which he speaks is a water ram or hammer in the suction pipe. If he will tap the top of the suction pipe for a ½-inch pipe and use either a valve or a pet cock to admit a little air, the pound will stop. The cock should be closed when shutting down the pump so as to prevent the water from going back to the well. I have tried this scheme and know that it will work.

C. E. TALLMAN.

Cripple Creek, Colo.

I have read of Mr. Dew's trouble in the February 21 issue and I would like to offer a few suggestions.

In the first place, is there a foot valve on the lower end of the suction line?

When a volume of water in a suction pipe of a pump is once set in motion it is quite important, especially when dealing with high speeds, to stop it gradually. For this purpose a vacuum chamber is often placed on the suction side of the pump. Perhaps a vacuum chamber would eliminate some of Mr. Dew's trouble.

WILLIAM A. VINSON.

Fort Logan, Colo.

In the issue of February 21, F. A. Dew requests information regarding air chambers.

As a rule for diameters I have taken three times the diameter of the discharge pipe for the diameter of the air chamber and sixteen times the diameter for the length.

Water hammering of check valves is easily overcome, if the operator will study the conditions that cause the hammering. The size of the air chamber used to overcome the hammering depends upon the amount of air that the water absorbs and the means at hand to

POSITION OF AIR CHAMBER AND METHOD OF REPLENISHING IT

refill the chamber with air. The proper point at which to install the air chamber is at some elbow near the pump, preferably on a tee in a vertical pipe in direct line with the flow of water as shown at *A* in the accompanying figure. With this arrangement the air chamber takes the direct blow of the water from the pump and then transmits it gradually to the line. The aim is to keep the water flowing as uniformly as possible.

With no pressure on the line the chamber would be full of air; with 15 pounds pressure the chamber would be one-half full of water; at 45 pounds it would be three-fourths full and at 105 pounds the air would occupy only one-eighth of the space that it did at atmospheric pressure. At high pressures the water absorbs the air very rapidly.

To refill the air chamber with air, close the suction valve and open a valve between this valve and the pump and place a hose in the short section of pipe, as shown in the figure. As nearly all pumps have two suction connections, one on either side, the one not in use can be used. By the means just described air will collect in the air chamber because the water, being heavier, will force the air to the top. The air chamber can thus be refilled whenever the check valves give the slightest indication of hammering.

C. A. Davies.

Cincinnati, O.

Advice on Giving Advice

In answer to E. L. Morris' appeal for aid in solving his radiator trouble there were several suggestions printed in the February 21 issue, each of which is adjudged by its author to remedy the difficulty and warm the cold radiator. What surprises me is to see that no two correspondents come to the same conclusion. If I were in Mr. Morris' position I believe I would be in as much of a quandary to decide which bit of advice to follow as to solve the heating problem itself.

This multiplicity of advice (often conflicting) I believe to be one reason why so few interesting problems of this kind are sent in for the consideration of the practical readers of Power; and it has been the reason, in past instances which can be pointed out, why some smart (?) writers have sent in perplexing and often ridiculous conundrums, the correct answers to which were immaterial to them, and beneficial to neither art, craft nor science. I do not wish it to be understood that the editors should restrict the number of published answers to the two or three which may agree—for, often, replies bearing little on the subject under consideration contain some instructive matter applicable to other cases—but that the editors should review the replies sent in, and at the end of a discussion issue their own advice or give some one correspondent's answer such a conspicuous position in the paper as to denote that they favor it.

If Mr. Morris should write directly to the Power editors, I do not doubt that he would receive a satisfactory solution or, at least, some kindly suggestion that would aid him to reach a conclusion which would lead to the elimination of the trouble. Now, why cannot Power make public such answers? Do the editors suppose that their own opinions would be uninteresting to the readers or do they fear criticism of their answers? Possibly they refrain because they were not asked for their own advice. Surely that is a poor extenuation, but it is more charitable to surmise this than that they forbear because of the humor derived from the diversity of opinions which are sent in.

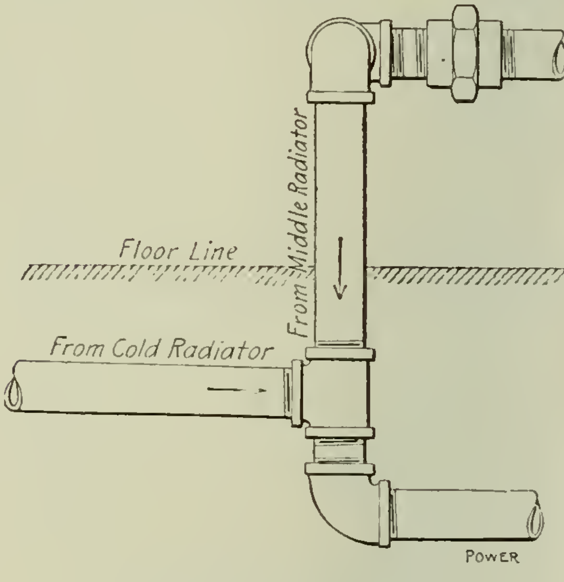
It may be considered somewhat imperious of me in giving advice as to the lines along which answers should be given to such an inquiry as the one under consideration, but it may benefit some writers who are willing to state their opinions, to learn how their advice could be made more valuable. Also, the inquirer may benefit by my endeavor to show how to glean and adopt what is valuable in the replies given. I do not proffer an opinion of my own but merely point out the facts already given by my fellow correspondents.

It is essential that the adviser place himself in the position of the inquirer and remember that the trouble must be eliminated at as little expense and with as little inconvenience to the tenants as possible; therefore, it is unreasonable to expect expensive changes to be made unless it is certain that such changes will improve matters materially. It is, then, the recipient's first duty to discover whether any of the remedies suggested are applicable to his case. Applying this principle to the case under consideration, one may infer from Mr. Noble's communication that the trouble is due to the water of condensation in the supply pipe. To test the correctness of this assumption Mr. Morris should "break" the union between the valve and the radiator and let out all of the water until steam issues freely. If now the coil heats up after reclamping the union, he would at least have found the cause but the remedy suggested—supplying an extra line of piping—may be inconvenient.

If the water of condensation flows out slowly when the union is apart, a lack of pressure may be inferred and Mr. Dixon's theory that all of the steam condenses before reaching the radiator is correct. The remedy would be either to lessen the percentage of friction by supplying larger sizes of piping, as he suggests, or to carry a higher boiler pressure. It would be well, however, first to make sure that there is no obstruction in the pipe itself. This can be ascertained by closing the valves on the other two radiators and maintaining a good head of steam on the line.

Mr. Plowman's suggestion that air-vent valves be placed on the outlet end of the radiators is good advice, but this is so well understood by the veriest novices that it is here taken for granted that Mr. Morris' radiators are equipped with them.

From Mr. McCoffin's letter it might be inferred that the water of condensation chokes the riser tee when steam emanates horizontally from two outlets. If this is the case, closing the valve of the right-hand radiator should cause the left-hand radiator to heat up. If this fails, Mr. Morris could try Mr. McCoffin's idea on the return tee of the middle radiator as shown in the accompanying figure. The condensate from the middle radiator will now have a tendency to siphon the air in any pocket that might exist in the left-hand return pipe. In any case, the arrangement is an effectual check to the backing up of the water of condensation and should be beneficial if its advantages are not offset by a too great reduction of the general angle or dip of the return pipe. To test this suggestion Mr. Morris should close the valve on the middle



Rearrangement of Tee

radiator, when, the cause of the choking at the return tee having been eliminated, the entrained water should flow freely from the cold radiator.

These are but a few suggestions whereby Mr. Morris can aid himself to detect the trouble without tearing things apart. If it be possible, answers to inquiries should contain a statement of some method whereby the suggestions which they contain may be tested without undue expense.

Owen R. Owen.

Roxbury, Mass.

Low Pressure Turbines

I read with interest Mr. Fenno's letter published in the January 30 issue in which he took exception to the statements made in the catalog published by one of the turbine manufacturers. I also noted in the February 28 issue, Mr. DeGroot's attempt to disprove Mr. Fenno's analysis.

While all of the statements that Mr. DeGroot made are true and really do occur in practice, I believe that they have no application in the present instance, as the original assumptions were all made on theoretical grounds alone, that is, the comparison of the number of B.t.u. rendered available by a pound of steam expanding adiabatically from 150 pounds gage pressure to atmosphere, and the same pound expanding adiabatically from atmospheric pressure to a 28-inch vacuum, was made on theoretical grounds alone. If it was made on theoretical grounds, Mr. DeGroot's criticism is not warranted. If it was not made on theoretical grounds, the original figures, giving the amount of energy available in the two ranges of expansion, are not correct.

If a pound of steam expands adiabatically from 150 pounds gage to atmospheric pressure, it must of necessity have a quality at the end of expansion of about 86 per cent., as pointed out by Mr. Fenno. If it does not have this quality, the pamphlet referred to had no right to assume that 160 B.t.u. were rendered available for useful work. Furthermore, I do not believe that Mr. DeGroot has any right to introduce the subject of reevaporation, because if this is present then the expansion is not adiabatic, which would be contrary to the original assumption.

I also believe that Mr. DeGroot errs in introducing the subject of a drop in pressure at release, which would evaporate the wetness fraction in the steam. The original assumption being that the reciprocating engine expanded the steam adiabatically down to atmosphere, and that the turbine started with steam at atmospheric pressure, of course precludes the supposition of any drop in pressure.

As mentioned above, I believe that all of Mr. DeGroot's statements are correct, but the original assumptions do not allow the application of his argument to the case in hand. I, therefore, believe that as we are arguing solely on theoretical grounds, Mr. Fenno's criticism is perfectly just and warranted.

Sol. Siegel.

New York City.

Organization

The first-page editorial in Power for February 21 should cause engineers to "sit up and take notice." Comment is made on the fact that economic engineers, lubricating experts and specialists of other types are used by owners of steam plants more frequently than ever before. The opinion is given that the operating engineer, who is constantly about the plant, should, and generally does, know more about the plant than any expert that can be called in.

The writer of the editorial sees no reason why a chief operating engineer should not be able to install a new plant, if called upon to do so; and, further, advises all engineers to break away from routine once in a while and view the plant as an outsider through a binocular. Such articles in theory and on paper look fine and tend to raise the pride of the "knights of the throttle," but an essential thing to determine is why the operating engineer is usually consulted at the last moment.

In the first place, the engineer in a one-man plant is usually regarded as a necessary evil. The mill cannot run without him and as his energy has disappeared in the products of the other employees there is nothing visible that he leaves behind him after the day's work that can be sold for a profit. Such being the case, the object is to get as much work out of him as possible and give him as little in return both in money and credit as he will consent to accept. The chief of a one-man plant has to use more ingenuity on and do more scheming over a two-cent job than does the average business man over the problems with which he meets in the business world.

The owner of the one-man plant demands first-class results from all the old junk that has been collected in the course of time. When these results do not materialize the engineer is immediately dubbed no good. He is asked to buy and use second-hand pumps, belting, pulleys, hangers, shafting, engines and boilers; in fact, he runs up against the second-hand proposition so often that when he begins to think of dying he more than half expects to go to a second-hand hereafter. If the second-hand goods do not look as well and give as good results as first-class new goods, the engineer is unceremoniously told that he has done a poor job and the "main guy" audibly wonders why he cannot have things looking as well and giving as good service as in some places where only first-class machinery is purchased, and he comes to the sage conclusion that it is because his engineer is no good.

There is not much doubt that the average engineer could install a new plant and is perfectly able to replace an old one without the aid of a specialist, expert or consulting engineer. But he is seldom given the same latitude that the so called expert is given. For instance, the engineer says to the boss, "We must have a separator on the steam line."

"Nonsense," is the reply, "we have gotten along for years without one and they cost money."

The boss listens to all of the engineer's arguments, gives bored attention to his data and does no more about the matter until an "expert" comes along and gives one-half the reason already advanced by the engineer and the boss "falls" for the separator.

The engineer in a plant of under 150 horsepower capacity has no routine. His work is all over the shop. He is the engineer, fireman, machinist, electrician, wireman, dynamo repairer and tender, carpenter, plumber, steam- and gasfitter, beltmaker, etc.; he must be able, ready and willing to jump in and repair any machine that may go on a strike. If he cannot or will not do any or all of these things, he is either no good or lazy or both. Now, why are things thus? There is one very good reason: the average engineer does too much and, because he does so much, he loses the respect of his employer who comes to look at him as a little higher grade man-of-all-work than the general run of "lumpers."

The carpenter, machinist and other skilled laborers in a factory do what they are hired to do and no more; and they are not asked to do more. Why? Because they have an organization back of them that defines their hours of labor, kind of labor and the wages they shall receive and the employer, if he can help it, does not care to clash with the trades union, recognizing that it is an unprofitable argument. But as the engineer has no organization back of him, the employer gives it to him for all that he will stand.

All the engineers realize their need for more and better knowledge. But, in my opinion, there is something else they need to acquire as well, and that is, "organization" knowledge. "To earn more, learn more," is a mighty fine motto, but when we find mechanics who master their trade in three or four years getting a shorter day and higher wage than the engineers, who may not hope to ever master theirs, we know that they have learned something that the engineers have not. They have learned that collective bargaining for hours and wages "knocks the spots" out of individual bargaining and, having learned, they have put their knowledge to use.

It seems to me that the engineer should take a night course in some good school that teaches organization and when he has learned a little, get together with his fellows. If he applies his knowledge of organization one quarter as well as he has his knowledge of mechanics, he will put his trade in the lead of all trades.

G. G. Hall.

Dorchester, Mass.

A Practical Compression Test

I have read with some interest the article by Charles J. Mason under the above caption in the February 28 issue. I cannot see wherein it was a "compression test" at all. He says that the engines had "considerable compression" in both high- and low-pressure cylinders and were operated under a boiler pressure of 150 pounds and a receiver pressure of 15 pounds. Now, instead of changing both compression and receiver pressures, why did not the engineer change only the compression? Then there would have been a test. But I should think that any engineer would know that 15 pounds receiver pressure with full-load conditions, the usual ratios for cylinder volumes and a boiler pressure of 150 pounds, was not a proper amount. Had the engineer simply increased the receiver pressure and left the compression just as it was, he would have made a great improvement in the efficiency of the engines.

It is unfortunate that diagrams were not shown in connection with the report of this test. The term "considerable compression" is rather vague. If the compression was excessive in both cylinders, then there was an unnatural condition, under which any amateur ought to be able to effect an improvement. This matter of compression is one on which engineers are in better agreement than they really know themselves to be. I do not know of any engineer worth mentioning by that name who defends compression as a *brake on the engine.*

Mr. Mason states that positively, the changes having been made—that is, the receiver pressure raised and the compression reduced—the engines used less steam with the same load. This may be readily conceded without even admitting that it was the result of reducing compression, although I am willing to concede that it probably helped. But how could we expect that a heavily loaded engine, with properly proportioned steam cylinders, high- and low-pressure, 150 pounds boiler pressure and only 15 pounds receiver pressure, would give satisfactory performance? How could we expect compound results from so nearly simple conditions? I think that the vast majority of engineers will agree that the increase in receiver pressure from 15 to 25 pounds caused most of the improvement.

It is quite clear that if the cylinders were properly proportioned, the high-pressure cylinders were doing most of the work during the moderate- to heavy-load periods. Naturally, one would not expect economical operation under such conditions.

To claim that this test demonstrates that the compression was or was not economical is hardly warranted. Had the receiver pressure been left as it was, that is, at 15 pounds, and the changes of valve setting made, and the test made under this condition, then we would have had something that could really be called a compression test.

William Westerfield.
Concordia, Kan.

Sizes of Turbine Steam and Exhaust Pipes

With reference to W. J. A. London's charts for selecting the size of steam-turbine steam and exhaust pipes, which appeared in Power for February 21, I agree that the curves are convenient and will save much calculation; but they are not, I consider, based on correct principles. I will confine my remarks to the size of exhaust pipes.

Mr. London has fixed on a constant velocity for all vacua down to 24 inches. This is not, I think, scientific, neither will it work well in practice. The lower the pressure of the exhaust steam, the greater is the velocity which can be employed with a given loss of head; and, moreover, the cost of reducing the velocity by increasing the section of the pipe is, with low exhaust pressures, and consequently large volumes, much greater than with higher pressures. It therefore follows that with high vacua a greater velocity should be allowed than with low vacua, other conditions being the same. Mr. London has, to a certain extent, acknowledged this by allowing a velocity of only 100 feet per second for steam exhausting at atmospheric pressure, while for vacua above 24 inches he allows 400 feet per second.

Another point should, in my opinion, be considered. The friction in a small pipe is greater than in a large pipe for the same fluid at the same pressure and the same velocity. The curves should, therefore, I believe, be based on the allowing of higher velocities with large pipes than with small ones.

I would be pleased to have Mr. London consider and criticize the following formula for the area of exhaust pipes and ducts:

$$A = \frac{W^{0.8} V^{0.5} f^{0.4}}{C}$$

where

A = Area of exhaust-steam pipe or duct in square feet;
W = Pounds of steam per hour passing through the pipe or duct;
V = Volume in cubic feet of one pound of this steam;
f = Periphery in feet of a figure of the shape of the cross-section of the exhaust pipe or duct and of an area of one square foot, and
C is a constant which for condensers for land turbines may be taken at 16,000. Where weight is of greater import or back pressure of less consequence, C may be given a higher value.

The formula was given in my paper on "The Design of Surface Condensers," which was read before the Institution of Engineers and Shipbuilders in Scotland in February of last year. It will be seen that it applies whatever be the section of the exhaust ducts. The ducts sometimes have a rectangular section. It does not matter whether W represents the weight of steam only or the combined weight of steam and water of condensation, so long as the corresponding value is taken for V.

R. M. Neilson.
Glasgow, Scotland.

Homemade Tube Cleaner

In the February 14 issue, E. H. Marzolf describes his homemade tube cleaner. He does not state what size of tubes he can clean with it. If he uses it for 3- or 4-inch tubes, 16 to 18 feet long, he will learn that the greater portion of the soot will accumulate near the back end of the tubes. The perforated cap at the end does scatter the steam in a number of currents and impedes the velocity, which should be as great as possible. Volume and high velocity of steam are essential to a good tube cleaner and I fail to see why he uses the perforated cap.

J. W. Dickson.
Memphis, Tenn.

Emergency Pipe Repairs

I was much interested in Mr. Taylor's description of two kinds of pipe clamp in the February 14 issue.

On two occasions I stopped a leak in a pipe where it was not convenient to apply a clamp.

Fig. 1 illustrates the arrangement used in the first case. The leak was in a 2-inch feed-water pipe. Some 1¼-inch fittings and nipples were put together as shown. A 2x2-inch piece of No. 10 gage iron and some packing were placed over the leak. Then, a 1-inch nipple was placed between the valve disk and the sheet iron and the disk screwed down

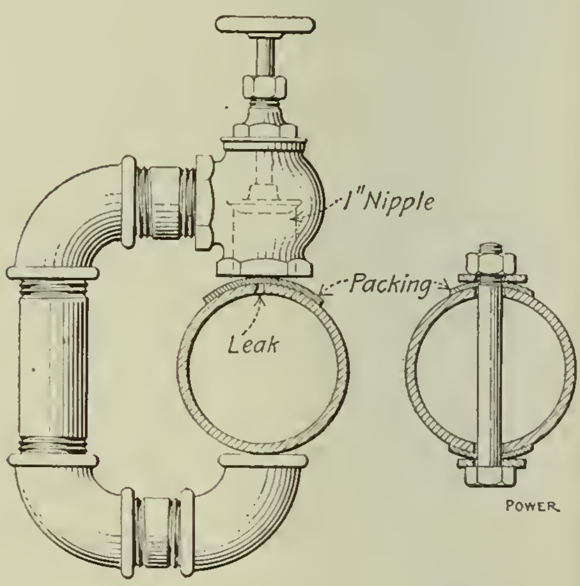


Fig. 1 Fig. 2

Two Methods of Stopping a Leak Temporarily

hard. The job lasted until a more workmanlike repair could be made.

In the second case, a leaking 2-inch feed pipe was repaired as shown in Fig. 2. I bored a hole clear through the pipe and inserted a bolt with washers and packing under the head and nut as shown. This makeshift did the trick until the pipe could be replaced.

Harry E. McArthur.
Port Blakeley, Wash.

An engineer who is envious of his neighbor's lot, because the latter has a more uptodate plant, is assuming an attitude which will hinder him in reaching the top of the ladder. As a matter of fact, in opportunity to gain experience and show his worth, he possesses a distinct advantage over his neighbor. Good equipment and ideal operating conditions never contributed toward the making of a good engineer; it is the experience gained in making the best of a poor equipment and devising means to overcome operating troubles that increases an engineer's worth.

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POWER

Contents

Will an Isolated Plant Pay?

What with depreciation and amortization and obsolescence and apportionment of charges and all the other intricacies with which the modern exponent of power-plant economics cumbers up the process, the plain business man may be excused for not knowing how much his output costs per horsepower-hour or per kilowatt-year. The central-station solicitor, whose salary or commission depends upon landing contracts, will naturally try to convince him that it is costing him a great deal, and will try to charge the electrical equipment with "its share of the burden." He will want it to pay rent and part of the manager's salary, subject it to quick depreciation, make it put aside from one-tenth to one-twentieth of its cost each year for renewal and go on charging interest on the full investment, and in every way try to enhance the apparent cost.

He is not to blame. This is what he is paid for, and he may call attention to some items that might otherwise be overlooked.

But the way for a manager to look at the question is this. It is not a matter of equitable charge between departments. He does not care whether the power is the main product and the heating the byproduct or whether it is the other way around. He should say to himself, if these are the facts, "Here I have a steam plant which I must have anyhow for heating, hot-water service, etc. How much extra will I have to pay out or lose in other ways if I tack some engines and generators on to it?" If he has to rent additional room for them, if they crowd out a department which might make money, the investment should be charged with rent to that extent; otherwise not. If he has to hire more help to take care of them or has to pay the present help more, the investment should be charged with labor, otherwise not. If the manager gets more salary because there is a generating set or two in the basement or if his efficiency in other departments is seriously impaired by reason of the executive ability which he will have to bestow upon this, then the expense of management should be considered; otherwise not. There should be charged, in addition to the fuel and supplies and ordinary upkeep and repairs, the amount of engine, generator, etc., which will be used up annually. That is to say, if the machines will cost twenty thousand dollars and will be used up in twenty years, he will be using up a thousand dollars worth of machinery a year and must charge the investment with it; but he must also credit it with the compound interest on that thousand dollars which is earned every year even if it is not invested at the assumed rate but is used in the business where it earns more. He may consider the chances of obsolescence, i.e., of the machinery becoming so out of date, of something so much more efficient being produced within the assumed lifetime, that he could not afford to run it; but he must also take into account his ability to profit by that increased efficiency. If the investment figures out to pay with machinery now procurable it will certainly pay with machinery so much better as to make it advisable to scrap the old to put it in. He should charge insurance and taxes if he will have to pay any extra; otherwise not. He should charge interest at the rate at which he can get the money and not at what he could make with that amount of money in another department of the business, or on the stock market, for he can get money at the same rate for these purposes. And if with all these charges the investment promises a profit over and above what the cost from the central station would be, and the permanency of the business warrants tying up the amount of money involved for the ordinary lifetime of a plant, he is justified in making the investment; otherwise not.

The Marginal Principle

If a business were making a profit of thirty per cent. per annum on all the money which its owner could raise, he would be foolish to invest a part of such money in a steam plant which would pay a profit of less than thirty per cent. upon the investment.

This is the "marginal principle," the latest bookkeeping device of the central-station solicitor to convince the power user that he can make money by paying the central station more for current than he can make it for himself.

The marginal principle is all right, but it has been proved that a manager should sell his steam engine and electric generator to get money to put into his business than that the owner of a department store should rent instead of own his building if he can rent at any percentage of the cost of building less than the percentage of profit made by his most profitable department. If the most profitable department is capable of extension and he cannot get money at less than the profit which his electrical plant is paying, then by selling it he can make the difference between the profit made by the electrical plant and that made by his most profitable department. But a man so circumstanced can usually command capital at a less rate than that of the profit which the electrical generating machinery pays when tacked onto a steam plant which he must have anyway and operated in connection therewith.

Improve the Personnel

Myriads of articles have been written and orations delivered at great length on almost every phase of power-plant operation. Automatic devices without number and with more or less worth have been invented, patented and put on the market, with the intention of eliminating in so far as possible the reliance that would ordinarily have to be reposed in the human element. This literature has accumulated and automatics good and bad have been scrapped, while but fragmentary articles appear and desultory attempts are made to improve the efficiency of the plant through the medium of the personnel.

A code of rules, drawn up with the intention of making them fit all conditions and adaptable to all classes of humans, would be worthless and impossible to apply. Different conditions call for different treatment, and man is too complex, with moods too varied, to bring within the application of any such method; but a set of rules intended for the maintenance of discipline—and with proper discipline minor troubles will right themselves—is not only possible to enforce but absolutely necessary to the harmonious operation of the power plant.

A ship without a rudder can be managed and brought into port with a jury rudder, but a plant without discipline is a derelict.

When it is considered that no machine is so intricate as to call for the same delicacy of handling demanded by human beings and that subordinates very often kindle a feeling of resentment toward the "old man," traceable in a large number of cases to ignorance and its handmaid stubborness, it is difficult to blame the chief engineer for any continuity of a disagreeable condition. Still there are very few instances where matters could not be remedied by the application of that valuable reagent common sense reinforced with the higher degree of intelligence accredited to the chief engineer, but which is sometimes sadly lacking.

Consideration of the feelings and working conditions of the help should not be overlooked by the man in charge. Attention and care must be given to any machine if it is to work at its highest efficiency; this is applicable with double force to the human machine. It is unwise, and a dead loss to the plant, for a chief engineer to belittle the ideas of those working under him. Many a successful man owes a major portion of his success to the proper discrimination and application of such suggestions. Some engineers when they graduate from the overall class assume such an air of superiority that they consider a suggestion from a subordinate with scorn. It is such men as these that constantly prate and seem to lament the fact that they are placed in any other category than that of a profession. If those that are so particular about the cognomen of their calling would devote more time to education through the medium of engineering journals and societies, and live up to the same standard of ethics demanded of other professions, they would soon find that, according to their standard of worth, the public would put them in the class to which they rightfully belong.

It would be unjust to the chief engineer to infer that all trouble with employees could be avoided. There are men who in their mental arrangement or derangement are so constituted that no one could work amicably with them. They will malign a chief from pure cussedness, and they cannot accept a consideration of any kind from the boss with the same grace that the courtesy was extended. If any chief is so unfortunate as to secure one of this breed he will soon find that tact and diplomacy will eventually have to give way to harsher means. The man must go. Sometimes it will be noticed that two otherwise good workmen cannot work together in harmony. If the chief cannot reconcile one to the other, the wider he makes their paths of duty the more efficiency will he secure from the individual unit.

There is a class of men, and these are generally found among the ranks of assistant engineers, who resent any show of authority toward them, but who are constantly on the alert for some order from the chief that will give them the appearance of superiority. Such men as these provoke trouble in any plant, as they work on the theory of Milton's devil who preferred to rule in hell than serve in heaven.

A congenial feeling must exist between a chief and his crew if the best work is to be derived from all. This feeling on the part of the chief should not be carried to the extent of making any particular man a favorite or pet, but should be applied impartially; nor should it be interpreted by the help as meaning that they can take privileges that would not otherwise be accorded them. A medium founded on respect, courtesy and consideration can be found that will work to the advantage of the station.

Cleanliness in Power Plants

It is said that a man may be judged by his appearance, meaning by this not necessarily fine clothes but neatness. This rule applies not alone to the human element but to the machine as well. Visible cleanliness about a plant is generally an indication that the internal parts of the machines are also well cared for. This is due not only to the fact that an engineer or fireman who keeps his engine room or boiler room spick-and-span is very apt to pay due attention to the invisible parts, but also if there is no accumulation of dust, oily waste, oil leaks, etc., there is less chance of grit getting into bearings, oil getting into generator windings, or dirty commutators. Attention to such matters requires very little additional time and has a marked effect upon the life of a machine, not to mention the saving in repair bills and increased plant efficiency.

"Never use electricity to do anything that can be done equally well some other way." This was one of the maxims of the late Lord Kelvin, and it illustrates the "horse sense" that made him one of the foremost engineers of the world in addition to being one of the foremost scientists. But the "equally well" mustn't be overlooked.

Misleading or over enthusiastic statements are not restricted to American manufacturers. An English builder of suction gas producers advertises "20 horsepower-hours for 1 penny" of fuel cost, using coke; in other words, one-tenth of a cent per horsepower-hour for fuel. The claim is a trifle over 100 per cent. above the fact.

A jack operated by compressed air and capable of a ten-ton thrust was recently used by the police of New York City to break into a gambling house, forcing open a steel door. And yet it is said there is nothing new under the sun.

The business manager of a certain central station always rammed both hands deep into his trousers' pockets when he went into the generating room of the power house. He wanted to guard against unconscious contact with the teeth of a 2300-volt circuit.

A woman's club out in Nebraska has discovered that bald-headed men are "trusting and confiding by nature." Now it is plain why some engineers are buncoed with imitation goods.

Rowdyism is none the less obnoxious when it is practised by a gang of well dressed ruffians from a technical school.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Mean Effective Pressure

What is meant by the term mean effective pressure, and how is it found?

T. L. R.

Mean effective pressure is the average unbalanced pressure urging the piston forward. There is always some back pressure tending to hold it back and the effective pressure is the difference between the forward and the back pressure. It can be determined accurately only from an indicator diagram, but when the cutoff is known, it may be approximately estimated by the use of the formula

$$M.e.p. = \left(p_1 \frac{1 + hyp\ log\ R}{R}\right) - p_b$$

in which

$m.e.p.$ = Mean effective pressure;
p_1 = Absolute initial pressure;
p_b = Absolute back pressure;
R = Ratio of expansion.

Factor of Evaporation

What is the factor of evaporation, and how is it found?

F. O. E.

It is the number by which the evaporation at any given pressure from feed water at the temperature it enters the boiler must be multiplied in order to reduce it to evaporation equivalent to that from and at 212 degrees. It is found by subtracting the number of heat units in a pound of feed water from the number of heat units in a pound of steam at the given pressure, and dividing the remainder by 970.4.

Blowing Out Boilers

Under what pressure is it best to blow all the water out of a boiler?

B. B. D.

It is best to allow the boiler and setting to cool off entirely and allow the water to run out. In this way all of the loose sediment settles in the form of mud and may be washed out by a stream of water from a hose; while if the boiler is blown out while the brickwork is hot the mud is dried, and sometimes baked into a hard mass which is difficult to remove.

Adjusting Corliss Engine Cutoff

When there is but one reach rod from the governor of a Corliss engine to the valves, how are the knockoffs adjusted?

C. I. C.

The rod extending from the governor to the first valve is made right first and then the rod connecting the knockoff of the second valve to the first is adjusted.

Movement of Valve

The shaft of an engine is 15 inches in diameter and the throw of the sheave 5 inches; then if I move the eccentric 1/4 of an inch, how much will that move the valve, providing there is no lost motion?

J. B.

Some authors use the term "throw of

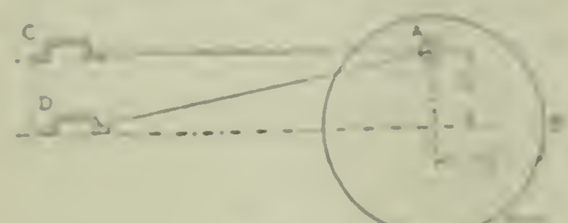


FIG. 1

the eccentric" to signify the total movement, that is, the diameter of the circle described by the center of the eccentric; others, the "throw or movement of the valve to each side of its central position"; in other words, the radius of eccentricity or the radius of the circle described by the center of the eccentric. The latter use is the more usual and it is assumed that is what is meant by the "throw of the sheave."

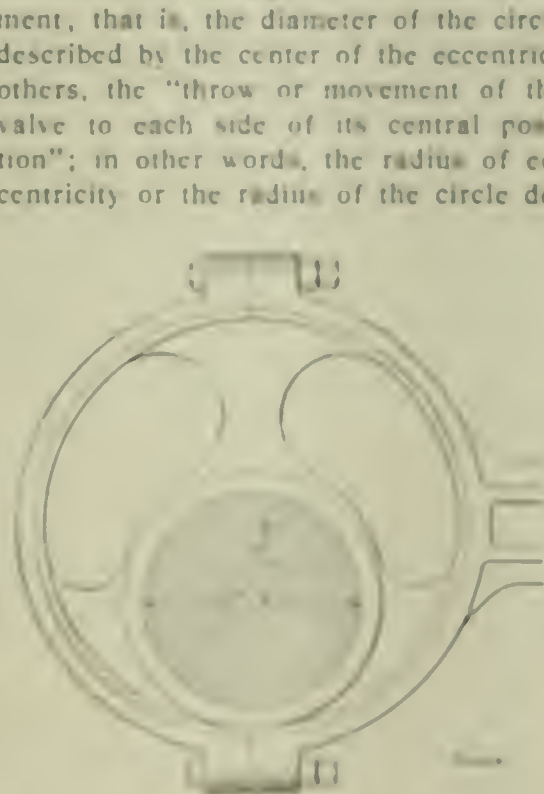


FIG. 2

Suppose a crank pin as at A, Fig. 1, in the end of the shaft, and with its center 5 inches from the shaft center. Then it is evident that the center of the crank pin A would move $\frac{5}{7.5}$ times as far as a point B on the surface of the shaft, and if the shaft were moved forward 1/4 inch the crank pin would move forward

$$\frac{5}{7.5} \times \frac{1}{4} = \frac{1}{6} \text{ inch.}$$

If this were connected off to the valve in a line square with the line connecting the centers of the crank pin and the shaft, the valve would move as far as the pin; but as soon as the angle of the crank and valve stem departs from a right angle the movement becomes less.

It is easily seen that for a given movement of the crank pin the movement of the valve would be less in the position C than in the position D, and when the crank pin gets around on the center so that the center line of the crank is in line with the valve stem, it will take a good deal of movement of the pin to make any appreciable movement of the valve.

If the diameter of the crank pin is increased until it embraces the shaft as in Fig. 2 it is seen that it is also true of an eccentric, the eccentric being but a crank with a pin surrounding the shaft.

Temporary Tube Repair

If one of the tubes in a horizontal return-tubular boiler splits or starts to leak at or near the middle of its length, how may the leak be stopped temporarily?

T. T. R.

A soft-wood plug about six inches longer than the split in the tube may be driven into the tube until the middle of the plug covers the leak. The water will cause the plug to swell and the leak will stop.

Spring Loaded Safety Valve

It is desired to change the blowing point of a spring-loaded safety valve from [illegible] pounds to [illegible]. How can it be done?

S. L. S.

By changing the spring. The springs of safety valves are not intended to operate at a variation of more than 20 per cent. from the calculated load.

Protecting Handhole Crabs

How may the nuts and crabs on the rear handhole plate be protected from the fire?

H. H. C.

By covering with asbestos or a mixture of asbestos and fire clay.

Notes on the Cost of Industrial Power

Abstract of written discussions upon the papers of Messrs. Parker and Hibner delivered at a joint meeting of the A. S. M. E. and A. I. E. E.

Mr. Peck (Rochester Railway and Lighting Company): Referring to Mr. Parker's paper, other methods of providing for amortization might be mentioned, as, for instance:

1. A yearly sum, equal to the investment divided by the number of years of expected life, should be set aside annually, allowing the variable earnings of this fund to be added to the other earnings of the company.

2. A variable yearly sum, equal to a fixed percentage of the decreasing value of the plant, may be set aside; for example, 10 per cent. of the full value at the end of the first year, 10 per cent. of the remaining value at the end of the second year, and so on. This method would never completely amortize the plant, but would more nearly represent its actual depreciation in value, and leave a relatively small amount to be charged off in one sum at the end of its natural life.

"Inadequacy" should properly be mentioned with obsolescence, as, in general, the same considerations hold good for both conditions. Similarly, "business risk" is an element of fair profit, although not always so associated in one's mind.

The depreciation rate, as fixed by Mr. Parker, on certain details, considered by themselves, is not correct when they are considered as part of a plant; for example, a building which might be in excellent condition after fifty years, probably would not be useful that length of time, nor for a period any longer than the life of the equipment in it.

I emphatically disagree with Mr. Parker's statement that obsolescence has essentially no existence in private power plants, even under stress of competition. If I purchase a plant to furnish power to operate a factory, finance it on a 20-year basis, and in five years' time improved equipment can be purchased with double the efficiency of the original apparatus, a new competitor would be able to undersell me by an annual amount equal to one-half the power cost. It would then be necessary to choose between the loss of one-half the power cost annually, or the unamortized part of the plant, less its sale value.

Considering the subject "fair profit," it should be noted that items of necessity do not have to carry their own burden of profit; for example, an ordinary business cannot be carried on without artificial heat in the winter. The total cost of heating must be carried by the profit-making parts of the business, assuming that heat cannot be purchased from a heating company. Thus the various elements making up the cost of heating must be deducted from the corresponding elements making up the cost of combined heat and power before figuring the actual cost of the power alone.

I have observed that if 100 tons of coal per month are required for heating a building, and if 100 tons are required for power alone, it is often assumed that 110 tons will be sufficient for both heat and power. Where the requirements so nearly balance, this is manifestly not the case, for the heating requirements are distributed throughout the twenty-four hours of the day with a marked peak early in the morning before the power part of the plant begins operation. The power requirements, however, are limited to from eight to ten hours a day, with the peak occurring usually during the warmer parts of the day, or during the late afternoon, when it is permissible to allow the temperature to drop slightly. This means that the coal for combined heat and power may easily amount to from 150 to 175 per cent. of the coal required for either purpose alone.

Mr. Tillman (Consolidated Gas, Electric Light and Power Company, Baltimore): Licensed isolated-plant engineers who are responsible for the entire care and improvements of the power portion of an industrial plant; consulting engineers who are to decide, plan and recommend the type and class of equipment for any given problem of their client; and the central-station industrial engineers who recommend and plan the best and most efficient layout of equipment for their customers or prospective customers, should all work together for one great and important purpose: that of giving to the man who is spending the capital a plant which will produce the greatest return upon the necessary investment.

The return on the investment cannot be estimated offhand, because it includes numerous items which must be taken under careful consideration in each and every proposition. The engineering profession demands an honest decision on all points connected therewith.

The advancement of engineering has been so rapid within the past few years that it is difficult for any one man to be thoroughly posted in all lines of engineering practice which come in the industrial-power work. It, therefore, becomes necessary to weigh all conditions from different viewpoints rather than to recommend past practices. Each and every problem has a right solution, but it requires more than guesswork to solve them and obtain efficient results.

Mr. Norris (National Meter Company): The following figures of gas-engine installation costs are presented to show the economy that can be obtained even down to small sizes when using the gas engine for power purposes. I have selected a few typical plants running on various fuels:

Plant No. 1 contains a 50-horsepower three-cylinder gas engine direct connected to a generator and running on natural gas. An 11-hour service of 300 days per year is furnished at an average load of 15 kilowatts.

Cost of plant installed	$3500	
Interest and depreciation at 10 per cent.		350
Repairs and supplies		175
Labor per year		900
Operating cost, exclusive of fuel		$1,425
Gas bill for year		$315.56
Total yearly charge		$1,740.56
Total kilowatt-hour for year		49,500
Cost per kilowatt-hour		3½ cents

Plant No. 2 contains a 25-horsepower engine belted to a 15-kilowatt generator and one 20-horsepower engine belted to a 12-kilowatt generator, both running on natural gas and furnishing light and power at approximately full load for 365 days per year at 16 hours per day.

Cost of plant installed	$4200	
Interest and depreciation at 10 per cent.		420
Repairs and supplies		210
Labor per year		700
Operating cost, exclusive of fuel		$1,330
Gas bill for year		$1,270.18
Total yearly charge		$2,600.18
Total kilowatt-hours for year		128,480
Cost per kilowatt-hour		2.02 cents

Plant No. 3 consists of one 65- and one 30-horsepower gas engine furnishing power for a manufacturing establishment and running on illuminating gas at 80 cents per thousand cubic feet.

Cost installed	$4375	
Interest and depreciation at 10 per cent.		437.50
Repairs and supplies		220
Labor per year		360
Operating cost, exclusive of fuel		$1,017.50
Gas bill for year		3,279
Total yearly charge		$4,296.50
Total horsepower-hours for year		228,000
Cost per horsepower-hour		1.89 cents

Plant No. 4 consists of one 300-horsepower anthracite producer of the suction type, furnishing gas for two vertical gas engines connected to 100-kilowatt generators; 24-hour service.

Cost installed	$22,000	
Interest and depreciation		$2200
Supplies and repairs		1100
Labor per year		2400
		$5700
Cost of fuel per kilowatt-hour		0.3 cent
Operating charges		0.4 cent
Total per kilowatt-hour		0.7 cent

Plant No. 5 consists of a 300-horsepower anthracite suction producer supplying a four-cylinder vertical gas engine connected to a 200-kilowatt generator. Fuel used: No. 1 buckwheat at $4 per ton.

Cost installed	$18,000	
Interest and depreciation		$1800
Supplies and repairs		900
Labor per year		1500
		$4200
Cost of fuel per kilowatt-hour		0.3 cent
Operating charges		0.65 cent
Total per kilowatt hour		0.95 cent

I have a record of a three weeks' run on this plant, in which the following figures may be of interest:

Total kilowatt hours furnished	19,368
Elapsed time, hours	480
Running time, per cent	36
Shutdown time, per cent	64
Average kilowatts	113.85
Percentage of full load	56.9
Coal per kilowatt hour, including all standby losses, pounds	2.36

In this run no attempt was made to meet test conditions; it represented simply the readings of the instruments and the actual amount of coal supplied to the producer during the time specified.

Plant No. 6 consists of three 200-horsepower producers, supplying one 600-horsepower double-acting tandem gas engine driving a 400-kilowatt generator. The fuel used was Texas lignite, containing 8000 B.t.u. per pound and costing $1.50 per ton delivered; 24-hour service.

Cost installed	$40,000	
Interest and depreciation		$4000
Supplies and repairs		2000
Labor per year		3200
		$9200
Cost of fuel per kilowatt-hour		0.160 cent
Operating charges		0.32 cent
Total per kilowatt hour		0.480 cent

Mr. Timmis (consulting engineer): The equipment of a certain power plant consists of three 250-horsepower water-tube boilers, two 150-kilowatt generators driven by compound engines, one 100-kilowatt generator direct connected to a compound engine, and one 50-kilowatt generator direct connected to a simple engine. Also, two 7½-kilowatt balancer sets. The cost of this outfit was as follows:

Boilers, including settings	$11,190
Engines	12,190
Generators	6,100
Balanced draft	2,325
Steam fitting, including all auxiliaries	6,378
Total cost of plant	$38,182
Cost per kilowatt	$84.85

This plant has been in operation for over three years. It was installed to accommodate a much larger load than it has been called upon to carry; with a capacity of 450 kilowatts, the average load, considering a period of one year, has been 127 kilowatts.

The following table gives the actual cost of running the plant for a period of one year from January 1, 1910, to January 1, 1911:

Wages	$5,233.84
Coal	4,417.00
Water	700
Ashes (removed)	227.21
Oil and waste	164.10
Supplies	139.77
Repairs	258.26
Interest and depreciation on cost of plant, $38,183 at 12 per cent	4,581.96
Total	$15,[illegible]

Kilowatts metered, 581,500.

Cost per kilowatt, $0.0[illegible], without interest and depreciation.

Cost per kilowatt, $0.0[illegible]12, including interest and depreciation.

During the year there were 722 hours overtime at time-and-a-half which amounted to $1024.32. This was included in the total amount under wages.

The foregoing figures include the cost of heating the building, the value of which is estimated as follows:

Coal, 785 tons	$1940.75
Two firemen, 30 weeks, at $15 each	900
Part time of chief engineer	300
Water	30
Removal of ashes	50
Interest and depreciation on boilers of 250 horsepower and disinfecting plant, $1700 at 12 per cent	208
Total	$3[illegible].75
Deducting from the total cost of running the power plant for one year the amount for heating, the cost of running the power plant is	$11,765.94
Actual cost per kilowatt-hour	$0.0[illegible]
The cost of Edison service at wholesale rates for the amount of current generated would have been	$17,000.16
As against the cost to operate plant, including all charges	11,765.94
Balance in favor of plant	$5,[illegible]

Mr. Tompkins, of the Brooklyn & Coney Island Railroad, submitted figures showing that, at the power house of this company, power is delivered at the switchboard for $0.007715 per kilowatt-hour. However, as this did not include interest upon the investment, depreciation, taxes, insurance nor *pro rata* expenses of any of the officials of the company, it is of little value in the present discussion.

Mr. Gasche (Illinois Steel Company): The element of depreciation is unquestionably subject to variant views, but the evidence of past experience of many engineers would indicate that depreciation rates are generally too low. I refer particularly to the rapid changes in the method or process which characterize an industry, thus making a power plant obsolete so far as its primary functions are concerned. To illustrate this: Twenty years ago the simple vertical, long crosshead type of blowing engine was installed at a group of four blast furnaces. About eight years after, half the group of engines was replaced by larger machines with large steam cylinders, so as to operate them as disconnected compound units. In fifteen years' time from the start they were superseded by improved forms of compound engines. About two years ago the new engines were assisted by gas-driven blowing engines using blast-furnace gas, with the implied intention of displacing all steam blowing engines. Now arises the specter of the turbine-driven blower. The point I wish to emphasize is that fundamental changes in the iron and steel business imposed these changes and not the mere "obsolescence" of the elements of the power plant. Nevertheless, they had a short life. Other lines of industry, not excepting the business of furnishing electric current, have exhibited similar crises in their development.

There is another element of growing importance in power-plant investments which may, for the want of a better name, be called "insurance on reliability." This consists of an annual charge that should be set against the gross earnings by the provision of spare units to insure uninterrupted service of the plant for any trade that may be assumed. In some cases a full examination of this "reliability" charge indicates that a mistake has been made in the installation of prime movers of excessive capacity to handle the load.

Mr. Edgerton: For the last year I have been paying particular attention to the cost of electric current as generated in private plants. I have here the data as to costs in one case that may be considered fairly typical in regard to equipment and results for equal output. The plant is of 400 kilowatts generator capacity.

Total engine and boiler-room expenses, 1909 [illegible]	$[illegible]
Total expenses for electric service	12,[illegible]
Credit for exhaust steam used for heating	5,137.2[illegible]
Net cost of 403,000 kilowatt-hours	$[illegible]
Net cost per kilowatt-hour	[illegible] cents
Interest and depreciation	0.[illegible] cent
Total cost per kilowatt-hour	[illegible] cents

The electric service includes lighting, motors driving ventilating fans and vacuum-cleaning service; also, 28.4 per cent of the heating and hot-water service. The elevator service (six elevators), pumping service, ice machine, sewage ejector and the remainder of the heating and hot-water services is from other than electric-power sources.

The cost of fuel (pea coal), was $4.20 per ton. The division of the fuel and labor accounts was based upon a series of engine indicator cards, taken over the period of a year.

I notice in Mr. Parker's paper that the selling price of central-plant current is estimated at about three cents per kilowatt-hour. In this locality that figure would not cover interest and depreciation, let alone production and distribution costs.

The rapidly revolving flywheel of a smooth running engine gives no evidence of the tremendous amount of energy stored in it, and few who have never experienced a flywheel accident give the matter a thought. Suppose, instead of a flywheel, the normal operation of your engine required a counterweight of 25 tons or more constantly suspended about 120 feet above your plant and office. Also assume that this weight, by the derangement of the machinery, might be suddenly raised to a hight of 550 feet or even a half mile and then separate in pieces of a ton or more each and fall on your plant. Do you think damage would result? The conditions assumed above are true illustrations of the destructive possibilities of a flywheel when disrupted at normal speed, or when speeded to the bursting point.—*H. E. B. [illegible] Gas Engine.*

Governing Waterwheels

The importance of refinement in waterwheel regulation has appeared only in recent years, since electrical accomplishments have made commercially practicable the development of powers previously unregarded and have imposed new and more exacting service upon those which are in use.

For years cotton mills have been driven by water powers with crude governing apparatus, often with none at all; and a cotton mill is regarded as requiring a high degree of uniformity in speed. But a cotton-mill load is also one of the most constant. If the load does not change, a wheel under constant head and gate opening will run at a uniform speed any way, and the small fluctuations made by throwing individual machines on and off are readily taken care of by comparatively simple apparatus.

When, however, a waterwheel is set to driving an electric generator, subject to abrupt and excessive load variations, the degree of regulation required by the most exacting service upon the line can be effected only by a study of conditions to which little attention has previously been paid, and by the use of refined apparatus adapted to control those conditions. A very important factor is the mass of the water already in the penstock; and when, as in many of the large Western installations, this penstock is miles in length and contains tons and tons of water in motion, a partial closing of the gate results in a conversion of velocity into pressure, a pressure generated by the momentum of the column the flow of which it is attempted to restrict, which interferes seriously with the effort of the governor to control the speed. All that the governor can do is to regulate the amount of water flowing to the wheel; but, if its movement to restrain the flow results in a virtual increase in head, its effect is minimized and a complication introduced which may set up all sorts of hunting and racing. The last meeting of the American Society of Mechanical Engineers at Boston was devoted to the presentation by William F. Uhl of his paper upon "Speed Regulation in Hydroelectric Plants," and its discussion. Although the subject is an abstruse one and the paper (which, by the way, had been previously presented at the general meeting of the society and is to be found in the February number of *The Journal*) is forbiddingly mathematical, the hall of the Edison company's building was filled and all of the time available occupied by pertinent and interesting discussion.

The governor is very materially aided by the flywheel effect of the turbine, generator and attached masses and it is often desirable to put on additional weight in flywheel form. The water will drive the shaft only at a certain maximum speed even if its flow is unrestrained. Above that speed the wheel would be running away from the water, so that a flywheel designed with an ample factor of safety for this "runaway speed" is safe from centrifugal force and not subject to practically unlimited acceleration as is the wheel of a steam engine.

Mr. Uhl explains the derivation of the simple formula for the regulation due to any given flywheel effect, and modifies it for the effect of the friction load, change of efficiency, pressure variations, etc. The time factor is of extreme importance. It takes a certain amount of energy to move a gate a given amount. If this is done in half the time, it takes twice the power. The "mechanical" governor, usually belt driven, has only a limited amount of power to expend and must therefore exert that power for a longer time to exert the energy required; and unless the governor is made inordinately massive this time is too long for close regulation with considerable gate movement. With the hydraulic governor of the type in which Mr. Uhl is interested, gates are moved by pistons actuated by fluid pressure under the control of the governor through a pilot valve, and the regulating time for all gate openings, according to the author, is nearly constant.

It is a well known fact that if penstock conditions are disturbed by moving a gate anywhere in the line, a wave will be produced which will proceed along the flume with a certain velocity. In closed penstocks these waves take the form of pressure variations. Vibrations in water travel with the velocity of sound, 4650 feet per second. The penstock walls are flexible, however, and under the influence of pressure variations expand and contract in a rather remarkable degree, producing what is called the "breathing" of penstocks. This has a dampening effect upon the vibrations, and 4650 feet per second may be regarded as the maximum velocity with which any vibrations of pressure in the contents of the penstock will proceed. The time required for a vibration to pass from the gate through the penstock and back to the gate is twice the length of the penstock divided by the rate of travel of the vibration. It is better then not to reduce the time required to operate the gate below this amount, so that the effect of the waves produced may be minimized by the countereffect of the returning waves which will then have time to get back.

A change of velocity of one foot per second will have a very considerable effect upon pressure variation; hence large penstocks and slow normal velocities, which will require small velocity changes for change of load are desirable. They also avoid loss from friction.

Efforts have been made to avoid the difficulties introduced by this impact of the moving body of water when partially arrested, by the use of pressure regulators, in which the pressure is made a factor in controlling the position of the gate. If the gates are closed suddenly and a sufficient amount to disturb the regulation on account of pressure rise, the regulator will be opened by the governor and allow water to be bypassed around the turbine sufficiently to keep the pressure rise within limits.

The pressure drop when the gates are suddenly opened is always less than the pressure rise when they are closed. It may be corrected by the use of standpipes or equalizing reservoirs, the effect of which is to reduce the effective length of the penstock. The minimum hight of such a standpipe must be such that in no case will the water level in it drop to such a point as will admit air into the penstock. Formulas are given for their design. In a plant with long penstocks where it is impossible to install a standpipe, out of the question to increase the size of the penstocks and impracticable to provide sufficient flywheel effect, recourse must be had to a synchronous bypass which discharges that part of the full-load flow of the water which is not necessary to run the turbine with the given load. The full flow is maintained in the penstock, but that not needed by the turbine is switched to the tail race. The same effect is produced in impulse turbines with deflecting nozzles. With a reduced load the flow of water continues uninterruptedly but one or more of the nozzles is deflected so that its jet is discharged into the casing without hitting the wheel.

In discussing the paper, Mr. Warren, of the Lombard Governor Company, said that they found in the tests to which they had subjected it that the formula upon which the paper was based gave results which were too high for load changes of less than 50 per cent. He called attention to the danger of whirlpools with wheels not sufficiently submerged.

The author was asked about the possibilities of electric generators, operating upon changes of voltage rather than of speed, and replied that they had been tried but never with any degree of success. In one case at least the failure was due to the use of liquid contacts and the production of depressions and elevations in the level by quickly repeated movements.

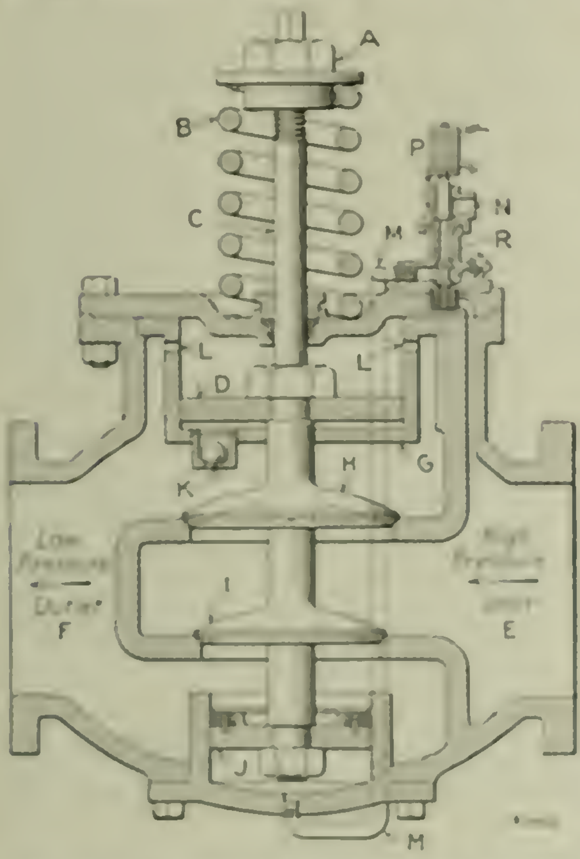
The author had referred to trouble in the draft tube produced by the persistence in its downward movement of the column after the gates had been closed, producing a vacuum behind it into which it returned when its momentum had been spent with a blow which was often productive of disastrous results. One of the auditors told of trouble experienced in the West where the water coming down from the mountain snows often had 1.5 per cent. of entrained air which, under the reduced pressure of the draft tube, assumed a greatly increased volume, and went out in gulps with closings up of the water column, which produced serious shocks. Draft tubes frequently have to be shortened on this account.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Anderson Automatic Regulating Valve

This valve, illustrated herewith in section, is shown in a closed position. When the spring *B* is adjusted by the nut *A* to the required pressure, the valve disks



Sectional View of the Anderson Automatic Regulating Valve

H and *I* are forced open. The high pressure side, or inlet, is at *E*. The outlet is at *F*. When the pressure on the low-pressure side has reached the pressure at which the valve, or spring, *B* is set, the pressure, still increasing, is exerted on top of the piston *J* (the valve *H* and piston *D* being balanced), causing the valves *H* and *I* to close.

In order to have the valve open freely and at the same time close very slowly, there is placed a ball check *K* in the bottom of the dashpot *G*. The ports *L*, placed in the upper rim of the dashpot *G*, prevent any accumulation of air while the valve is in service. The water above and below the piston *D* and the air beneath the piston *J* prevent any water hammer and cushion the valve in opening and closing.

The solenoid *P*, which controls the auxiliary valve *R*, is wired to a switch at the pumping station or any other convenient point and, in case of fire, the switch is thrown into contact, which causes the solenoid *P* to open the auxiliary valve *R*, allowing the high pressure from the inlet side of the main valve to pass up through the auxiliary valve and down through the small pipe M to the under side of the piston *J*, which causes the main valves *H* and *I* to open to the full area. When the full pressure is no longer required the switch is thrown out of contact. This allows the auxiliary valve to close and the pressure from the under side of the piston *J* returns through the auxiliary valve, exhausting through the port *N*. The pressure being released from under the piston *J*, the main valves *H* and *I* will automatically return to the regulating position without the necessity of readjusting the reducing feature.

This valve is made by the Golden-Anderson Valve Specialty Company, Fulton building, Pittsburg, Penn.

Best High Pressure Pump

This high-pressure double-acting duplex steam pump is shown in Fig. 1 and in a sectional view in Fig. 2. It is manufactured by M. W. Jamison & Co., Warren, Penn.

Fig. 1. Exterior View of Pump

Both the steam and fluid cylinders are made more than double their necessary strength. Each set of cylinders are separate castings, and are each divided into two compartments, making four distinct and separate pumping heads. The cylinders are tied together by steel rods,

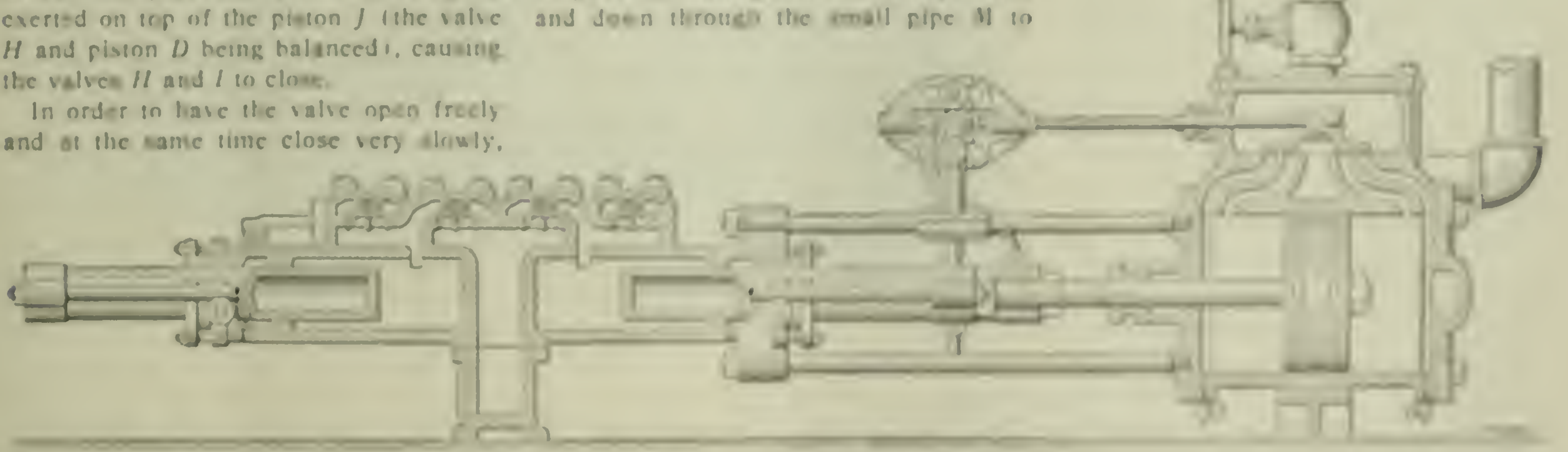


Fig. 2. Sectional View of Pump

made extra heavy, to act also as a support to the valve-motion stand. This forms a rigid construction, and yet makes it possible to replace any cylinder if such a necessity should arise.

The arrangement of the steam valves is shown in Fig. 2. The valve plate is machined to receive a valve-stem block, which is finished to allow no play or lost motion. The stem instead of being run through the valve plate and held by a nut is grooved at the end and held in the block by two set screws, the groove making slipping impossible. This arrangement permits the taking out of a valve with the least possible delay. All adjustment is effected outside at the valve yoke by means of set screws held firmly by jam nuts. The motion levers and rocker shafts are situated between the valve stems, thus placing all moving parts out of the way of the operator as well as making it more compact and neat in appearance.

The distribution of the steam, owing to the proper location of the steam ports and to the valve motion, causes the pump to cushion at the end of each stroke regardless of the speed, steam pressure or pressure against which the pump is working. No cushion valve is used, and the pump has a uniform stroke regardless of the pressure.

All water valves are of the self-adjusting, hardened-bronze type, and seat on an absolutely flat hardened-bronze seat. The valve is guided and held in position by a stem situated on the top of the disk. This stem is bored out to receive the spring and operates in a guide cast in the valve cover and projecting down over it. This arrangement completely incloses the spring and makes it impossible for a broken spring to get free and cause trouble. In addition to this, four lugs or wings project down from the bottom of the disk to assist in guiding the valve. The wings are turned off to allow the valve sufficient play to allow a free passage of any foreign matter without breaking the valve. This arrangement for guiding the flat valve with the valve seat allows it to adjust itself perfectly to all wear and makes troublesome grinding unnecessary. Each valve has a separate cover, making it easy to get at each valve independently.

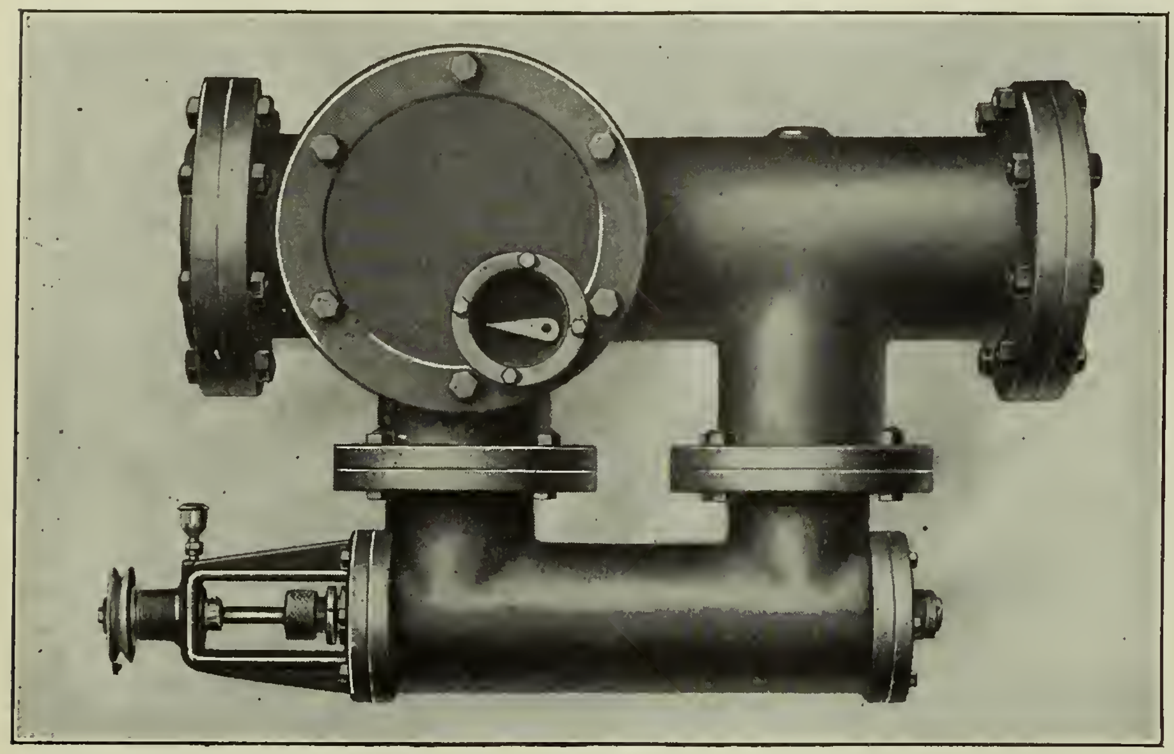


Fig. 1. Belt-driven Water Circulator

The plungers, four in number, are of the outside-end packed type. They are cast in one piece, with extra-heavy flange on the back ends to receive the steel trombone rods which operate the rear plungers. The rods are supported by rollers to secure a perfectly straight and rigid pull and thrust. The power pistons are screwed directly into flanges on the power end so that that end of the pump may be operated independently of the rear end. The plungers are turned and ground perfectly smooth, insuring long life to the packing and preventing loss in fuel by leakage. Plungers may be made brass covered, if desired.

This pump is built to withstand a pressure of from 800 to 1000 pounds.

The Castle Automatic Water Regulator

Recently, hot-water heating systems have been improved by means of a circulating device known as the Castle automatic circulator. It is built in two types, belt driven and with the motor direct coupled to the shaft of the circulator, as shown in Figs. 1 and 2.

This device consists of a small propeller set in the branch pipe that is bypassed from the main return to the boiler and operated by a small electric motor. When ordinary gravity circulation suffices, the circulator is not operated, and it is only necessary to switch off the motor to cut out the circulator. As soon as the propeller ceases revolving an automatic valve cuts off the branch pipe and the water, in returning to the boiler, travels along the main return pipe exactly as though the circulator were not attached to the system. As soon as it becomes necessary to hasten the circulation the motor is switched on, the propeller revolves and the automatic valve takes up a new position, cutting off the main return pipe so that all the returns must necessarily go through the branch pipe and past the propeller.

There are no valves to be set and no attendance is necessary beyond the mere starting and stopping of the motor. In many installations the motor switch is placed at some distance from the circulator. Under ordinary conditions of hot-water heating the circulation depends upon the difference in temperature between the supply and the return lines, and opposed to the difference in head between the two sides of the system is the friction in long lines of pipes, fit-

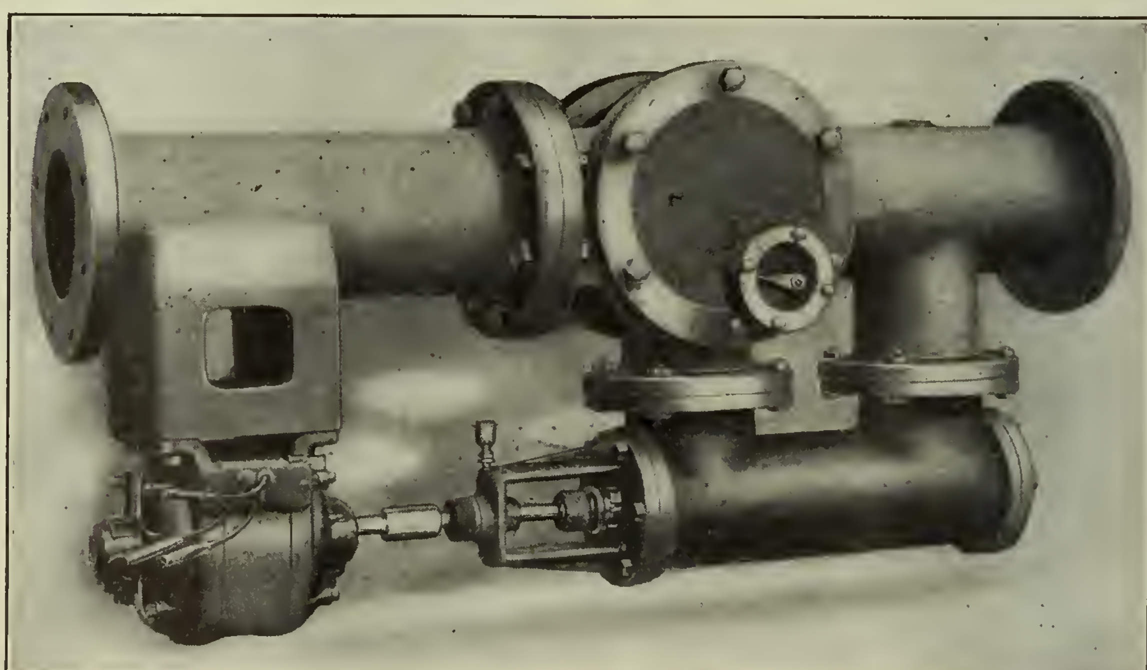


Fig. 2. Motor-driven Water Circulator

tings and valves. By circulating the water rapidly, the returns are but a few degrees lower in temperature than the supply lines; consequently, less coal is used to heat them again and the rapid circulation insures the greatest possible efficiency of the radiating surfaces. This rapid circulation is produced by the Castle circulator. It is small in size and design and requires but little power to operate it. It need be run but a short time per day and as soon as it is stopped, expenses cease. Sudden temperature drops are met by the circulator and it is not necessary to maintain an extra hot fire.

There are many actual examples of coal saving by means of this system. Unsatisfactory results from heating systems installed with piping of insufficient size or with many sharp angle turns can be prevented. This circulator is made in three sizes and is manufactured by the American Auxiliary Heating Company, Boston, Mass.

Sea View Plant Changes Hands

Among the improvements to be made by the Sea View Railroad Company, which has recently been purchased by President Sherman, of the Providence & Danielson Railroad, will be the enlargement of its power plant. A new 500-horsepower Babcock & Wilcox boiler has been ordered, and a new 125-foot brick chimney will be erected, to supplant the two sheet-iron stacks now in use. When the new boiler is installed the plant will have a capacity of 1400 horsepower. The Sea View company operates a trolley line from East Greenwich to Wickford, Saunderstown, Narragansett Pier and Wakefield, R. I. The main office is in Providence, R. I.

Institute Organizes First Branch

The members of the Institute of Operating Engineers of New York City and vicinity, with the exception of the Long Island members, met at the national headquarters on Saturday evening, March 18, and organized the first branch in New York State, which will be known as Branch No. 1 of District 2 of the I. O. E.

The election of officers resulted as follows: Branch chairman and branch representative, Willis Lawrence, chief operating engineer of the Interborough Rapid Transit Company; secretary-treasurer, W. P. F. Hill, chief engineer, Woman's Hospital; chairman of committee on education, F. C. Flickinger; chairman of committee on apprenticeship requirements, L. M. Glodell, chief engineer in the United States Express Company building.

Thirty-five members of the branch were present at the meeting and much enthusiasm was shown by the speakers. The organization starts out with about 80 members all told, and will in the future conduct the New York City meetings for the presentation of papers.

New Chemists' Building

The Chemists' building, which was inaugurated on March 17 at 50 to 54 East Forty-first street, New York City, is believed to be the first of its kind in the world. It combines the features of a first-class club, including restaurant and members' bedrooms, with finely equipped laboratories for analytical and consulting chemists and for investigators in pure and applied science, not to speak of a carefully planned scientific lecture room, a large library and scientific museum.

The building occupies 50x100 feet and cost upward of half a million dollars. It is owned by a stock company, whose shares have been taken by prominent chemists and by individual manufacturers and companies whose business largely depends upon chemical process, and who have realized that industrial progress depends upon scientific research. While it is expected that the building will be more than self-supporting, the shareholders limit themselves to 3 per cent. dividends, all surplus to be devoted to the betterment of the building and to the ultimate benefit of the science. The chief tenant is the Chemists' Club, which occupies the lower half of the building.

Engineering Societies Protest to Public Service Commission

A committee representing five engineering organizations—the International Union of Steam Engineers, the National Association of Stationary Engineers, the Marine Engineer's Benevolent Association, the New York Engineer's Protective Society and the Blue Room Engineering Society—have presented a letter to the Public Service Commission and to Mayor Gaynor protesting against the alleged discriminating rates employed by the New York Edison Company. It was claimed that nearly one-half of the electric current sold in the Boroughs of Manhattan and Bronx by the Edison company is charged at a rate over 300 per cent. greater than the average rate charged for the remainder, and that 40 per cent. of the total current sold is disposed of at a rate less than the pro rata interest and depreciation charge; hence these charges are carried by the small consumer paying 10 cents per kilowatt-hour. Accompanying the letter of protest was a petition signed by over two hundred and fifty small consumers, asking for legal action to prevent the alleged discrimination.

Nearly 400 employees were thrown out of work for about two days by the blowing out of the cylinder head of the main engine at the Consumers Rubber Company's factory at Bristol, R. I., on March 15. A new head was cast in Providence.

NEW PUBLICATION

MATHEMATICS FOR THE PRACTICAL MAN. By George Howe. Published by D. Van Nostrand Company, New York, 1911. Cloth; 143 pages, 5x8 inches; 42 illustrations. Price, $1.25.

Beginning with the fundamentals of algebra, elementary geometry, plain trigonometry, analytical geometry and calculus are taken up in order. The book has been kept within the limits of its title and no attempt has been made to go deeply into these subjects, only such portions being covered as are essential to the needs of the engineer. The author is to be complimented upon the simple yet adequate treatment of the subjects, which should enable anyone of ordinary intelligence and having a fair knowledge of arithmetic to acquire a working knowledge of them. Having made such a good start, it is to be regretted that the author did not go a step farther and include a number of engineering problems showing the application of the pure mathematics to the practical cases. This would have materially increased the value of the book to the practical engineer.

SOCIETY NOTES

On Thursday evening, April 13, the regular monthly meeting of the Institute of Operating Engineers will be held in the Engineering Societies building, 29 West Thirty-ninth street, New York City, commencing at 8 p.m. sharp. J. C. Jurgensen will deliver a paper on the "Economical Aspects of the Institute of Operating Engineers." This will be discussed by prominent engineers.

The American Electric Railway Manufacturers' Association announces the opening of the offices of this association at room 1002, 165 Broadway, New York City. This office will be the official headquarters of the association, and all members are cordially invited to visit same, out of town members being welcome to use this headquarters for the receipt of their mail and for carrying on correspondence, etc., while in the city.

The problem of making the earth yield an increase adequate to supply the needs of the population will be considered on Tuesday evening, April 11, at a meeting of the American Society of Mechanical Engineers, in the Engineering Societies building, 29 West Thirty-ninth street, New York, when a paper upon the "Economic Importance of the Farm Tractor," by L. W. Ellis, will be presented. Following this paper, Dr. Charles E. Lucke, professor of mechanical engineering of Columbia University, will give a talk on the mechanical equipment of farm tractors which will be illustrated by views taken last summer at the Canadian industrial exhibition held in Winnipeg, Manitoba.

The Cleveland branch of the American Chemical Society at its March meeting was addressed by W. R. Hulbert, manager of sales, Goldschmidt Thermit Company, on the thermit-welding process. In addition to a general description of the process and its various applications, with lantern slides, Mr. Hulbert gave a demonstration of thermit welding, comprising a number of experiments to show how the process is used commercially for repairing wrought-iron and steel sections, and for welding pipes up to 4 inches in diameter. Much interest was shown in the demonstration, which was witnessed not only by the local members of the American Chemical Society, but by members of the American Society of Mechanical Engineers and others who came from cities as far out as Akron and Lorain and towns in the vicinity of Cleveland.

PERSONAL

The Crocker-Wheeler Company announces the appointment of Clarence E. Delafield, *vice* R. N. C. Barnes, resigned, as district manager with headquarters at the company's offices in the Boston Safe Deposit and Trust building, 201 Devonshire street, Boston, Mass.

H. H. Laughlin has been placed in charge of the branch office recently opened in Pittsburg, Keystone building, 324 Fourth avenue, by the Richardson-Phenix Company, of Milwaukee, Wis. Mr. Laughlin has been with the Richardson-Phenix Company for several years and is familiar with the methods of lubrication of all kinds of machinery.

At a recent meeting of the board of directors of the Pawling & Harnischfeger Company, Milwaukee, Wis., S. H. Squier, who has been with the company for a number of years, was elected secretary and a director of the organization. W. H. Hassenplug, sales manager, was elected a director and second vice-president, and F. P. Breck, also associated with the company for many years, was elected a director.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

TURBINE. Gustaf de Laval and Ernst Elis Fridolf Fagerstrom, Stockholm, Sweden. 986,472.

INTERNAL COMBUSTION ENGINE. Nelson Edward Davies, San Francisco, Cal. 986,552.

ROTARY ENGINE. Thomas H. Lindley, Cedar Rapids, Iowa, and Herman Schreier, Sheboygan, Wis. 986,636.

ROTARY ENGINE. William L. Merrill, Portland, Me. 986,641.

WAVE POWER GENERATOR. Robert Max Morius, San Diego, Cal. 986,740.

WAVE AND CURRENT MOTOR. Joseph T. Cross, San Francisco, Cal., assignor to Frank H. Howard, San Francisco, Cal. 985,802.

FLUID-OPERATED TURBINE. Eric Brown, Baden, Switzerland. 986,902.

CURRENT MOTOR. Lincoln Guynn, Seattle, Wash. 986,919.

ROTARY STEAM ENGINE. Robert I. Miller, Sandusky, Ohio, assignor of sixteen and one-third one-hundredths to William F. Thomas and sixteen and one-third one-hundredths to William J. Duffy, McMechen, W. Va., and sixteen and one-third one-hundredths to Martin J. Malooley, Wheeling, W. Va. 986,932.

TURBINE. Charles Algernon Parsons, Newcastle-upon-Tyne, England. 986,942.

STEAM ENGINE. Nathaniel Greene Herreshoff, Bristol, R. I. 986,982.

BOILERS, FURNACES AND GAS PRODUCERS

STEAM-GENERATING PLANT. Minott W. Sewall, Roselle, N. J., assignor to the Babcock & Wilcox Company, Bayonne, N. J., a Corporation of New Jersey. 986,648.

STEAM-GENERATING PLANT. Minott W. Sewall, New York, N. Y., assignor to the Babcock & Wilcox Company, Bayonne, N. J., a Corporation of New Jersey. 986,649.

ARTIFICIAL-GAS BURNER. Jacob Weintz, Cleveland, Ohio, assignor to the Strong, Carlisle & Hammond Company, Cleveland, Ohio, a Corporation of Ohio. 986,663.

HYDROCARBON BURNER. Virgil H. Mills and John H. T. Mills, Hubbard, Tex. 986,739.

STEAM BOILER. Charles William Todd, Manchester, N. H., assignor of one-third to Lewis W. Crockett, Manchester, N. H., and one-third to D. Arthur Burt, Boston, Mass. 986,876.

MECHANICAL STOKER. Levi F. Torrey, Buffalo, N. Y., assignor to Margaret E. Torrey, Buffalo, N. Y. 986,877.

FURNACE. Carl Wegener, Berlin, Germany. 986,881.

FURNACE. Harry Moor, Philadelphia, Penn. 986,934.

HYDROCARBON BURNER. Rudolph Hoffman, Battle Creek, Mich., assignor to American Stove Company, St. Louis, Mo., a Corporation of New Jersey. 987,067.

POWER PLANT AUXILIARIES AND APPLIANCES

VALVE MECHANISM. William K. Rankin, Philadelphia, Penn., assignor to John E. Reyburn, Philadelphia, Penn. 986,592.

AUTOMATIC DAMPER REGULATOR. William J. Turner, Providence, R. I., assignor to Putnam Foundry and Machine Company, Providence, R. I., a Corporation of Connecticut. 986,658.

THERMOSTATIC VALVE. Frederick W. Robertshaw, Pittsburg, Penn. 986,760.

ENGINE GOVERNOR. John W. Sargent, Providence, R. I. 986,762.

VALVE. Conrad C. Schoeneck and Ivar F. Warme, Syracuse, N. Y. 986,765.

STEAM, AIR AND WATER-TRAP VALVE. John E. Boegen, Berwyn, Ill., assignor to Charles P. Monash, Chicago, Ill. 986,797.

CENTRIFUGAL PUMP. Franklin H. Jackson, West Berkeley, Cal., assignor to Byron Jackson Iron Works, West Berkeley, Cal., a Corporation of California. 986,827.

LUBRICATING DEVICE. John Christopher Nichol, Ottawa, Ontario, Canada. 986,849.

ELECTRICAL INVENTIONS AND APPLICATIONS

ELECTRIC SWITCH. Horace Hull, Denver, Colo. 986,714.

DYNAMO ELECTRIC MACHINE. Carl M. Page, Chicago, Ill., assignor of one-half to Horace D. Reynolds, Chicago, Ill. 986,748.

ELECTROPLATING MACHINE. John W. Heaphy, Philadelphia, Penn. 986,823.

ELECTRIC SWITCH. Columbus Woods and Whitman H. Sayles, Peoria, Ill. 986,958.

SAFETY COUPLING FOR ELECTRIC CONDUCTORS. Angel Belgorder, Mexico, Mexico. 987,036.

DYNAMO ELECTRIC MACHINE. James Burke, Erie, Penn., assignor to Burke Electric Company, a Corporation of Pennsylvania. 987,044.

POWER PLANT TOOLS

WRENCH. Peder Roisum, Edmore, N. D. 986,593.

LIFTING JACK. Jotham B. Taylor, Auburn, N. Y. 986,781.

JACK. Ralph F. Schofield, Olathe, Kan. 986,868.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City. Spring meeting in Pittsburg, May 30 to June 2.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York. Next meeting in New York City, May 29 to June 2.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Commander U. T. Holmes, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., O. P. Chamberlain; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill. Meeting first Wednesday of each month.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., Walter Riddle; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Pres., R. P. Bolton; sec., W. W. Macon, 29 West Thirty-ninth street, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio, September 12-15, 1911.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June 5-10, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting at Detroit, Mich., January 15-19, 1912.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres. A. N. Lucas; sec., Harry D. Vaught, 95 [illegible] street, New York. Next meeting at [illegible] Neb., May 23-26, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

POWER

NEW YORK, APRIL 4, 1911

THE watch engineer was making his tour of duty. Day after day, month after month, he had gone the rounds of engine stops, receivers, traps, etc., and everything was always found in good working order. Little whisperings at times urged the watch engineer to skip things here and there which, of course, were all right (?). Tonight the whisperings said the engine stops were all right. It was a winter evening and the peak load would be on in a few moments, and there were many little things to do to prepare for it. Why not let the nonessentials slide? Old No. 5 wouldn't run away—not under the load that was coming. But the watch engineer was obdurate. Every little thing must be done. There should be no slighting of the smallest detail.

The stops were of the type that closes the throttle valve. The stop of No. 5 tripped all right, but there was something queer about it. Instead of running down, the valve hung still and the engineer's hand caught a vibration of the wheel as though the stem were dancing up and down. The fact was that the throttle was open less than a turn. On the light load it had not been noticed. Had it not been found out, a "down-and-out" would have been registered against the station.

Another engineer, of another sort, relieved Dave that night before No. 5 went down. When the switchboard man interrupted him in the midst of the closing scenes of "The Great Diamond Robbery," he reluctantly tossed the paper down and went over and closed the throttle of the big engine. He glanced over No. 2, which would run till morning, saw that the oiler was at work, then went over and lay down on the big broad belt of No. 4. No. 5 would be needed for the morning load, but the only preparation she got was the little wiping the oiler gave her.

At five o'clock in the morning steam was turned on again and—snap, bang—the low-pressure rocker arm had broken off. The station got a black mark that time, of course, for part of the load had to be dropped—and the cause? Well, they found the wrist plate had run hot, and when she shut down it "froze." After several attempts to free it, the stud was removed from the cylinder and the whole thing sent to the shop, where 14 tons pressure was required to pull the wrist plate from the stud.

A month later, the watches had been shifted. Dave was now on the night run. His program was of another sort. While the big engine was slowing down he felt each bearing. The moment she stopped he was at her with wrenches. Wedge bolts, keys, set screws and lock nuts were all gone over and the oil pipes examined.

As he was trying the lock nut on the low-pressure crank-pin oiler, his sharp eye discovered something wrong. It was another little thing, a tiny little thing, but so important. In the oilers on this engine there were holes opposite the center of the crank pin through which a wire might be inserted for the purpose of cleaning. Tiny plugs screwed into these holes. If a plug worked out the oil would decorate the crank case instead of lubricating the crank pin—and trouble was not far ahead. And this was just what Dave had noticed. The plug was missing. A search light was brought to the scene, and after a short hunt the plug was found. No black mark that morning. But suppose the other fellow had been on the job!

It is a little thing to go over the wedge bolts and set screws every day, but it will often save you a shut-down and a black eye.

How many engineers, when it comes to regularly feeling the bearings of their engines, "let George do it"? And how many of those who regularly go over their engines every hour or every half hour, shut the throttles and leave the engines, not knowing what has happened to the bearings in the last half hour? It is a little thing, but do it. Go over the engine after you shut it down. It may help you to start up.

Power Plant of C. & N.W. Ry. Terminal

By Osborn Monnett

First new plant which has installed low-pressure turbine in connection with engine units. Special arrangement of boiler settings for heavy overloads. Piping connections of heating system of unusual interest.

One of the most important real-estate improvements made in Chicago in late years is that of the new terminal station of the Chicago & Northwestern Railway, with passenger entrance fronting on West Madison street, from Canal to Clinton street. The property extends north to the junction of Clinton and Milwaukee avenue, the elevated tracks admitting street traffic underneath the structure and also permitting entrance to the Washington street tunnel, which has lately been reconstructed. The power house to light, heat, ventilate and is other ways serve the public at this station, occupies a triangular shape of land between Lake street, Clinton street and Milwaukee avenue, and is an ingenious utilization of an area which would ordinarily be useless. The plant has been laid out with special reference to the unusual ground-plan conditions, with the stack occupying the apex of the triangle and the arrangement has been such as to secure all necessary room for the desired purposes. Pressed brick on the inside walls, set off with a green Rockwood tile wainscoting around the visitors' gallery and the engine room and in the engineer's office, adds greatly to the appearance of the station and gives the impression of attention to detail which is characteristic of the entire work.

In the boiler room are six 500-horsepower Babcock & Wilcox boilers, the type of setting being similar to that lately used in one other of the large plants around Chicago, and specially designed to permit forcing the boiler to heavy overloads. They are, as will be noted in the drawings, of the vertical-header type, with three gas passes through the tubes and are set in the reverse position to that ordinarily followed, with the chain-grate stokers under the mud drum. This gives large combustion space wherein the products of combustion may mix, and the setting has been unusually successful from the standpoint of eliminating smoke. Directly over the stoker arches, which are protected by water-tight sheet-iron pans, three blowoff connections are brought off to the side of the stoker, as shown in the photograph of the boiler room. These are easily manipulated by

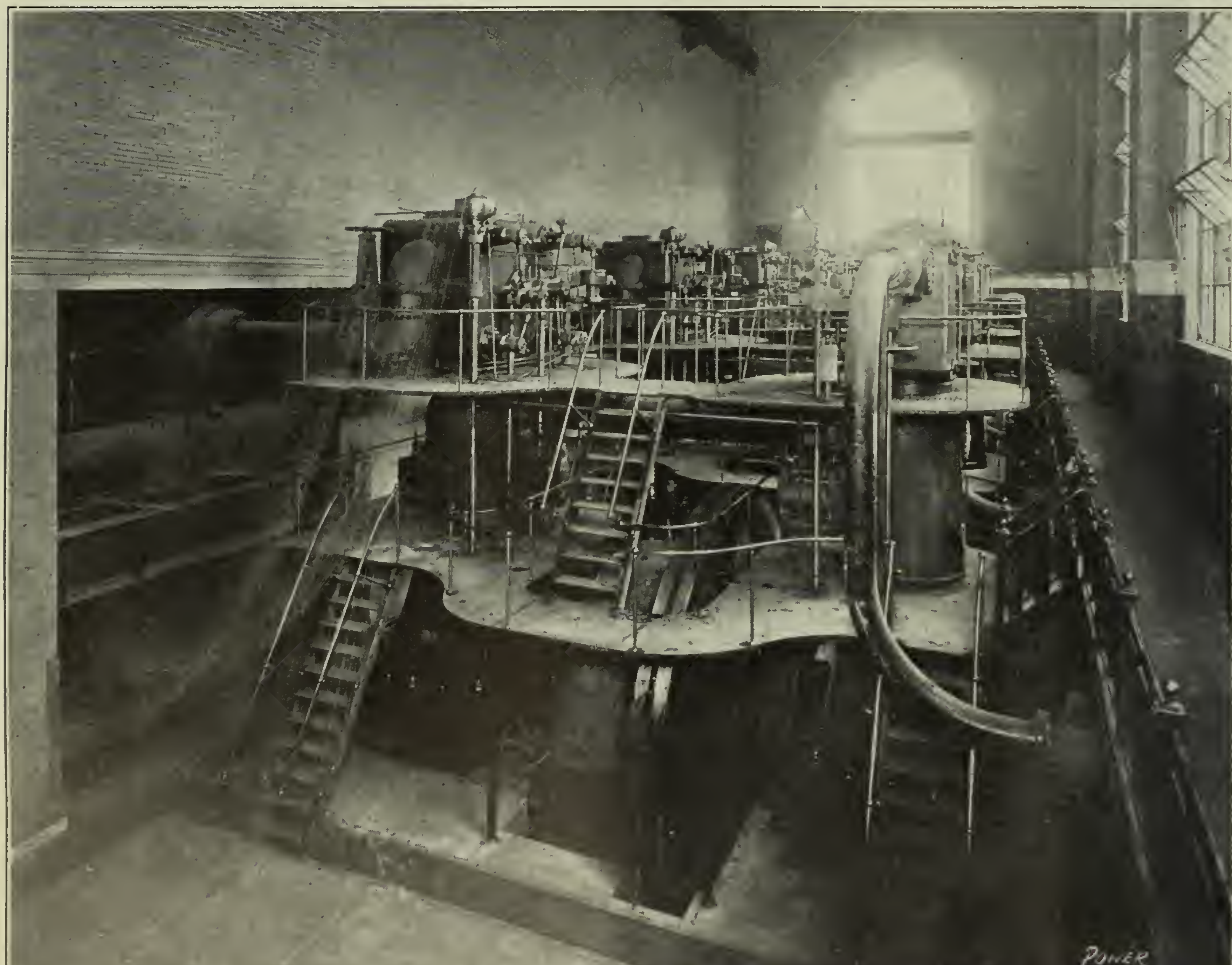


Fig. 1. General View of Main Engine Units

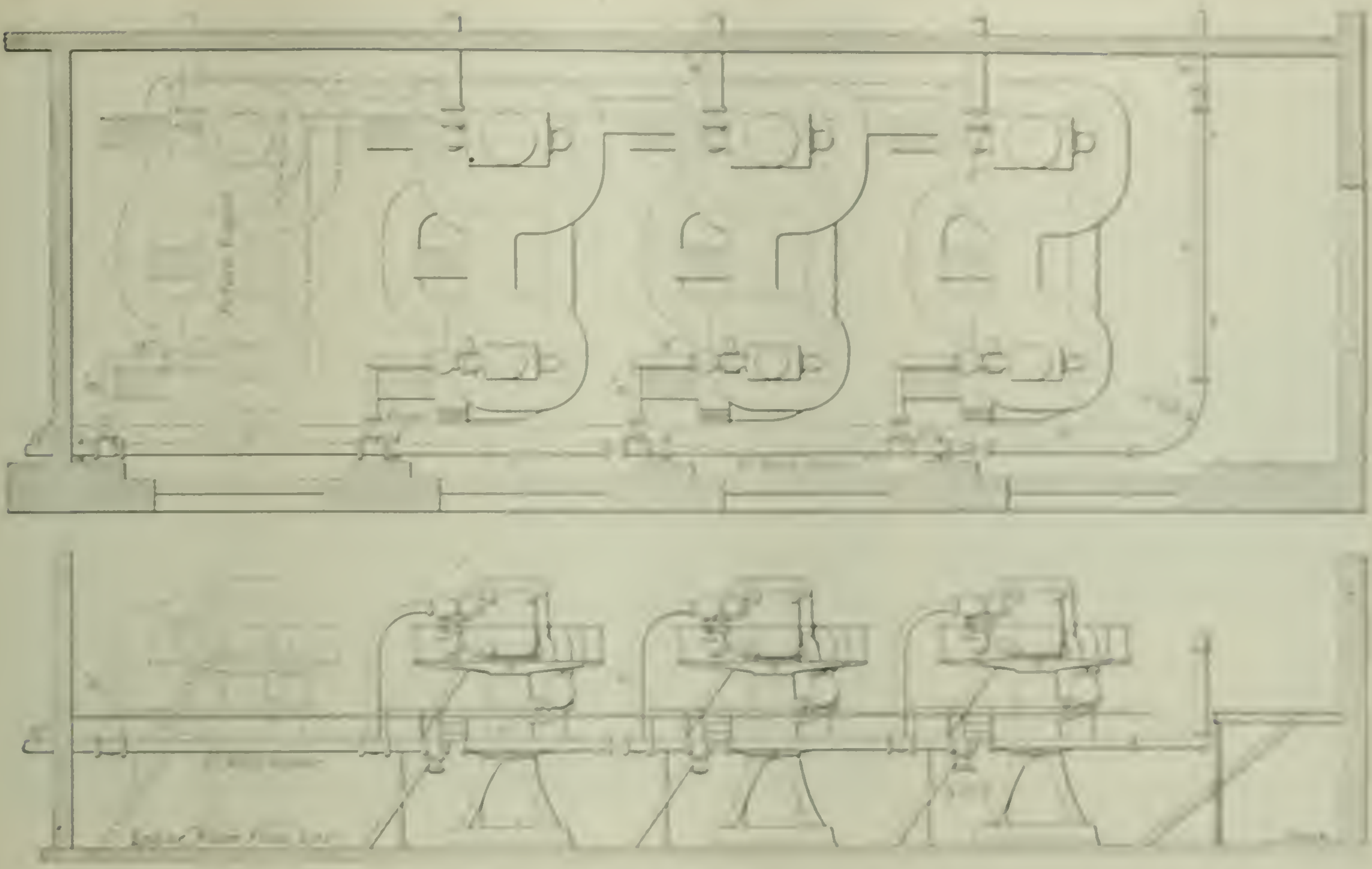


Fig. 2. Piping Connections in Engine Room

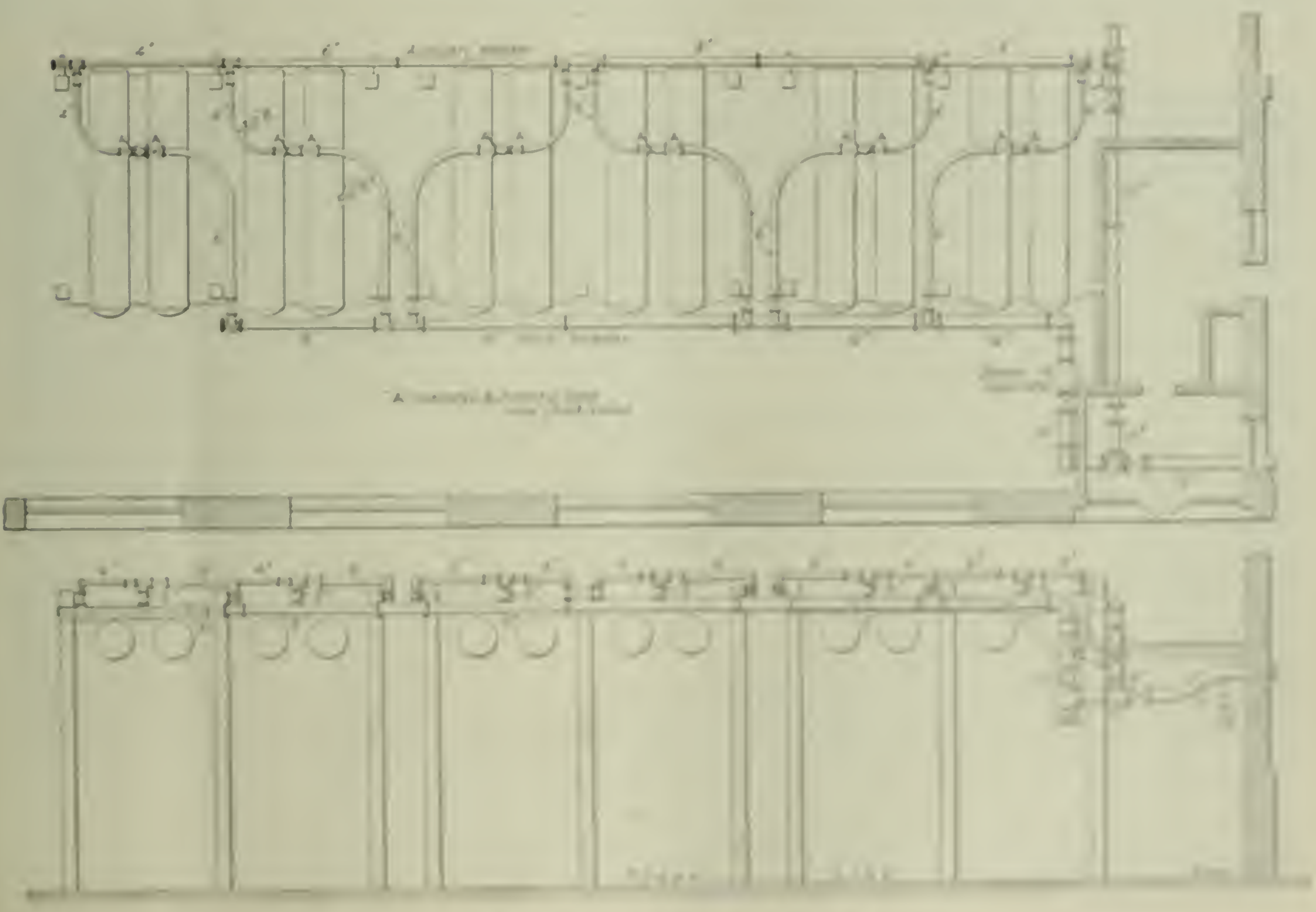


Fig. 3. Plan and Elevation of Boiler Piping

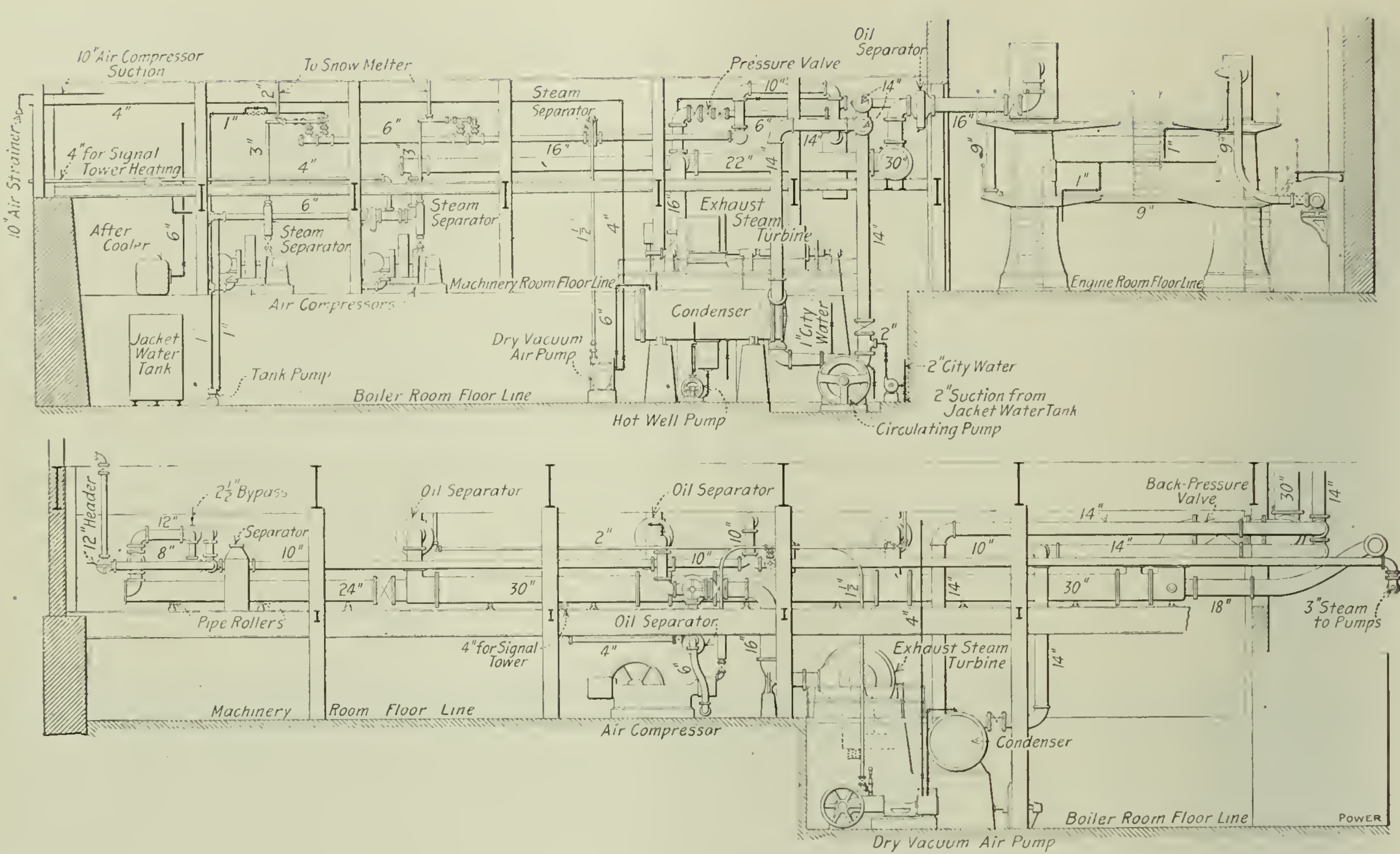


Fig. 4. Sectional Elevations through Engine and Machinery Rooms

the fireman, who is not required to go behind the boilers for any purpose, the feed valve also being conveniently located at this point. Every detail in the boiler setting has been worked out for the greatest efficiency. Vulcan soot blowers are installed for keeping the heating surfaces clean, and if desired it is possible to run the boilers at 75 to 100 per cent. above rating, or approximately 800 to 1000 horsepower per boiler.

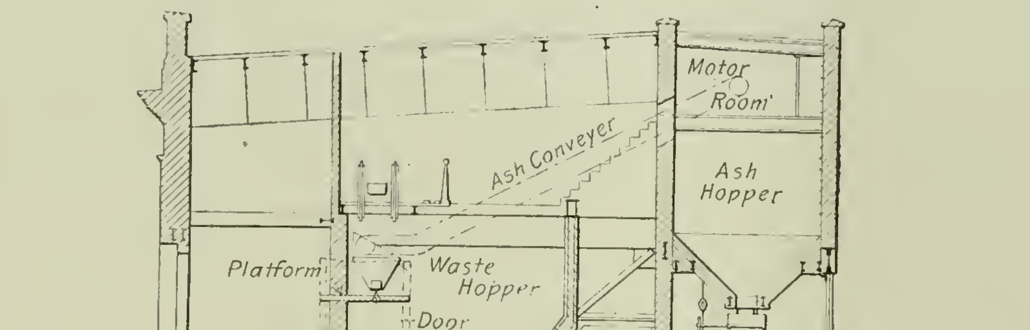


Fig. 5. Transverse Section through Boiler Room

Coal- and ash-handling apparatus has been so designed as to handle coal in carload lots from the track elevation. The unloading hopper has a capacity of 300 to 400 tons and a length which will permit two cars being unloaded at one time. From the bunker underneath the tracks the coal passes on to a horizontal conveyer, through a crusher into a Peck, continuous, pivoted, bucket conveyer, which elevates it to concrete bunkers over the boilers, the latter having a capacity of 750 tons without trimming or 1000 tons if trimmed.

Ashes are discharged from the grates into hoppers below the boiler-room floor line and carried by the same conveyer which transports the coal, to an inclined pan conveyer discharging into an ash bunker located above the coaling track and capable of holding 100 tons of ashes. The unloading arrangement has a rated capacity of 40 tons per hour.

Although the type of boiler setting chosen necessitates extremely high headroom, still there is plenty of space provided for convenient operation and the boiler plant is unusually light and roomy. Auxiliary storage capacity of approximately 300 tons of coal is provided under the sidewalk on the Canal street side, immediately in front of the boilers. This storage space is liberally supplied with sidewalk lights, while the boiler-room floor itself between the boiler settings is

Fig. 6. The Boiler Room

Fig. 7. Power House of Northwestern Terminal

also fitted in this manner, lighting up the ash tunnel. A feature worthy of note is the special means of taking care of expansion in the boiler breeching. This is supported on saddles and springs resting on the building I-beams and allows for free movement with varying temperatures. The breeching is covered with 2 inches of vitribestos and the method of suspension insures that no leaks or cracks will develop in the structure. Passing to the stack, which is of Custodis construction, 11 feet in internal diameter at the base and 10 feet 6 inches at the top, the gases are discharged 225 feet above grade or 247 feet above the boiler-room floor line.

One of the unusual features in the design of the plant is the convenient location of the engineer's office. This is at the grade line, with the entrance on Clinton street, and is located between the boiler and engine rooms with windows on each side so that both departments are visible from this central point. In case of trouble in any part of the plant the point can be

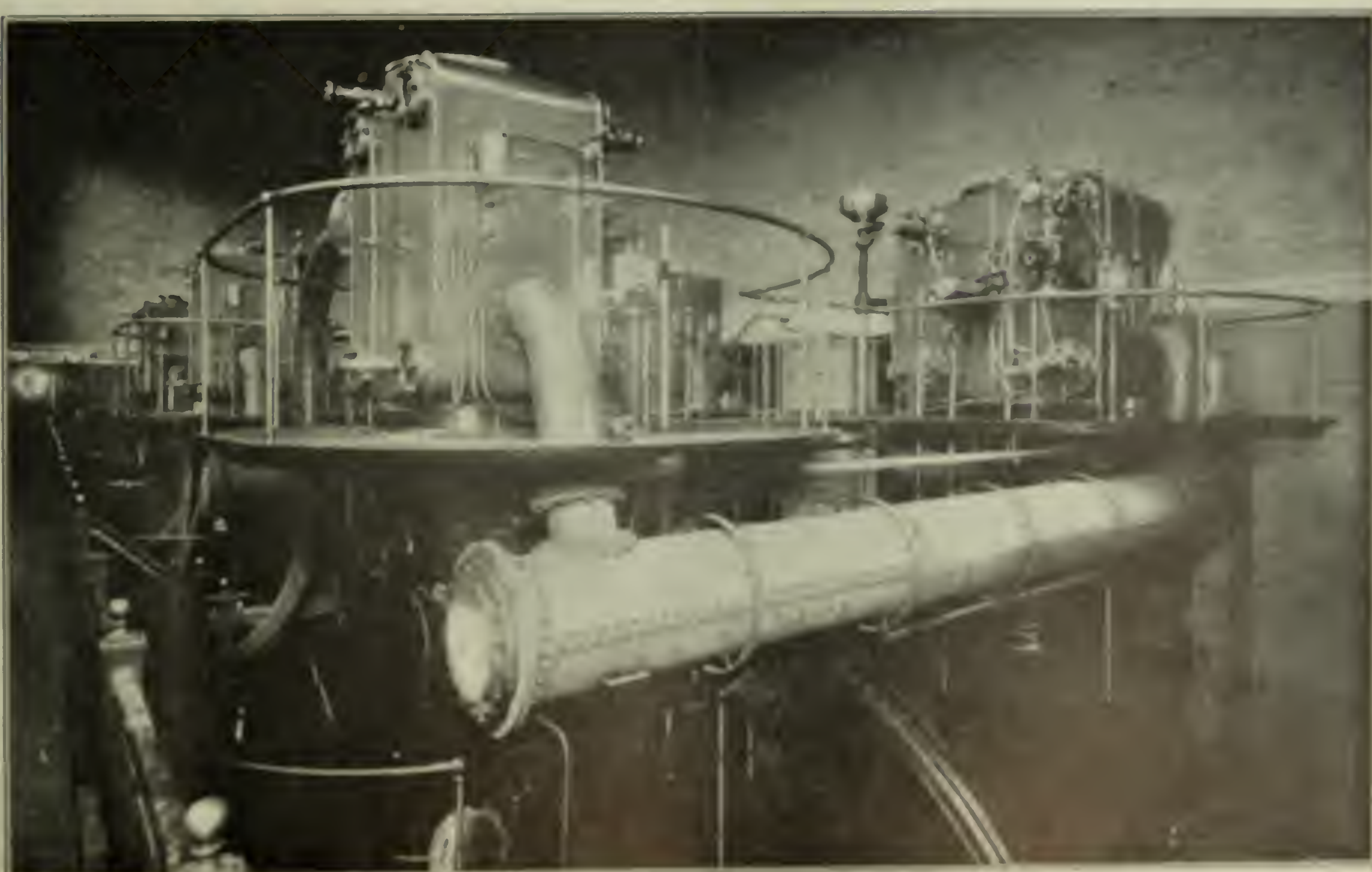


Fig. 8. View of Engine Cylinders from Gallery Level

conveniently reached from the engineer's headquarters in the shortest possible time. This central division of the power house continues to the roof so that both engine and boiler rooms can be entered at any level by means of stairways conveniently located. A gage board is located here with all the usual instruments for checking operation.

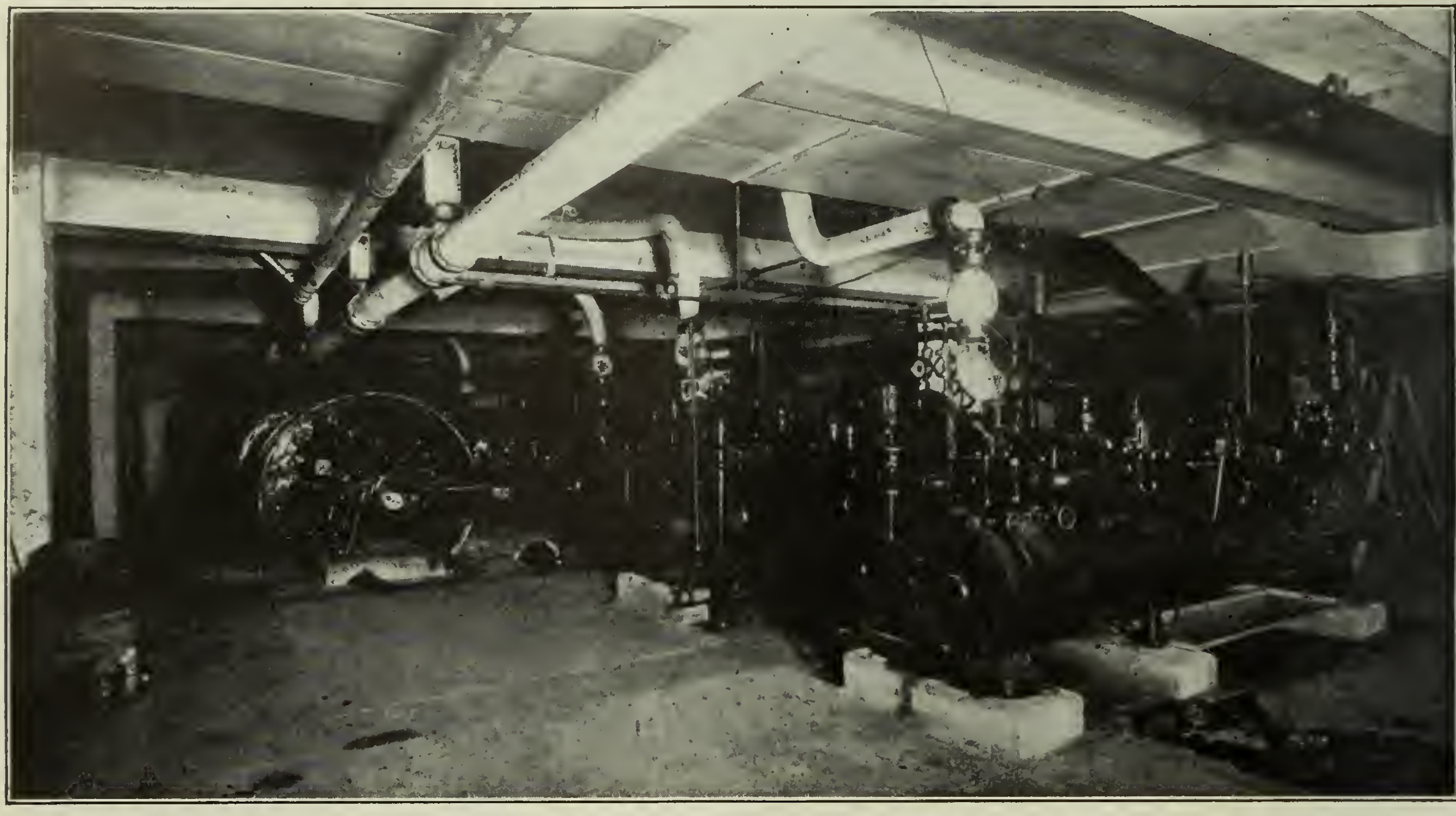


FIG. 9. ELEVATOR PUMPS UNDER MADISON STREET END OF STATION

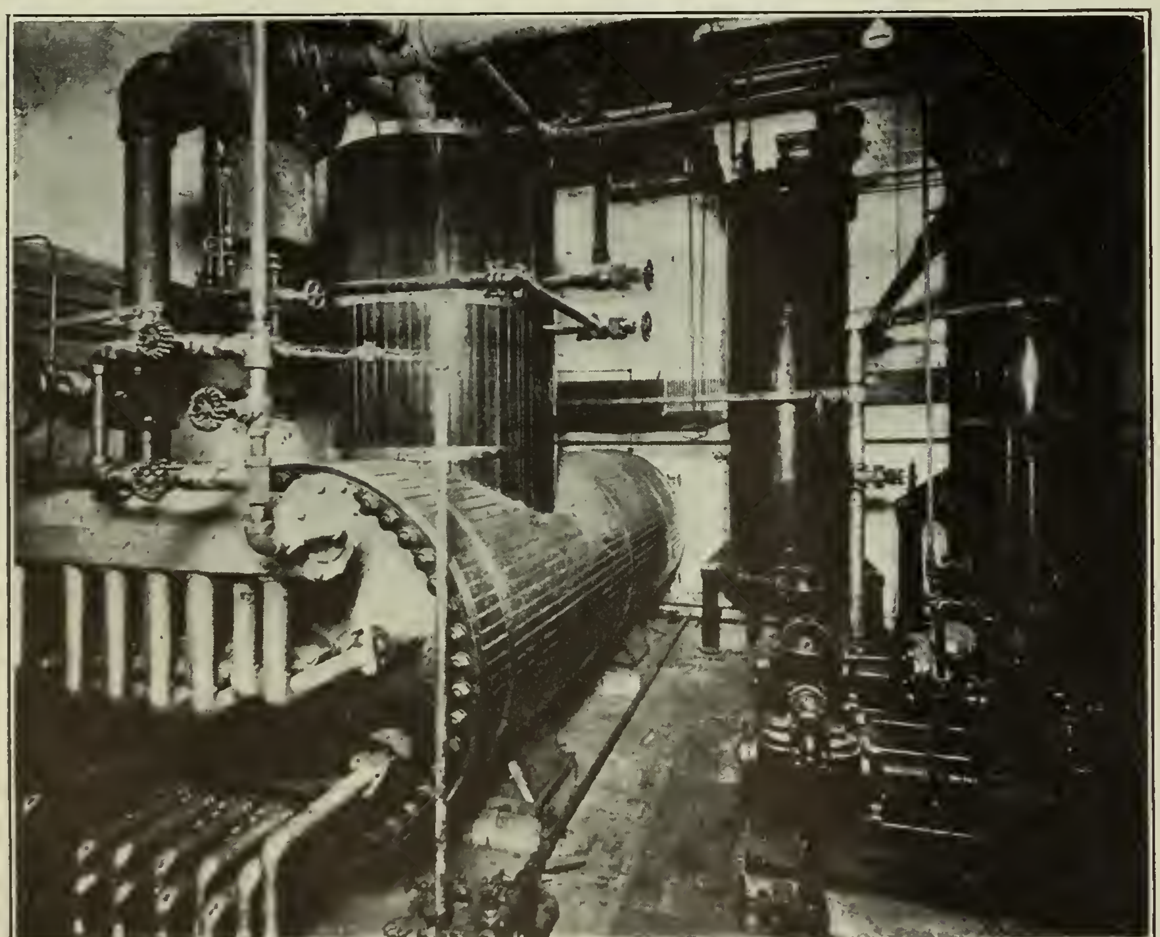


FIG. 10. ABSORPTION REFRIGERATING SYSTEM

In the engine room there are at present installed three vertical cross-compound noncondensing Allis-Chalmers Corliss engines, with 25 and 44 by 42-inch cylinders, each rated at 1150 indicated horsepower, at 100 revolutions per minute, with steam pressure at 155 pounds and 60 degrees, Fahrenheit, superheat. Space has been left for an additional engine and dynamo unit of the same size as above. The engine platforms are all interconnecting and arranged for maximum convenience of the operators. One Curtis low-pressure steam turbine and generator unit of 500 kilowatts capacity is installed in the machine room. It is the intention to run noncondensing during seasons when steam for heating will be necessary and use the low-pressure turbine only at such times as exhaust steam would ordinarily be allowed to waste to the atmosphere. When not running on the heating system the light loads will be taken care of by one of the Corliss engines and as the load increases beyond the capacity of one engine unit it will be thrown on to the low-pressure turbine up to a point where the combined units are fully loaded, when another engine outfit will be cut in and so on. The engine sets are guaranteed to run on 18.6 pounds of steam per indicated horsepower at full load, against 16.5 pounds absolute back pressure. This will mean 21,400 pounds of steam exhausted to the low-pressure turbine. The latter has been installed under a guarantee to deliver a kilowatt-hour on 43.5 pounds of exhaust steam, or a horsepower-hour on 32.7 pounds. Using the 21,400 pounds of steam exhausted from the engine unit, the low-pressure machine will develop an additional 786 horsepower, making a total of 1936 horsepower for the combined outfit, on 21,400 pounds of steam, or a horsepower-hour on 11.8 pounds of steam.

Under present conditions it is possible to operate the turbine for eight months in the year and if plans under consideration go through, the turbine will be used the year round.

As far as the writer is aware, this is the first time an exhaust-steam turbine, installed in connection with engine units, has been included in the original layout.

Fig. 11. Engineer's Office at Power House

This, of course, is largely due to the newness of this type of machine in this country. The reduction in steam consumption per horsepower-hour developed in this particular installation is considerable, and besides it would be difficult to devise a more flexible system for utilizing to the best advantage the supply of exhaust steam.

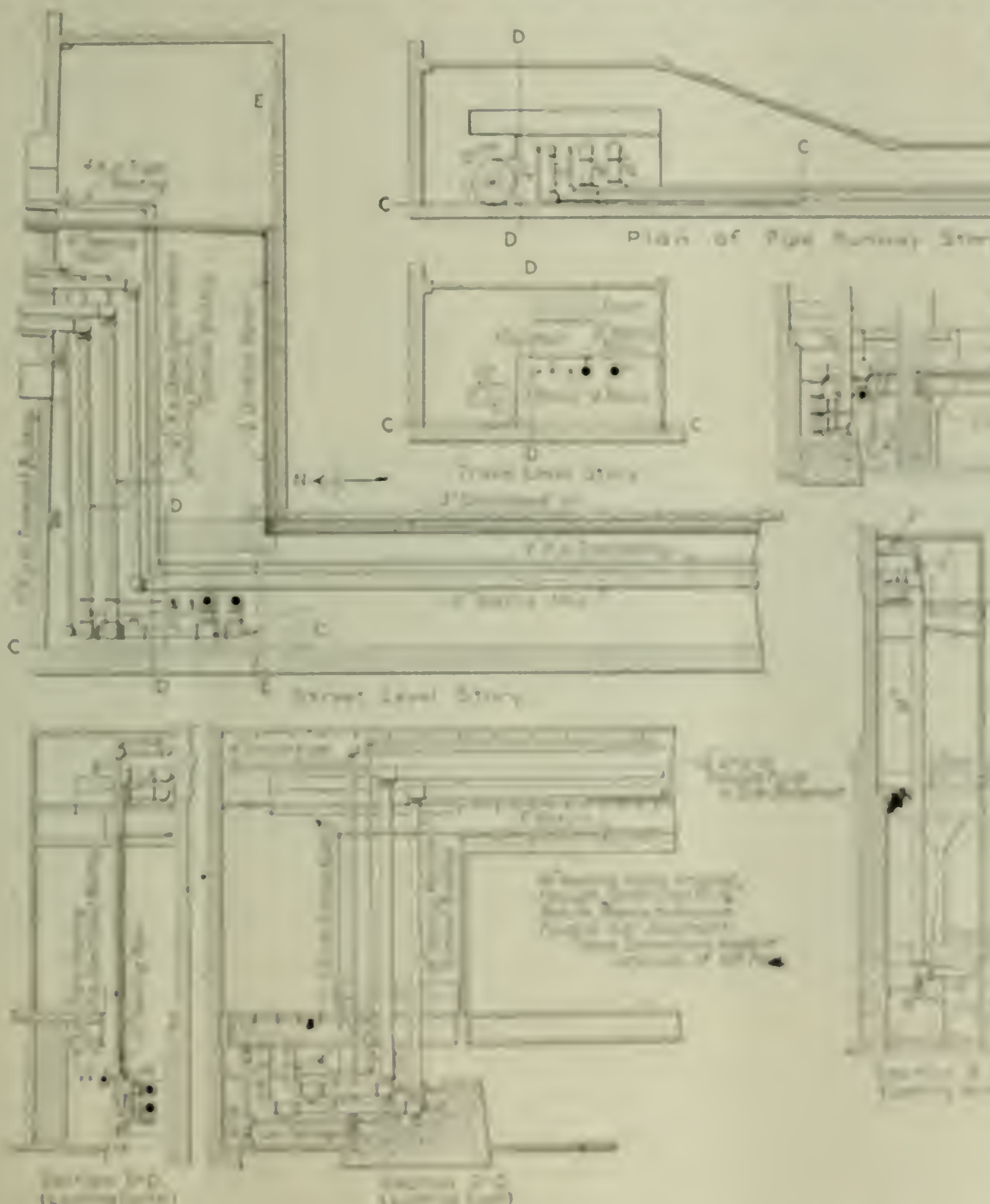
The connection of the turbine to the exhaust piping of the plant is clearly shown in Fig. 4, which shows sectional views running through the engine and machinery rooms. From these views it may be seen that it is possible to use in the low-pressure turbine the exhaust steam from the auxiliaries as well as from the main engine units.

There are already installed in the machine room, two 500-kilowatt motor-generator sets, which will be used to convert the 250-volt, direct-current, generated in the plant, to 6900-volt three-phase 60-cycle currents for lighting service along the Northwestern line inside the city limits. This current will be used for the entire switch and signal system and lighting the Chicago terminal, subways, freight houses, yards, etc.

When running condensing the exhaust from the turbine is discharged into a Worthington surface condenser with 4000 square feet of cooling surface, guaranteed to hold a vacuum within 3 inches of absolute when condensing 23,000 pounds of steam per hour, with circulat-

Fig. 12. Switchboard

ing water at 75 degrees Fahrenheit. In connection with this condensing outfit a cooling tower has been installed on the roof. This tower will cool the necessary amount of condensing water when the atmospheric temperature is 75 degrees Fahrenheit with relative humidity of 70 per cent. The tower is of the four-fan type, the fans being driven by two 25-horsepower motors. All jacket water



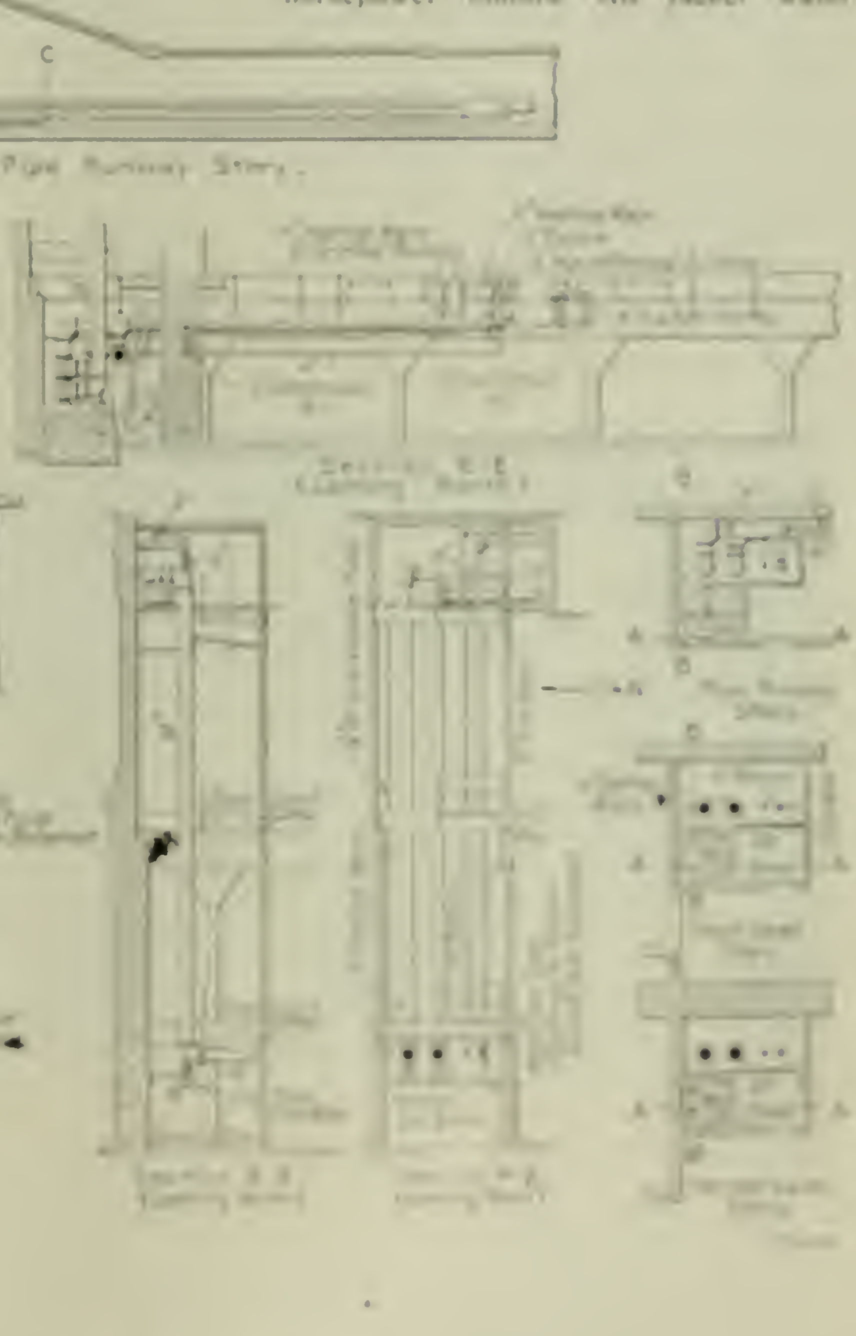


Fig. 13. Details of System Designed to ... West Terminal

from the air compressors, main engine journals, aftercoolers, etc., is collected in a tank from which a small centrifugal pump furnishes the make-up water for the cooling tower. In this way water which is supplied from the city mains is economized.

In the south end of the engine room on the balcony are located the switchboard and benchboard for controlling the electrical units. The operator stands facing the machines and makes all connections by means of remote-control switches. A busbar tunnel runs under the engine-room floor, with circuit breakers on the generator leads. The generator rheostats are controlled by push-botton switches on the benchboard. The main buses in the busbar tunnel run to the distributing switchboard which is furnished with switches connected to circuits leading to the main building, outgoing lines, etc.

Unusual precautions have been taken to guard against breakdown in the piping system. From the steam nozzles the steam passes through 6-inch stop and check valves into the main header lying in front of the boilers at a level with the drums. This header, starting at 8 inches in diameter, increases to 10 inches and finally in the engine room to 12 inches, extends under the balcony and entirely around the engine room, where it meets a 10-inch auxiliary header and forms a loop so that steam can be supplied in either direction from the boilers. The auxiliary connection from the boilers starts at the boiler nozzles in a 4-inch connection, the auxiliary header behind the boilers being 6, 8 and 10 inches in diameter as shown on the piping layout. Superheated steam is used in all of the main and auxiliary piping. It is the intention to maintain the entire system of live-steam headers under steam at all times, so that in case of a break in any portion of the system, manipulating one or two valves will shut off the section of header affected without delaying operations in the plant and without danger of turning superheated steam suddenly into a length of cold piping. Extending along one side of the engine room, as shown in the plan, is the 30-inch main exhaust header with an atmospheric relief run to a point above the roof. From this header a 16-inch connection leads to the low-pressure turbine. There is also a connection from the auxiliary header to the throttle of the low-pressure machine, enabling it to be supplied with live steam independent of the exhaust from the engine units. This makes it possible to generate 500 kilowatts of electricity and still shut down the entire system of main headers and low-pressure piping, other than the auxiliary header, for repair.

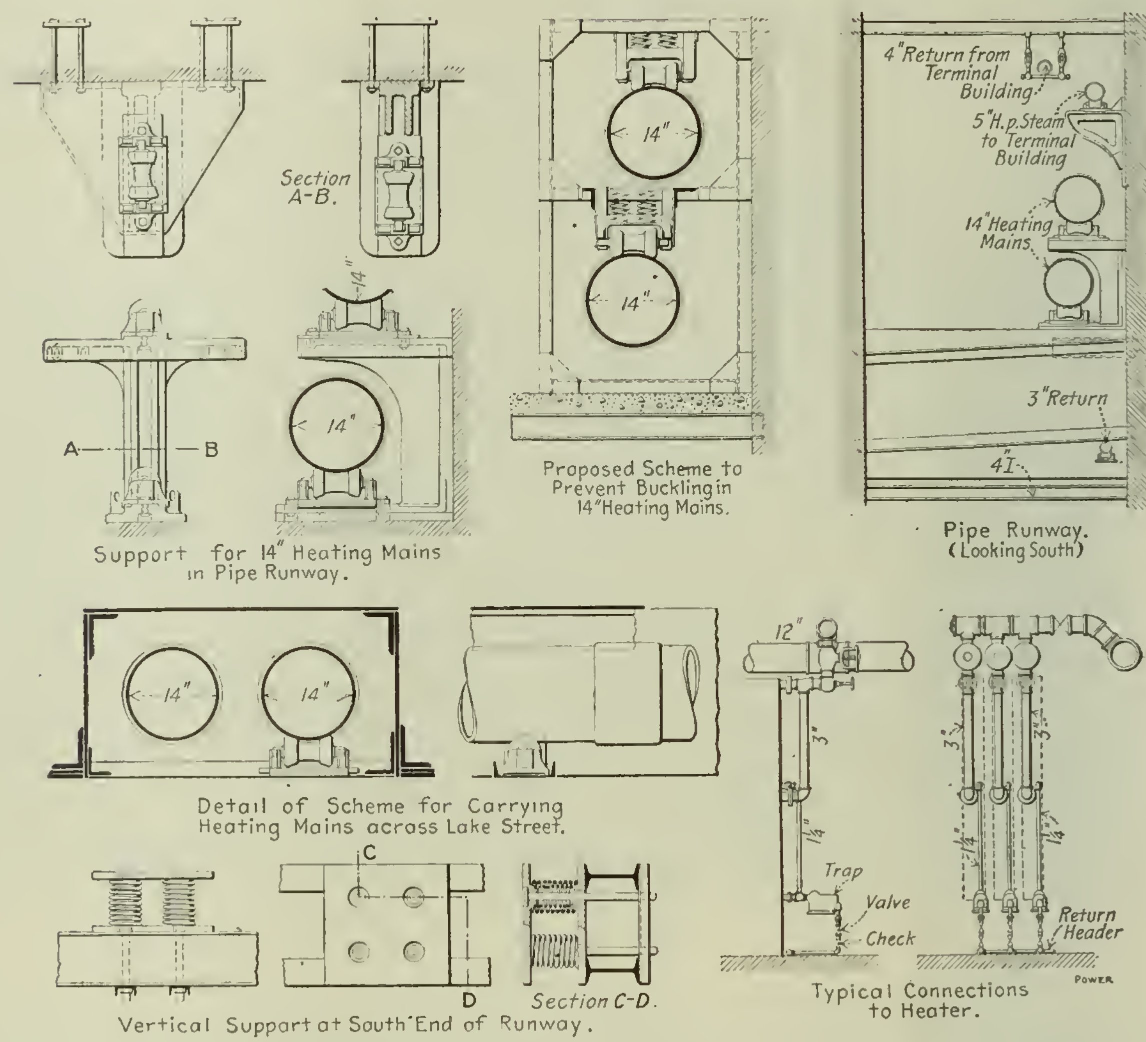


Fig. 16. Supports for Heating Mains and Typical Connections to Heater

To act as an auxiliary on the heating and elevator load in the station building should a breakdown occur in the transmission piping from the main power house, a steam plant has been installed in the passenger-terminal building at Madison street. This consists of two 150-horsepower single-drum Babcock & Wilcox boilers fitted with Water-Arch hand-fired furnaces. All of the elevator-pumping equipment is installed in this end of the plant. There are in all thirteen hydraulic elevators in the passenger-terminal station, four for passengers and nine for

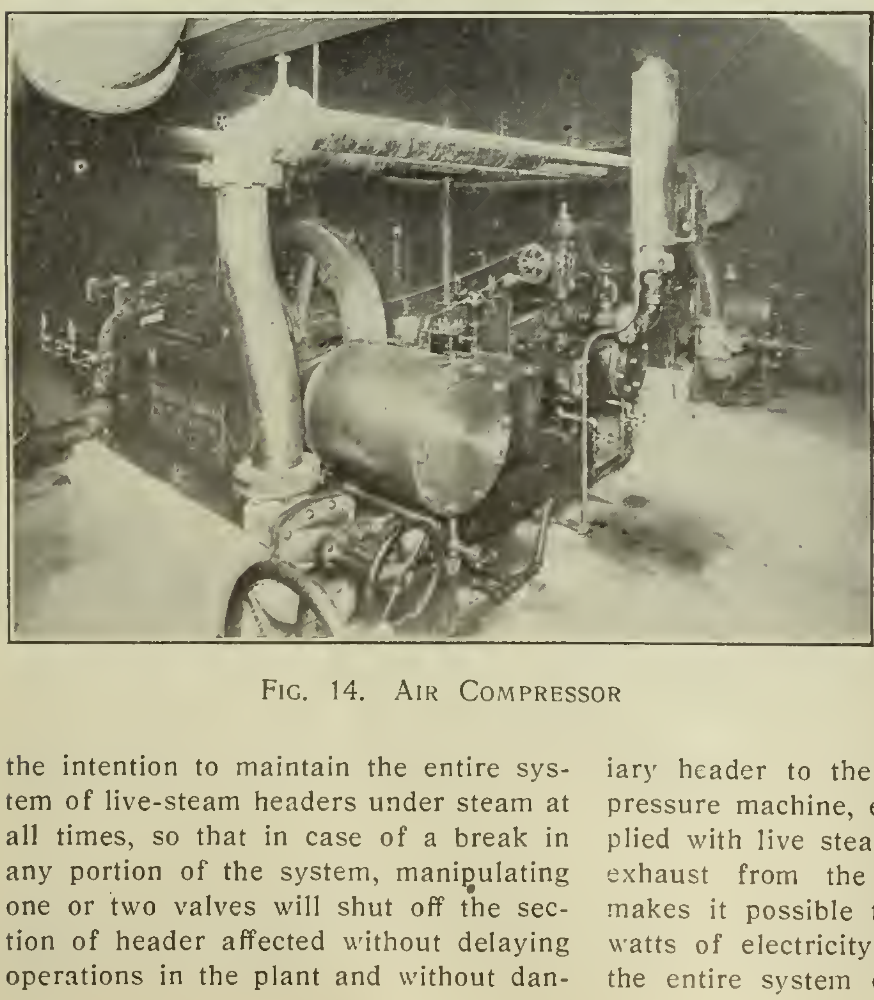


Fig. 14. Air Compressor

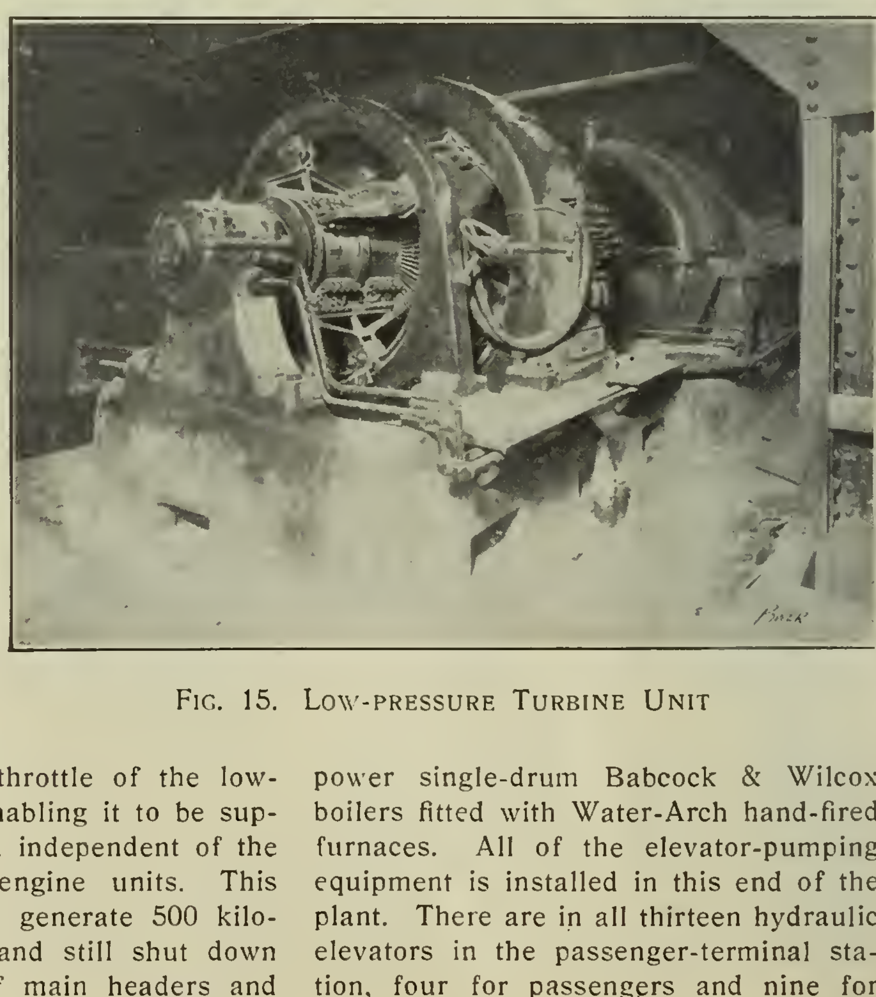


Fig. 15. Low-pressure Turbine Unit

baggage. They are all operated with water at 800 pounds per square inch. Two three-cylinder compound, crank-and-flywheel elevator pumps, and two tandem-compound pot-valve pumps take care of this service. In addition to this there are ten electric elevators for baggage, express and mail, and three dumb waiters with push-button control.

A complete Carbondale absorption refrigerating installation of 50 tons capacity is also located in the basement of the station for cooling drinking water and furnishing refrigeration for the various ice boxes in the restaurants and lunch rooms located throughout the building.

Of special interest is the heating and ventilating arrangement in the passenger station. This is done by the indirect blast system, except a small amount of direct radiation installed to take care of building losses. One of the largest air-heating plants ever installed in one chamber is located in the basement, having 25,000 square feet of Vento heaters, consisting of cast-iron elements taking steam from the low-pressure mains. All main supply ducts are in concrete tunnels carried beneath the floor line and the blast is supplied by electrically driven Sirrocco fans. Starting at the plenum or tempering chamber, galvanized-iron ducts distribute the heated air to the different portions of the building. The plenum chambers are centrally located and provided with automatically controlled dampers which temper the air delivered to the ducts. A complete system of exhaust ducts parallel the supply ducts throughout the building, with the exhaust fans located in the attic regulated by remote-control switches placed in the basement on the same operating board from which the corresponding supply-fan unit is controlled.

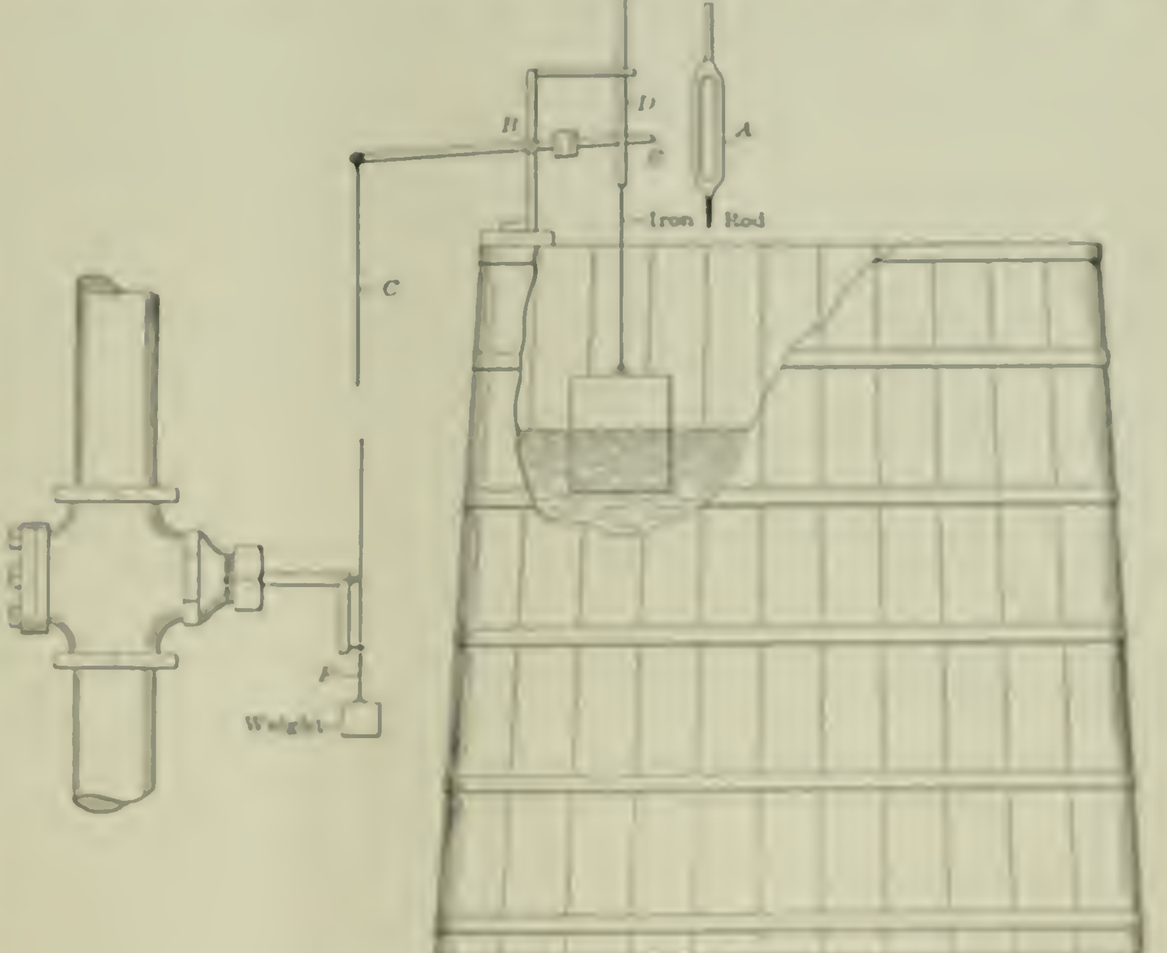
As the main and auxiliary plants are separated by no less than 1300 feet, some of the piping problems encountered are worthy of notice. There are two 14-inch exhaust-heating mains coming from the central plant; one 5-inch live-steam line for power; one 4-inch train-heating steam line, and one 3½-inch down-spout heating line. The 4- and 5-inch lines are fitted with automatic stop and check valves to automatically shut off the steam in case of accident. No expansion joints were used in the 14-inch lines, the expansion being taken up entirely by swing joints at either end as shown in the drawings. These lines are anchored at the center and expand both ways, being supported on special cast-iron brackets, allowing for the removal of any length of pipe without disturbing the bracket or the other piping. They are made up in sections of three lengths of pipe, fitted with extra-heavy screw couplings and at the end of each section with flange unions. The stretch of pipe between flanges constitutes a pipe unit and the presence of the flange unions three lengths apart permit a flexibility that would not otherwise be possible, as too many flanges would tend to stiffen the line and cause leaks. When steam is first applied to the lines they expand on top and the sections between the flanges raise from their supports until the pipe has been brought to a uniform temperature, and the condensation has been drawn out. The line then settles to its position on the brackets without shock or jar. In the design of the brackets it was arranged to bring the weight on the foot and relieve any stress on the side walls. It was calculated that there would be an expansion of 14 inches in the length of 1300 feet and in practice a movement of 14½ inches has been observed.

One of the special problems worked out in connection with the station was the method of keeping the horizontal runs of down-spout piping draining the roof of the train sheds from freezing in cold weather. The ordinary method of solving this problem is to let live steam blow into these spouts, which not only proves unsightly and wasteful, but also tends by condensing in the pipe, to increase the trouble from freezing. In this installation the horizontal runs are each fitted with a steam line laying immediately underneath the drain pipe and inside the lagging of same. This heating pipe is supplied with live steam at 40 pounds pressure throughout the entire train shed and has the effect of keeping the down-spouts entirely clear of frost in all weather and at the same time in the entire area underneath the train shed there is no steam escaping to the atmosphere. These heating lines are trapped, the condensation being discharged into the main heating system of the building. As this hot water is at 40 pounds pressure the effect of liberating it into the heating system at exhaust steam pressure is to cause it to flash into steam and it thus becomes useful for heating in the building after it has served its purpose in the down-spout system.

The steam and electrical work for the complete plant was designed by and erected under the supervision of Pierce, Richardson & Neiler, consulting engineers, Chicago. F. J. Ravile, chief engineer of power stations for the Chicago & Northwestern Railway, is in direct charge of operation of the plant.

Unusual Float Control of Pump

In this instance the steam pipe supplying the pump is fitted with a quick opening valve, the valve stem of which is fitted with a lever instead of a hand wheel, as shown in the accompanying illustration. To the top of the tank is securely fastened a rod which is bent at right angles and serves as a guide to the rod attached to the float. The float rod is slotted, as shown at A, and the slot limits the distance through which the water is allowed to fall before the steam valve is opened and the pump brought into operation. Pivoted to the supporting rod at B is a lever at one end of which a hole is drilled for the cord C. The cord extends over pulleys, conveniently arranged, down to the steam valve of the pump. The other end of this rod passes through the slot A of the float rod. From the sketch the operation will be apparent.



Steam Valve Controlled by Float

Flow of Water in Clean Iron Pipes

By Albert E. Guy

Darcy's formula for the flow of water in pipes converted into United States units and applied to a convenient chart, whereby having given any two of the three quantities, gallons per minute, diameter of pipe and frictional head, the third can be read directly from the scale.

The chart herein given is based upon the work of Darcy, the well known hydraulic engineer who was assigned, by the French government the task of establishing a water system at Dijon in Burgundy. He found that the formulas in use at that time for determining the flow of water, the frictional loss of head and consequently the proper diameters of pipes, were very unsatisfactory; therefore, in order to bring about effective results with a minimum cost, he found it necessary to undertake new experiments from which, it was hoped, reliable data would be derived.

The experiments, numbering about one hundred and ninety-eight, were conducted on pipes made of various materials and sizes, these including pipes of drawn wrought iron, of lead, of iron coated inside with tar, of glass, of cast iron both new and clean, and also coated with deposits. The wrought-iron and cast-iron pipes were over 330 feet long; those of lead over 170 feet, and those of glass 146 feet. They were all well calibrated and the diameters were determined with extreme care. The lead pipes were about $\frac{9}{16}$, $\frac{13}{16}$ and $1\frac{5}{8}$ inches in diameter, and the wrought-iron and cast-iron pipes varied from $\frac{1}{2}$ to $19\frac{3}{4}$ inches in diameter.

The quantity of water was measured in each case by means of calibrated tanks, and velocities as high as $19\frac{1}{2}$ feet per second were used. The slopes of the pipes were carefully regulated so as to avoid all possible perturbations from elbows, abrupt changes of direction, or from air chambers sometimes formed through lack of care in assembling. The pressures at various points of the conduits were measured by means of piezometer tubes.

The thoroughness of the undertaking brought about splendid results, and these enabled Darcy to establish extensive tables which have proved very useful to engineers. The main points ascertained by Darcy were:

1. The friction of liquids is independent of the pressure.
2. The friction is proportional to the area of the surfaces in contact with the flowing liquid.
3. The condition of the surfaces of contact has a great influence on the friction.

Regarding the last point, he found that through the tar-coated and glass pipes, one-third more water was discharged than was indicated by the formula theretofore in use, and that deposits, even when forming but a very thin coating, caused an appreciable reduction in the amount discharged when no coating was present.

From the tables established, Darcy derived the following formula, which is known by his name:

$$hR = \left(a + \frac{\beta}{R}\right) u^2$$

in which,

R = Radius of pipe, in meters;
h = Frictional loss of head in fraction of a meter per meter of pipe length;
u = Velocity in meters per second;
$a = 0.000507$, $\beta = 0.00000647$ } constants for clean wrought-iron and cast-iron pipes;
$a = 0.001014$, $\beta = 0.0000013$ } constants for slightly coated wrought-iron and cast-iron pipes.

The transformation of the formula from the metric to United States measures is very easy. First,

$$hR = \left(a + \frac{\beta}{R}\right) u^2 \qquad (1)$$

which may be rearranged so that

$$u = \frac{R\sqrt{h}}{\sqrt{aR + \beta}} \qquad (2)$$

But if q is the volume in cubic meters discharged per second,

$$q = \pi R^2 u \qquad (3)$$

From (2) and (3),

$$u = \frac{q}{\pi R^2} = \frac{R\sqrt{h}}{\sqrt{aR + \beta}} \qquad (4)$$

whence,

$$q = \frac{\pi R^3 \sqrt{h}}{\sqrt{aR + \beta}} \qquad (5)$$

With the United States measures, q should be expressed in gallons per minute instead of cubic meters per second; the radius of the pipe in meters should be replaced by the diameter in inches; the frictional head h should be expressed in feet per 1000 feet of pipe length.

One cubic meter = 264.13 United States gallons.

One cubic meter per second = 15,848 gallons per minute.

One meter = 39.37 inches, and R (in meters) =

$$\frac{D\ (\textit{diameter in inches})}{2 \times 39.37}$$

Equation (5) then becomes

$$\textit{Gallons per minute} = \frac{D^3 \times \sqrt{h} \times 15{,}848 \times \pi}{(2 \times 39.37)^3 \times \sqrt{\dfrac{(0.000507 \times 2 \times 39.37 \times D) + 0.00000647 \times (2 \times 39.37)^2}{(2 \times 39.37)^2}}}$$

This reduces to

$$\textit{Gallons per minute} = \frac{40.152 \times D^3 \times \sqrt{h}}{\sqrt{D + 1}}$$

But h is here expressed in meters per meter length of pipe; to express it in feet per 1000 feet of length, it must be written:

$$\textit{Gallons per minute} = \frac{40.152 \times D^3 \times \sqrt{h}}{\sqrt{(D + 1) \times 1000}}$$

$$= \frac{1.27 \times D^3 \times \sqrt{h}}{\sqrt{D + 1}} \qquad (6)$$

Another convenient form is

$$\textit{Gallons per minute} = \frac{D^3}{\sqrt{0.62 (D + 1)}} \times \sqrt{h} \qquad (7)$$

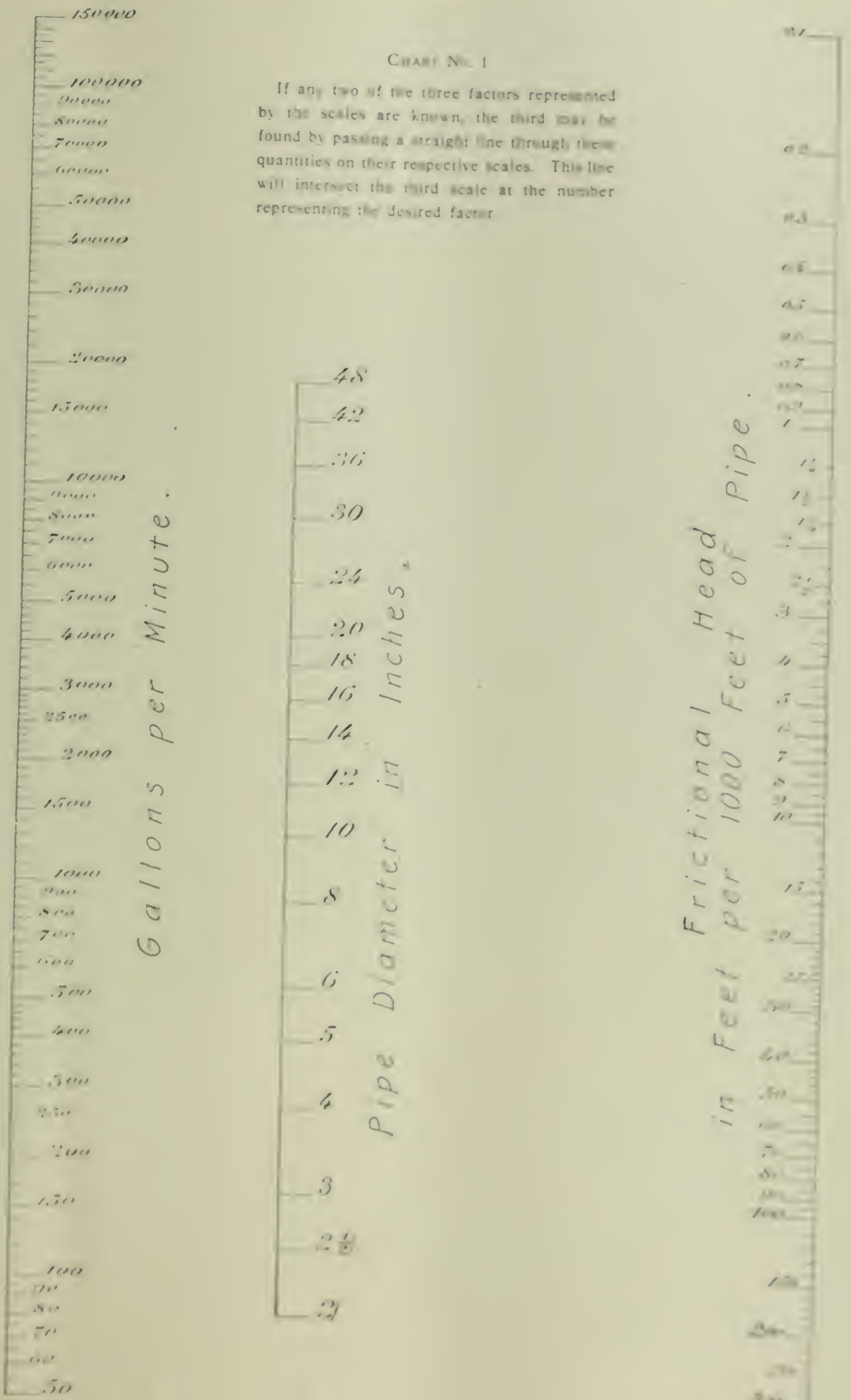
It is usual to employ the values of the constants a and β given for clear pipes. They have been found very reliable under a great variety of conditions. It would be practically impossible to establish, even through careful experiments, a series of values for such constants, that would cover the various conditions of coated inside surfaces of pipes likely to be encountered in actual practice. Hence, it seems proper to use as a first approximation a formula established for clean pipes, and then, according to one's experience, to so modify the results obtained in the calculations as to finally be on the safe side. The formula has been used successfully for many years by the writer, and is recommended in the convenient form, shown hereafter. Transposed to English units this formula becomes,

$$1.27 \frac{D^3}{\sqrt{D + 1}} \sqrt{h}$$

Chart No. 1 is intended for capacities between 50 and 150,000 gallons per minute, for pipes of 2 to 48 inches diameter, and for frictional losses of head varying from 0.1 foot to 300 feet per

CHART No. 1

If any two of the three factors represented by the scales are known, the third may be found by passing a straight line through these quantities on their respective scales. This line will intersect the third scale at the number representing the desired factor.



thousand feet of length of pipe. The chart consists of three parallel scales, the first of which represents the gallons per minute; the second, the diameter of pipe in inches, and the third, the frictional head in feet. These scales are logarithmic and are so arranged that a straight line intersecting the three scales will show the result at a glance; for instance, 1600 gallons passing through an 8-inch pipe per minute will entail a loss of head of 54½ feet, for each 1000 feet of length of pipe. For a lesser or greater length, the loss will be proportional.

The lengths of the scales depend on how close the readings are desired. Sometimes it is found very convenient to make two or more charts to cover a certain range of values. The distance between the first and the last scales must be such that a diagonal line joining the extreme

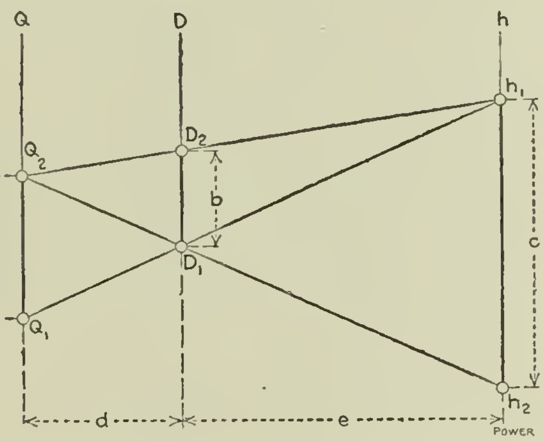


Fig. 1. Showing Method of Constructing Chart No. 1.

values of these scales would lie at an angle not much less than 45 degrees; if the angle were 20 degrees, for instance, it would be difficult to estimate correctly the readings.

The problem in making the chart is first to determine the relative positions of the scales and the "modulus" proper to each. By modulus is meant the length in inches, or more usually in millimeters, of a logarithmic scale ranging from 1 to 10. Neglecting, for the present, the denominator in equation (7), that is, considering it as a constant to be introduced later on, there remains:

$$\textit{Gallons per minute} = D^3 \sqrt{h} \qquad (8)$$

Let the gallons per minute be represented by Q (for quantity) and Fig. 1 the chart to be established. The straight *lines* $Q_1 h_1$, $Q_2 h_2$ and $Q_2 h_1$ are drawn through the three scales, $Q_1 h_1$ and $Q_2 h_1$ intersecting exactly at point h_1 on the third scale. Similarly $Q_2 h_1$ and $Q_2 h_2$ intersect exactly at point Q_2. This can be read as follows: For a quantity Q_1 passing through a pipe of diameter D_1, the frictional loss of head h_1 is precisely the same as for a quantity Q_2 traversing a pipe of diameter D_2. Also, a quantity Q_2 traversing a pipe of diameter D_2 will entail a loss of head equal to h_1, while in passing through a pipe of diameter D_1 the loss will be h_2 feet.

Let a, b and c be the distance in millimeters between the readings representing respectively the numbers Q_1 and Q_2, D_1 and D_2, h_1 and h_2. With m_1, m_2 and m_3, respectively, the modulus of the Q, D and h scales,

$$\left.\begin{array}{l} a = (log.\ Q_2 - log.\ Q_1)\ m_1 \\ b = (log.\ D_2 - log.\ D_1)\ m_2 \\ c = (log.\ h_2 - log.\ h_1)\ m_3 \end{array}\right\} \qquad (9)$$

The similar triangles, in Fig. 1, show

$$\frac{c}{b} = \frac{d+e}{d} \qquad (10)$$

$$\frac{a}{b} = \frac{d+e}{e} \qquad (11)$$

whence,

$$\frac{a}{c} = \frac{d}{e} \qquad (12)$$

Assuming the following values:

Q_1 = 1,000 gallons per minute [log. = 3],
Q_2 = 10,000 gallons per minute [log. = 4],
D_2 = 30 inches [log. = 1.4771213],

by equation (8)

h_1 = 0.13717 [*log.* = 1.1372722]
h_2 = 13.717 [*log.* = 1.1372722]
D_1 = 13.925 [*log.* = 1.1437879]

Replacing a and c in equation (12) by their values,

$$\frac{(log.\ Q_2 - log.\ Q_1)\ m_1}{(log.\ h_2 - log.\ h_1)\ m_2} = \frac{(4-3)\ m_1}{(1.1372722 - \bar{1}.1372722)\ m_2} = \frac{m_1}{2\ m_2} = \frac{d}{e}.$$

The quotient of the extreme values on scale Q and scale h_1 being the same, that is,

$$\frac{150{,}000}{50} = \frac{300}{0.1} = 3000$$

it follows that, other things considered, these scales can be made of equal length, and the same modulus can be adopted for the two. Then $m_1 = m_2$, and $e = 2d$.

From equation (9) and (10)

$$\frac{b}{c} = \frac{d}{d+e} = \frac{(log.\ D_2 - log.\ D_1)\ m_2}{(log.\ h_2 - log.\ h_1)\ m_3}$$

or,

$$\frac{d}{d+e} = \frac{1.4771213 - 1.1437879}{2} \times \frac{m_2}{m_3} =$$

$$\frac{0.3333\ m_2}{2\ m_3} = \frac{1}{6}\frac{m_2}{m_3}$$

but $e = 2d$, and

$$\frac{d}{d+e} = \frac{d}{d+2d} = \frac{1}{3}$$

then

$$\frac{1}{3} = \frac{1}{6}\frac{m_2}{m_3}$$

and

$$m_2 = 2\ m_3$$

The proportion between all the elements of the three scales are now established and there remains only to select the moduli most convenient for laying out the scales. Since,

$$\frac{150{,}000}{50} = \frac{300}{0.1} = 3000$$

$log.$ 150,000 — $log.$ 50 = $log.$ 300 — $log.$ 0.1 = 3.4771213,

and the length of the first and of the third scales will be 3.477 × the modulus selected. On the 10-inch slide rule the scale of numbers measures 250 millimeters and that of the cubes 83⅓ millimeters. If this length is adopted as a modulus, the first and third scales will be

3.477 × 83⅓ = 289.7 *millimeters,*

or about 11.4 inches long. This, of course, is somewhat reduced in chart No. 1 for reproduction, but the proportions remain the same.

Finally,

m_1 = 83⅓ millimeters
m_2 = 166⅔ millimeters
m_3 = 83⅓ millimeters.

Resorting now to the constant

$$\frac{1}{\sqrt{0.62\ (D+1)}}$$

each diameter marked on the second scale must be so located as to take this constant into account. The plan followed in this instance is as follows: The diameters selected ranged from 2 to 48 inches, and the expression of the constant was transformed thus:

$$\frac{D^3}{\sqrt{0.62\ (D+1)}} = \left(\frac{D}{\sqrt[6]{0.62\ (D+1)}}\right)^3$$

For each diameter, the corresponding value $\frac{D}{\sqrt[6]{0.62\ (D+1)}}$ was calculated and inserted on the scale instead of the diameter itself. Instead of plotting, for instance, 8, 12, 20, 36 and 48 inches, there were inserted 6.007, 8.475, 13.04, 21,357 and 27.111 inches.

This case is somewhat out of the ordinary, and if it had been necessary to have the scale of diameters continuous, the process would have been extremely tedious.

To locate the beginning of the second scale it is necessary to calculate exactly the corresponding value of the frictional head for one given diameter and a given value of gallons per minute. The position of the number representing the diameter is given by the intersection of the straight line joining gallons per minute and the friction head with the line on which the diameter scale is established.

The treatment of boiler water with lump and with hydrated lime has been tested by C. E. Thomas, general foreman of waterworks, Illinois Central Railway, whose findings regarding the comparative merits of the two materials are embodied in a paper before the Illinois Water Supply Association. A test was made on 24 tanks, each containing 65,000 gallons of water; 12 tanks were treated with hydrated and 12 with lump lime, 3432 pounds of hydrated lime and 2808 pounds of lump lime being used. Although about 22 per cent. more of hydrated lime than lump lime was used, the lower cost of the hydrated lime showed a saving of about 3 cents per tank over the lump lime. A more uniform treatment was maintained by the use of the hydrated product and the uncertain and deteriorating effects of storage upon lump lime were eliminated.

Uses of the Steam Engine Indicator

By H. T. Fryant

The importance of a proper reducing motion, the uses and limitations of an indicator, and some of the faults in engine adjustment as shown by the diagram.

Many engineers own indicators but comparatively few make a study of them with a view to what can be accomplished by their use. First, the indicator shows how nearly correct the valves are set; second, whether the valves or piston rings are leaking; third, the drop in steam pressure between the boiler and the engine; fourth, whether the compression is correct for the speed and weight of the moving parts of the engine; fifth, the back pressure; sixth, if the governor rods (when the engine is of the Corliss type) are properly adjusted to obtain the same cutoff at both ends; seventh, if the engine will run away when the governor is at its highest position, and eighth, the horsepower of the engine. Several other things can be learned from an indicator diagram, but these are the principal uses.

The most important thing to do when attaching an indicator to an engine is to have the drum move in unison with the crosshead; otherwise the diagram will be misleading. To illustrate this, assume that the engine has a 36-inch stroke and the indicator diagram is 4 inches long. In this case, one-ninth of the length of the card represents 4 inches of the stroke of the engine and a loss or gain of 7/32 inch in the travel of the drum would throw some of the events out nearly 2 inches. This shows the absolute necessity of having a correct reducing motion. The indicator is poor enough at its best, but, at the same time, it is the only thing which shows what is going on in the cylinder, and if properly attached it will be correct within 1 per cent. A few years ago the expert was the only man who did indicator work; the engineer had to take a back seat and was not supposed to know anything about this mystery; this day, however, is fast passing.

Considering the uses of the indicator as enumerated, the first is valve setting. Some claim to be able to set the valves by shop marks just as well as with the aid of an indicator. It is a fact, however, that every engine builder uses an indicator to prove the correctness of the shop marks. Even assuming that it is possible to set the valves on a simple Corliss engine by the shop marks, it is not so easy to take off all the bonnets to ascertain which valve is out of adjustment when there is a twisted stem or something else causing the engine to run badly or use more steam than necessary.

Regarding leaks, the indicator shows these better than any other way, and it does not require much study of the subject to be able to detect them. Many managers are learning to read this much about a diagram, realizing that if steam is leaking by the piston or valves, it means more coal.

The drop in steam pressure between the boiler and the engine as shown by the indicator is important. If this is found to be great, it may be reduced in some cases by taking out some of the short bends, small pipe, etc., which obstruct the flow of steam. The greater the drop in pressure, the longer the cutoff will be for a given load; the terminal pressure rises and so does the coal bill.

It is a well known fact that greater compression is required for a crank type of engine than for one of the disk type, and that it requires more on the head end than on the crank end. The greater the speed the greater the amount of compression necessary, but an indicator is about the only thing which will show how much compression the engine is running with.

The diagram will show whether the back pressure is higher than it should be, and if this is found to be the case, it may often be lessened by straightening the exhaust pipe.

As for equal cutoff, some claim they can tell this by the sound of the exhaust. This may be true, but sometimes it is hard to tell which end has the earlier cutoff. If the cutoff on one end is so late that it produces 15 pounds terminal pressure and the other is so early as to expand down to 3 inches of vacuum, it will not only cause a bad running engine, but will take much more steam than if the cutoff were the same on both ends. This can be detected accurately only by applying an indicator.

If the engine takes steam when the governor is at its highest position, it will run away. This has caused a number of flywheel explosions. It is possible to detect this without the indicator, by blocking the governor and turning over the engine, but it is much easier to use an indicator.

Considering the diagram itself, if the steam valve opens at the instant the piston is at the end of its stroke, the admission line will be vertical and at right angles to the atmospheric line, because the drum will be practically standing still. If this line leans in it shows that the valve is opening late, and if it leans out the valve opens before the piston reaches the end of its travel. If the card is 4 inches long with the stroke of the engine 36 inches and the admission line leans out 1/8 of an inch, the engine will be taking steam one inch before the piston reaches the end of its stroke; or if the line leans in, the engine will be taking steam one inch after the piston leaves the end of the stroke. Now, consider that portion of the diagram representing the travel of the piston from the beginning of the stroke up to cutoff. For this line to be theoretically correct, it should be parallel with the atmospheric line, but in practice this is never so, as the piston travels faster than steam is supplied to hold the pressure up, and as the piston moves faster at the head end, the drop is always more marked at this end of diagram. The next portion of the line is curved, this being caused by the closing of the valve; the slower the valve closes the more rounding this line will be. If a square corner were present instead of the curved line it would show that the valve had closed instantaneously. Next comes the expansion line, which closely resembles the hyperbolic curve; the variation of this expansion line from the theoretical line is due chiefly to leaks, reëvaporation, reopening of the valves, etc. If the engine is of the simple, single-eccentric type, this line should extend down to the atmospheric line at the end of the stroke. Many engines are too small to do the work required of them. This makes the cutoff so late that the full benefit of expansion is not attained.

At release the line makes a sharp turn, forming what is called the toe of the diagram. Sometimes this toe will turn down and even go below the atmospheric line, but on most single-eccentric engines it does not get down to the atmospheric until the piston has moved back 4 or 5 inches on its return stroke. This could be remedied to some extent by moving the eccentric ahead, but this is not advisable on most engines, as it makes the range of cutoff too short and the valves will not release.

Next is the back-pressure line. This line is usually above the atmospheric line, which is caused by pressure backing up in the exhaust pipe. It is good practice to take a diagram direct from the main steam pipe just above the throttle, and then, without removing the card, connect the indicator to the cylinder and take another diagram.

As to the amount of compression which should be used it may be said that just enough should be employed to make the engine pass over the centers without a pound. If an engine has a compression pound, it is nearly always on the head end. This is because the speed at that end is the highest, caused by the angularity of the connecting rod.

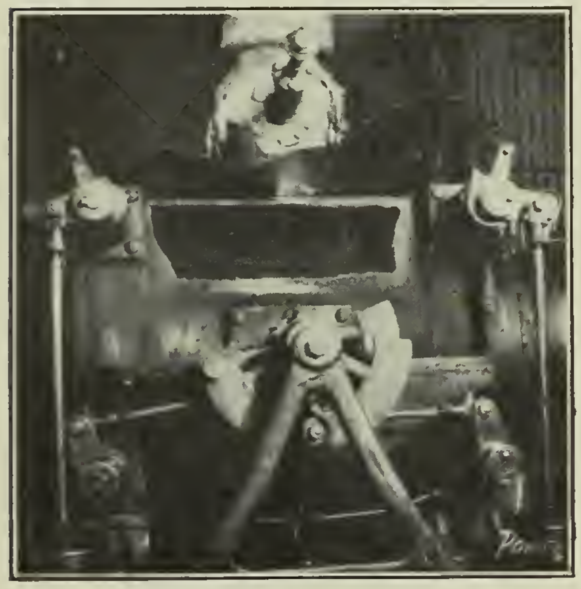
Any man who is interested and lets his boss see that he is interested, will not have much trouble in securing an indicator.

A Wrecked Engine Cylinder

By C. L. Greer

The accompanying photograph shows an unusual mishap to a 1000-horse-power compound engine which necessitated the buying of a new cylinder and which might have occasioned loss of life which it fortunately did not.

While operating, the side wall of the steam chest of the high-pressure cylinder let go on the valve-gear side with the result shown. As may be seen, the whole side was blown out. The flying fragments left only the hub of the throttle handwheel on the stem, broke both steam cranks smooth off, took away the top of both steam and exhaust wrist-plates (made in wheel form) and broke one of the reach rods on the low-pressure side.



Wreck of High-pressure Cylinder

The plant being overloaded a temporary steam line was run to the low-pressure cylinder, the high-pressure crank was disconnected and the engine delivered half power from the low-pressure side. The cause of the break is not known.

Smoke Abatement

Professor Watkinson, Liverpool University, delivered the fourth of the lectures for stokers and others interested in furnace management in the lecture theater of the Walker engineering laboratories at Liverpool on Friday evening, February 17, taking as his subject, "The Setting and Construction of Boilers and Furnaces, and the Methods of Producing Natural, Forced and Induced Draft."

After a few opening remarks dealing with the general aim and purpose of the lectures, and with the importance of accurate measurements of draft, temperature, steam pressure and of the composition of the exit gases as an aid to good work in boiler management, the lecturer dealt with the three conditions requisite to obtain good combustion of solid bituminous fuels and showed experimentally how essential these were to smokeless combustion. The details of construction of a Lancashire boiler were then illustrated by aid of lantern slides in order to prove the difficulty of obtaining smokeless combustion in this type of boiler, a difficulty due to the small furnace and the arch of water-cooled plates over the furnace grate. The purpose of the bridge was then discussed, and the lecturer stated that it produced eddies in the gases as they passed over it into the flue beyond, and therefore tended to promote mixture of the hot air and hydrocarbon gases given off from the burning fuel. A high bridge was therefore better than a low one, if sufficient draft could be obtained to work the boiler fires with it. In the absence of good draft the use of steam jets was often resorted to in order to increase the air supply and to promote the better mixture of the air and furnace gases. In the Belleville type of marine boiler, air at 30 pounds pressure was employed in place of steam, and the Howden system of forced and preheated draft was now generally employed for marine work; but this system in spite of its many advantages had not been adopted for boiler installations on land. Natural draft produced by a chimney rarely exceeded ½ to ¾ inch, measured by a water gage. This low draft limited the thickness of the fires and rendered it exceedingly difficult to keep the fuel lying on the furnace bars free from holes. For good combustion with thick fires, on the other hand, forced or induced draft was essential, and this was now generally recognized and adopted. The different methods of obtaining artificial draft were then discussed, and the comparative advantages of steam jets, air jets and fans were dealt with by the lecturer. As compared with steam jets, fans were more costly to install, but saved largely in running cost, a good fan requiring only 5 per cent. of the steam produced, in place of the 10 to 12 per cent. used by steam jets. The statements made by the makers and other interested parties that steam jets only consumed 3 per cent. of the steam were absolutely inaccurate.

The different methods of furnace construction and the use of firebrick arches for conserving heat and promoting good combustion were then dealt with. It was pointed out that a firebrick arch by increasing the temperature of a furnace may actually increase smoke production, owing to the greater rapidity with which the hydrocarbon gases will be evolved from the freshly charged fuel, unless precautions are taken to greatly increase the air supply at the same moment. The dutch-oven type of furnace construction for Lancashire boilers was condemned by Professor Watkinson for the reason that from 40 to 60 per cent. of the heat transfer in this type of boiler is by radiation from the glowing solid carbon lying on the bars of the grate to the plates above, and this radiation can only occur to the full extent when the furnace is inside the boiler. Luminous flames radiate heat also, but not to the same extent as glowing solids. Although steam boilers can be worked efficiently with the gaseous fuel, they require to be specially constructed for this duty, and no ordinary type of Lancashire boiler will give high efficiency with external furnace or with producer gas. The use of economizers was finally discussed, and the two chief types were described.

The lecture was illustrated by numerous experiments and lantern slides, and was followed by an exhibition of apparatus for making draft, temperature and the other measurements incidental to good boiler management.

The Stumpf Unidirectional Flow Steam Engine

In previous issues of Power, and particularly the January 31, 1911, number, the design and method of working of this type of engine have been given considerable attention. Since the date mentioned above, some illustrations of a marine engine and locomotives employing the straight-flow principle have come to hand and are presented herewith.

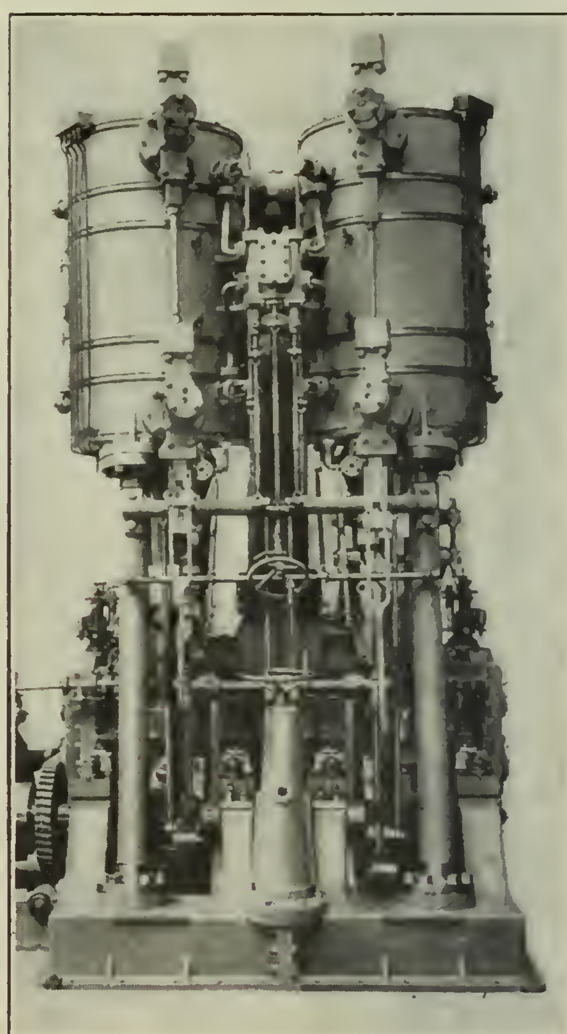


Fig. 1. Second Marine Engine Built of Straight-flow Principle

Fig. 1 is a photo-engraving of the second marine unidirectional-flow steam engine of this system. It was built by the Stettiner Maschinenbau Aktien Gesellschaft at Stettin-Bredow.

Fig. 2 illustrates an express locomotive, and Fig. 3 is a view of a locomotive

FIG. 2. AN EXPRESS LOCOMOTIVE UTILIZING STUMPF PATENT

exhibited at the Brussels exposition. Both of these locomotives have been in successful operation for several months, and six duplicates of the type exhibited have recently been put into successful operation.

Fig. 4 is a cross-sectional view of the cylinder of a locomotive which has five drivers and weighs approximately 85 tons. Five of these locomotives have been ordered by the Moscow Kasan Railway, and at present are in the course of construction.

Engines working on the unidirectional-flow principle are apparently making great headway in Europe, and it is only natural that they should for the efficiency of a single cylinder is practically equal to the best figures obtained with compound and triple-expansion engines.

On a 300-horsepower engine with a cylinder 23.5 inches in diameter, a steam consumption of 8.5 per indicated horsepower-hour was obtained. Besides the merit of high economy the straight-flow engine has a flat-efficiency curve, which means a steam consumption on fractional load or overload of but little more than at normal load.

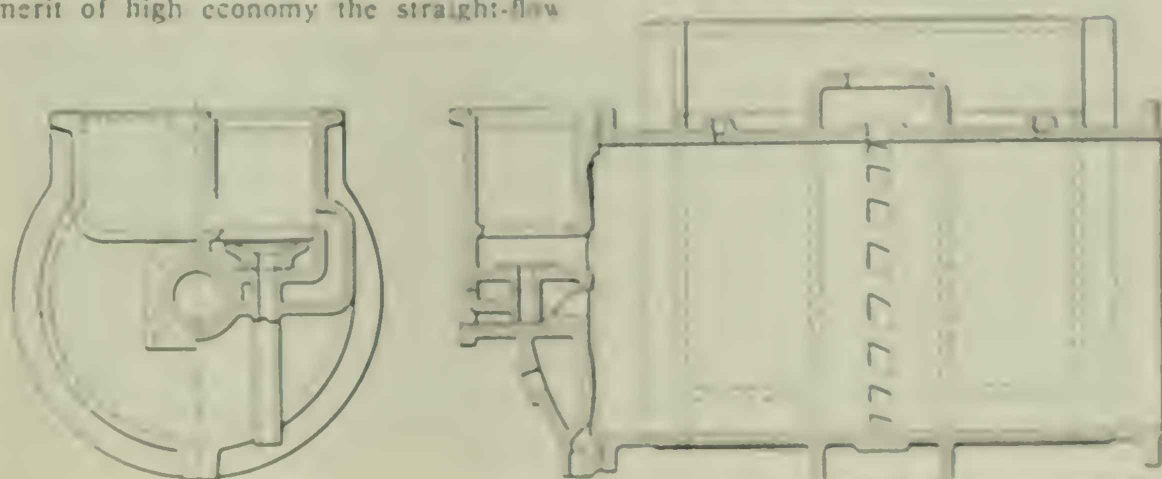


FIG. 4. SECTIONAL VIEWS OF LOCOMOTIVE CYLINDER

FIG. 3. LOCOMOTIVE EXHIBITED AT BRUSSELS

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

A Thriving Power Plant Developed by Protecting Low Ground from Floods

By D. A. Willey

The extent and variety of operations that may be actuated from a small water power are well illustrated by a canal in the Salt river district of Arizona. The locality which it serves has no available coal or wood for generating steam and depends entirely upon the electric current generated by the water flowing from the Salt river through this canal. To obtain the necessary hydraulic head the head gates of the canal were located on the Salt river 20 miles above the power station. The width of the canal is 15 feet at the top and 10 feet at the bottom; the minimum depth is 10 feet. The water is delivered from the canal through steel pipes to turbines direct-connected to alternating-current generators. Three of these units are rated at 900 kilowatts each, working under a head of 226 feet. The other three units comprise two of 900 and one of 1500 kilowatts, getting water under heads which range from about 70 to 220 feet.

Fig. 1. Dam and Power House at End of Canal

A maximum of 4400 electrical horsepower is generated and is utilized for the following purposes: Lighting two communities, operating a tram road six miles long and operating a series of electric pumps to irrigate 50,000 acres of land. During the construction of the Roosevelt dam the plant furnished power for actuating aërial cableways for conveying stone blocks, cement and other material for dam construction, and driving the motors in a cement mill producing 1000 barrels daily.

The current is stepped down to the proper voltage for service and distributed from the transformer station by a steel-tower transmission line carrying six wires of stranded hard-drawn copper. For the irrigating pumps the wires are carried on tripartite poles of varying hight, depending on location and the length of the line and topography of the country through which it passes. At a point about a mile east of the town of Mesa, a switching station is installed from which a line leads south into the pumping territory where 1000 horsepower is used for pumping. The wells have been drilled and many of the lateral canals built into which the water is pumped and otherwise diverted from the Salt river during floods. In all, thirty pumps are operated.

Seven miles south of Mesa the line enters another pumping territory and here ultimately from 20,000 to 40,000 acres will be served when the necessary machinery is installed. The pumping units are vertical-shaft centrifugal pumps direct-connected to 50-horsepower induction

Fig. 2. Part of 20-mile Canal from Salt River to Power Station

motors supplied with current at about 220 volts and 25 cycles.

The main transmission line carries current at 45,000 volts and the main distributing lines operate at 10,000 volts. The line mentioned as running south to the Indian reservation is a 45,000-volt line. There is a substation eight miles south of Mesa in which the transformers change this voltage from 45,000 to 10,000. The main transmission line continues through Mesa and terminates at the present time in Phœnix, 78 miles from the power source, where power is furnished to light the city.

The cement mill was constructed to furnish concrete for the Roosevelt dam and dismantled after the dam was completed. Its equipment, consisting of the separators, material conveyers, grinding and pulverizing apparatus, was operated by a number of motors through shafting and belting. The operation of this cement mill was one of the principal objects for which the power plant was established but the other industries which it serves have given it permanent usefulness.

LETTERS

Geared Dynamos and Turbines

The article by George W. Malcolm on "Reduction Gears for Turbine-driven Direct-current Generators," in the issue of February 14, comparing the efficiency of turbine-driven direct-current generating sets with and without gears, fails to include several important elements. Mr. Malcolm attempts to show that in order to attain an overall efficiency from steam to switchboard of 52.2 per cent., as claimed by advocates of the geared outfit, it is necessary to assume either an impossibly high generator efficiency or an impossibly high turbine efficiency.

For one thing, Mr. Malcolm's assumption of 97 per cent. as the efficiency of a gear of this character is too low, if applied to accurately cut gears; 98½ per cent. would be nearer the correct figure. The efficiency of such gears is not a matter of doubt or guess-work, since it can be determined within a very small percentage of error. With a gear efficiency of 98½ per cent. the figures for turbine efficiency and geared generator efficiency would be as follows:

Turbine Efficiency.	Generator Efficiency.
54 %	[illegible]
56	94.[illegible]
58	91.[illegible]
60	[illegible]

A turbine efficiency of even 60 per cent. is well within the limits of possibility for a 1000-kilowatt turbine, especially if advantage be taken of the gear to increase the speed of the turbine, as well as to reduce the speed of the generator. Doubling the speed of the turbine would reduce the number of stages of a velocity-stage turbine to one-half or those of a pressure-stage turbine to one-fourth, resulting not only in increased efficiency but possibly also saving more than enough on the cost of the turbine to pay for the cost of the gear.

Moreover, according to the above table, the generator efficiency would need to be only 88½ per cent., although there should be no difficulty in reaching 95 per cent. if the speed of the geared generator be only one-fifth that of the direct-coupled generator.

Further, Mr. Malcolm entirely ignores the many practical advantages of the standard-speed direct-current generator as compared with the high-speed generator for direct connection to turbines. Among the many disadvantages of the high-speed direct-current machine may be mentioned the following: Proper commutation involves carefully designed interpole construction; as the diameter of the commutator is limited by the allowable peripheral speed, it is usually necessary to use a double-length commutator in order to obtain the requisite area and keep down the current density within satisfactory limits; the number of commutator bars and distance required between brushes limits the number of poles which may be used; with very long commutators, or with two commutators in tandem, there is difficulty in securing uniform distribution of current between the different brushes on each brush arm; very careful shop work is required; the increased length of shaft necessary to accommodate the commutator increases trouble from vibration, which in turn interferes seriously with the commutation, especially if carbon brushes be used; while it is difficult to compute the critical speed of a direct-current armature, it is very important that that speed be not approached, also that the commutator and armature be in perfect balance; due to drying out or other change in the insulation after the commutator and windings have been assembled, there may be a displacement of the center of gravity which will give rise to vibration entirely beyond the skill of the attendant to remedy, making it necessary that the armature be sent back to the manufacturer for readjustment; the necessity of limiting the diameter of the armature restricts the space available for insulation and for armature windings, so that it is doubtful if the increased windage, iron losses and friction would be neutralized by a decrease in the purely electrical losses, as claimed by Mr. Malcolm; due to the very high speeds at which the armature must run, and the necessity of passing a large amount of air through it in order to keep it cool, there is a great tendency for the collection of dust, including carbon dust from the brushes, and it is found that under high-speed conditions, this dust assumes a very compact form, which frequently results in short-circuits or grounds; finally, while the standard speed electrical generator is entirely familiar to the ordinary operating man, who can make any small repairs as they may be required, the repair of the high-speed generator is entirely beyond both his knowledge and his facilities.

The majority of dynamo designers appear to be of the opinion that units of 1000 kilowatts should not exceed a speed of 1500 revolutions per minute and this speed has in fact been found most suitable also for much smaller machines, even down to 500 kilowatts. However, by installing a 10 to 1 gear, the speed of the generator can be reduced to 300 revolutions per minute, which is moderate and the usual speed for waterwheel-driven generators; at the same time the speed of the turbine can be doubled to 3000 revolutions per minute, which will permit the use of a much shorter, simpler structure, less liable to give trouble by vibration, rubbing, etc., than a longer turbine running at a slower speed. In addition to the saving by the reduced size of the turbine, there will be some saving in the cost of the generator, so that there will be no difficulty in covering the added cost of the gear.

GEO. H. GIBSON.

New York.

Mr. Gibson's assumption that I "attempt to show" that Mr. MacMurchie's economy figures are impossible appears to be due to a lively imagination; it certainly has no foundation in fact. All that my tables were intended to show is a list of possible combinations which would fit Mr. MacMurchie's steam figures. For the benefit of Mr. Gibson and any other readers who may feel impelled to read into my article a forced and sinister meaning, it may be advisable to state that the argument of the article was merely to the effect that the use of the Melville-Macalpine gear for connecting direct-current dynamos with turbines other than the De Laval would not make possible a higher dynamo efficiency and would probably not be of enough advantage to make it pay.

As I am informed that the builders of the gear claim only 98 per cent. efficiency for it, Mr. Gibson's slightly generous allowance is academic; furthermore, as no machinery except waterwheels and grindstones has ever succeeded in maintaining in actual service an efficiency equal to that developed in the maker's test, my allowance of 97 per cent. is quite rational.

Mr. Gibson's attempt to explain the effect of speed upon the design of a direct-current dynamo would be more interesting if it were entirely accurate and if even a corrected version referred to were relevant to any argument that I have advanced. Anyone who has the least familiarity with the subject knows that very high speeds entail serious commutation difficulties; if I had claimed the contrary to be true, Mr. Gibson's fifth paragraph might have been justified. As it is, he has merely indulged in the superficial pastime of demolishing a Frankenstein of his own construction.

Geo. W. Malcolm.

Brooklyn, N. Y.

Cutting Out the Compounding of an Alternator

I was once called to correct trouble on a single-phase compound-wound alternator which was reported as failing to hold the voltage up when running at full load. Fig. 1 shows the connections of the alternator as they were found. To simplify the sketch only two commutator segments are shown, but in reality there is always the same number of segments as of field-magnet poles.

Those familiar with this type of alternator know that the main armature current is rectified by the commutator *A* and passes through the series field winding. In this way the extra field excitation is obtained that is necessary to overcome armature reaction and to hold the voltage normal at full load.

After testing for faults in the machine, I found that the commutator was short-circuited, cutting out the current that should have gone to the series field winding. The repair of this commutator would have been a somewhat difficult job without having factory facilities, so I decided to do away with the compensating feature and connect the machine as shown in Fig. 2, also reinforcing the short-cir-

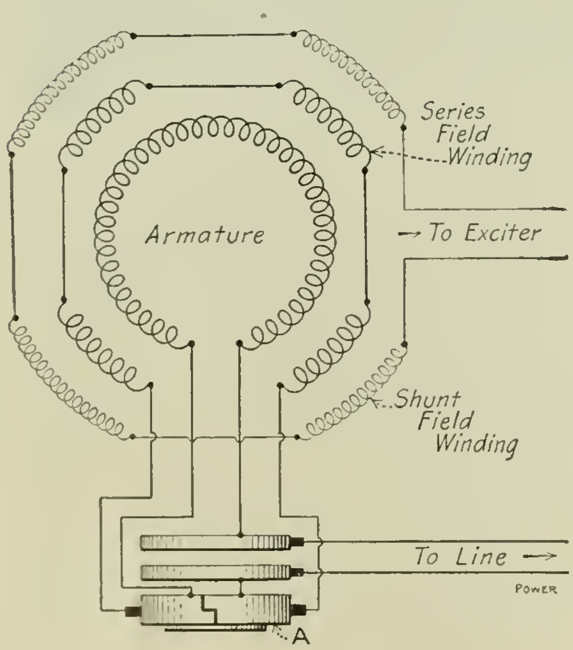


Fig. 1. Original Connections

cuit of the rectifying commutator *A*; a piece of wire was wound around the commutator for this purpose. The series field winding was connected in series with the main field winding, the coils of which were connected in parallel-series, as shown, and the combination was connected to the exciter. This increased the load on the exciter, but it was large enough to stand it. We had no difficulty in holding the voltage at full load and the operator was so pleased that the com-

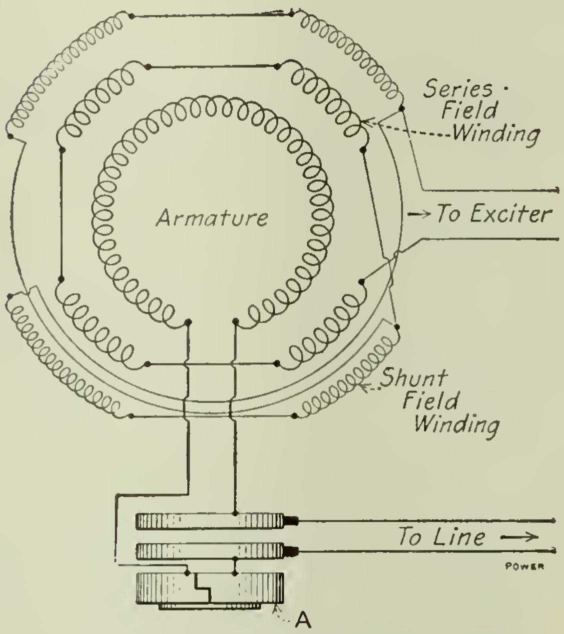


Fig. 2. Changed Connections

mutator and brushes had been cut out that we decided to leave the machine connected that way permanently.

G. J. Reynolds.

Anniston, Ala.

Mr. Hull's Erratic Belt

From reading Mr. Hull's letter in Power of February 14 it is evident that the two pulleys do not line up or the two shafts are not parallel, that is, one of them is not level—perhaps both.

The reason the belt runs true with the center of the pulleys when loaded and shifts from one side to other in stopping and starting is that the crown on the pulley guides the belt true with the center when it is pulling a load and tight, but when starting or stopping the belt is slack enough to run to the edge in response to the unsymmetrical influence of the pulleys.

If it is an endless belt it may have been glued together crooked, that is, with one edge longer than the other.

N. E. Woolman.

Danbury, Iowa.

The erratic belt behavior described by W. S. Hull in the February 14 issue of Power appears to be a duplicate of an experience I had with a similar outfit. In my case the trouble was due to the fact that oil worked out onto the flywheel from the engine bearing and moistened the inside half of the belt when running, causing that half to stretch. This forced the outside half to carry most of the load and that half, under the extra strain, stretched also; this enabled the belt to adjust itself true to the center of the pulley when the load was on it. As the outside half was dry, however, it contracted back to its original length when the load was taken off and then the belt was crooked, which accounts for its not staying on the center of the pulley when starting and stopping.

I opened the seams on the stretched side and tried taking up on them, but this did not help much as the belt was still stretched between the seams. I then tried to stretch the short side to match the other side by moistening it while it was running, also putting more tension on it, but with no better results.

By experimenting with the belt-adjusting wheel on the generator I learned that by reducing the tension on the belt before shutting down and increasing it before starting, the belt would run true with the center of the pulley. The amount of tension in each case must be determined by experiment.

This remedy, however, is not absolute, for, although an engineer may be able to operate the belt in this manner by careful attention, the load may suddenly change on the generator when he is not near to attend to the belt, or someone else may start the engine and cause a wreck that would be far more costly than having the belt put in proper condition. It should be sent to a belt manufacturer to be cleaned and straightened and the seams made over. In the mean time, I advise Mr. Hull to make sure that the pulley is in line with the driving wheel and the foundation bolts are tight; also, not to allow the generator to swing when the load is on it and to see that no water is allowed to drip on the belt from the roof or piping.

J. W. Blake.

New York.

If Mr. Hull, who had a letter in Power for February 14 regarding a dynamo belt, will test the face of the pulley with a straight-edge he will probably find that it has worn slightly hollowing in the center. This can be corrected by building up the center of the pulley by winding strips of thick paper around it. The paper can be fastened on with either glue or shellac; shellac will resist both oil and water, but Mr. Hull probably does not let either get on his dynamo pulleys. By using strips of paper of different widths the pulley can be built up so that it will have any desired crown. I have had a similar experience which was corrected in the manner described.

G. E. Miles.

Salida, Colo.

German interest is greatly aroused in the proposal to utilize the power of the Tinfos, which is estimated at 15,000 horsepower, to supply the energy for electrifying the whole of the Tinfos iron works. By the summer of 1911 it is estimated that one-third of the power will be in use for the electric furnaces, and that twelve months later the head of water will be fully utilized.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

A Composite Pressure and Suction Producer Plant

The accompanying engravings illustrate an equipment of pressure gas producers in a New England manufacturing plant, together with some details of the producer construction. Figs. 1 and 2 show the plant of three generators and the charging floor, respectively. Fig. 3 is a sectional elevation of one of the generators. The inside diameter is 8 feet and the generator is rated at 400 pounds of coal per hour on a 24-hour basis, burning approximately 12 pounds of coal per hour per square foot of grate surface. The generator is a heavy steel cylindrical shell, firebrick lined and set in a concrete pan; the shell is supported by four legs of structural steel, one of which is visible in Fig. 3. Coal is charged through double-sealed hoppers which rest on water-cooled tops, and poke holes are located at convenient points; the holes are closed by finished plugs and the construction is such that the poking bars cannot injure the finished surface and wear the holes out of true. A simple cast-iron bell is used in the feeding hoppers, held to its seat with a counterweight, as indicated in the illustration.

A notable feature of the generator is the annular tuyere, of dog-house cross-section, which distributes air and steam throughout the bed of fuel with an unusual approach to uniformity. The annular outline of the tuyere facilitates the removal of ash, as the latter can descend both around the outside and through the inside opening of the annulus. The tuyere is supplied with air and steam by two blowers of the Körting type, located at opposite ends of the diameter of the tuyere; this, of course, tends to uniform distribution.

The gas from the generator passes through an economizer consisting of two concentric circular shells of heavy steel plate, the gas passing through the inner shell and the air for the generator passing through the outer one in the opposite direction. Most of the available sensible heat that is in the gas when it leaves the generator is taken out in the economizer by the air passing to the blowers, with the result that the air is heated considerably beyond the condensing temperature of the steam used in the blower; consequently, no moisture is precipitated in the bottom of the generator.

Two scrubbers of the combination type are used. In the bottom part of the scrubber the gas is cooled and cleaned by means of a spray of water and a bed of coke and the upper portion is filled with excelsior for removing the moisture entrained by the gas passing upward.

Fig. 4 is a sectional elevation of a three-way water-sealed valve that is used at the junction of the purge and scrubber pipes. With the valve bucket in the position shown, the purge pipe is sealed off and the gas passes to the scrubber through the bottom outlet.

Fig. 3. Generator Construction

An unusual feature of this plant is the use of both suction and pressure to create the draft through the generator. Perhaps it would be more accurate to say that suction is used incidentally in addition to the steam blowers, not necessarily. Positive blowers are connected between the scrubber outlet and the delivery main

Fig. 1. The Producer Plant

Fig. 2. The Charging Floor

in order to maintain an actually constant pressure in the main, and these, of course, subject the generators to suction. The inlet and outlet of each blower are connected by a bypass in which is a regulating valve that allows some of the gas

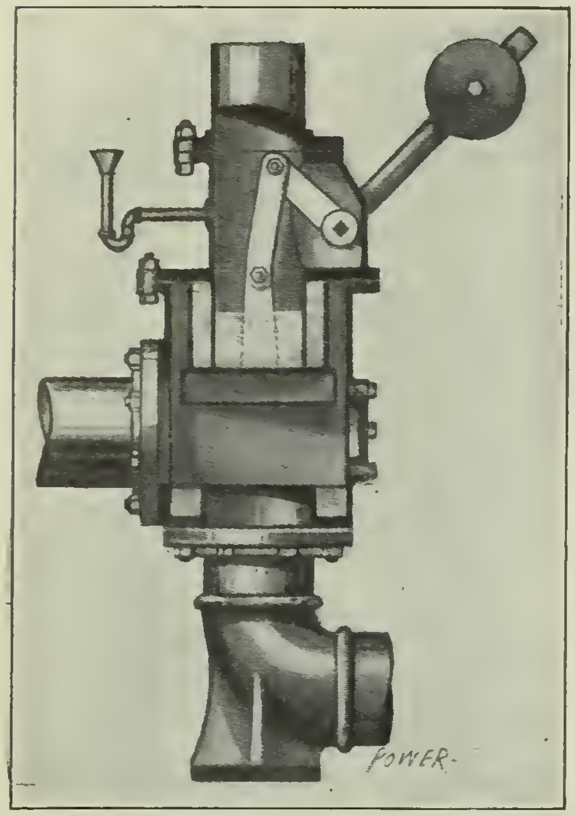


FIG. 4. WATER-SEALED VALVE

merely to circulate in the pump when the pressure in the main is normal. The pumps or blowers and their connections are illustrated by Fig. 5. To reduce the liability to shutdowns, one of the blowers is driven by an electric motor supplied with current from the central station of the town and the other one, which is nor-

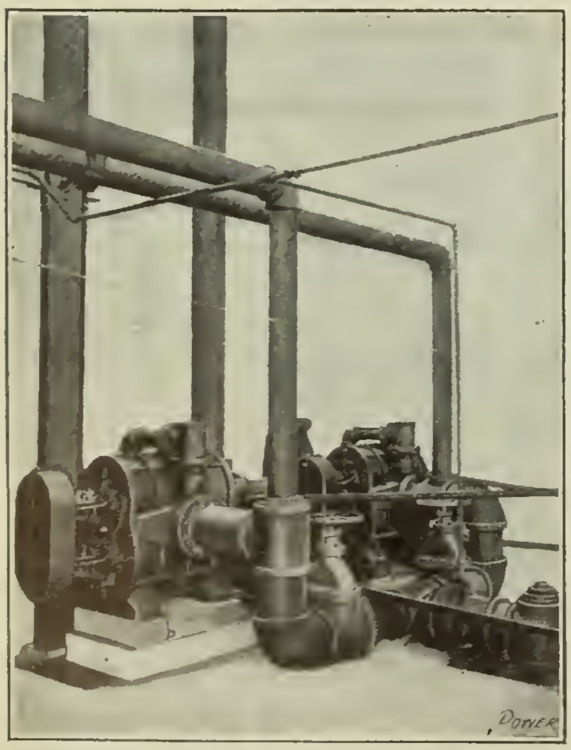


FIG. 5. THE GAS PUMPS

mally used, is driven by a small vertical engine supplied from the boiler which makes steam for the gas generators.

The coaling arrangements are so clearly shown in Fig. 2 that a verbal description is not necessary. A simple but excellent feature of the building is that the charging floor is open on the side toward the auxiliaries on the floor below, so that the operation of the pumps can be observed from the charging platform.

The equipment was designed and built by the Flinn & Dreffein Company, of Chicago.

Gas Power Plant Erectors and Operators

By W. E. Nelson

Do gas engines and producers need engineers, and do gas-engine and producer manufacturers need information or advice from the erecting men? Many manufacturers depend upon their engineering talent in the office and drafting room to work out the details and turn out a machine that will give reliable service, depending upon an indicator card, a brake test of two hours and one or two observations of the engine's performance while running nicely under a moderate load.

Two plants practically alike were installed under different conditions; one of them was accepted and the other rejected. The one that was rejected was installed by an engineer from the office and the other one by an erector from the test floor. Before the office engineer had gained enough practical experience to get his plant to operating successfully it was too late for a practical man to do any good.

On the other hand, many gas-engine installations that were installed by practical men have been rejected through the fault of the manufacturers in not sending men that were adapted to the particular line of work to be done. An experience with a small municipal electric-light plant will serve to illustrate one way in which the manufacturers are to blame for poor installations and unsatisfactory operation. The plant equipment consisted of a 55-horsepower engine and suction producer which was sold by a gasolene-engine agent, who, in an endeavor to save as much as possible, sent his regular gasolene-engine erector to install it. The erector was of the type that can use his hands to a good advantage but not his head. In the first place he hired a hobo who was looking for a day's work to put in the firebrick; the result was a leaky lining. He next piped the jacket water from the engine into the scrubber; the result was that the engine got warm gas laden with tarry vapors and small particles of dust that were carried over in the vapor. The next mistake and most serious was neglecting to open a drain which relieves the vaporizer of the water that does not vaporize, which resulted in filling it up to the air intake and shutting off the supply; this caused the engine to back-fire, slow down and finally stop. The manufacturers left a 2-inch pipe flange on the engine intake after testing it on natural gas; the erector connected about four feet of 2-inch pipe to the intake and connected that to the 5-inch gas main with a reducing coupling.

I am not criticizing the man; my object is to emphasize the advisability of employing men trained to do this particular kind of work intelligently; they cannot be hired for $60 a month.

The erector left the plant in the condition described and the town hired a local man to run it; he burned out a dynamo bearing the first week. They tried two or three other men and finally shut the plant down and notified the agent to take it out. He, as a last possible resort, wired the factory for a man, informing them that he must be a diplomat as well as an expert in every sense. The man who was sent was neither a diplomat nor an expert in the usual sense of that title, but he was instrumental in putting the plant in good condition and getting it accepted. In order to get a settlement the agent had to sacrifice the profit and considerable more, which would have made up the extra cost of a good man for several years.

In another plant, poor repair work on a generator lining was done by the operating engineer. The firebrick being badly burned out in the lower half of the generator, he decided to replace all of the badly burned brick; in finishing up the lower half of new brick he found that it did not connect with the upper half, of old brick, by nearly half an inch, so he filled the crack with fire clay. It held until it dried out; then the engines would slow down and would not carry full load, the producer would get a mixture of air and gas in the top and ignite it and blow dust and fine coal out at every joint. The greatest inconvenience would occur when cleaning the fire with the cleaning door open. It was not long before the engineer telephoned the factory for a trouble man; he had blown the fire several hours and could not get good gas at the engine. Upon inspection it was found that a trowel could be inserted all the way around the lining, in the crack between the old and the new parts of the lining.

A good rule to follow in replacing burned-out brick is never to replace them higher than half way to the extreme fire line, and then the greatest care should be taken to fit them perfectly; in case it becomes necessary to replace any more it is best to remove all the brick to make sure of getting a good tight lining. It may cost a little more at the time but will be a great saving in the long run.

Up to the present time there has been very limited publication of the experiences of gas-engine and producer men. Talking with several of them has given me the impression that they are laboring under the delusion that their experiences are too valuable to give away; the other fellow can find them out the same way they did. This is about as unprogressive and senseless as anything can be.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

The Oil Disappeared

During the summer months it was the custom to stop the engine, and not close the stop valve on the boiler, but as cold weather set in it was closed, and after draining the pipes, the throttle was also closed to prevent any leakage running into the drains and freezing.

Since that time I have been wondering why the engine took so much oil, as the oil pump had not been tampered with. One morning the engine had been running about an hour when the cylinder began to groan.

I looked into the oil-pump reservoir, which had been filled the day before, and found it empty. In thinking it over I came to the conclusion that, closing the stop valve and throttle created a vacuum in the pipe and drew all the oil out of the pump in the effort to supply the pipe with air. A cure was effected by opening the bleeder on the oil pump, thus supplying the pipe with air.

FRANK GARTMAN.

Sheboygan, Wis.

Graphite as a Boiler Compound

The value of graphite as a boiler compound is not generally known by operating engineers, and a recent experience in using graphite in boilers that were supposed to be perfectly free from scale may be of interest.

There were two 150-horsepower boilers of the shell type, when the plant came under my supervision, and a chemical compound, costing about $1 per day, was used to prevent scale from forming. The two boilers are in constant use, and evaporated on an average of 3000 cubic feet of water in 24 hours' service. The engineers claimed the boilers were free from scale, and all internal surfaces appeared to be very clean. I decided to try graphite as a scale preventive, on account of its supposed affinity for metals. When graphite is once in a boiler, the circulation of the water carries it to all portions and the graphite forms a thin coating on the metal which prevents the scale from forming. The graphite was ground to a powder, as ordinarily supplied as a lubricating graphite.

For the first two weeks one pint of graphite was mixed with one gallon of water and fed to the suction of the pumps between the feed water heater and pumps each day. At the end of two weeks the boilers were opened for cleaning and about 100 pounds of sludge was removed from the bottom of the boilers; this sludge contained considerable scale, about 1/16 inch thick, which appeared to be old scale from the back head. The boilers had been blown down twice a day, and the amount of sludge recovered was about twice that recovered when using the compound. The amount of graphite was then reduced to a pint every other day, and at the end of another two weeks the boilers were again opened and considerable white coating appeared on the surfaces, which at first appeared to be new scale, but on close examination was found to be old scale with the outer surface dissolved. In some places the old scale came off in large pieces, showing that the boiler had been covered with a scale so hard that it had been mistaken for the metal.

At the end of eight weeks one of the boilers showed but a few patches of scale. This boiler was nearest the pump and appeared to receive most of the graphite; however, the other is in as good a condition now, and both appear to be free from scale.

When the compound was used the feed-water line had to be removed every two months, and the scale cleaned out, but since using graphite the feed lines have not been taken down or does it appear necessary to do so; the pumps are now clean and are not coated with a gritty substance as formerly.

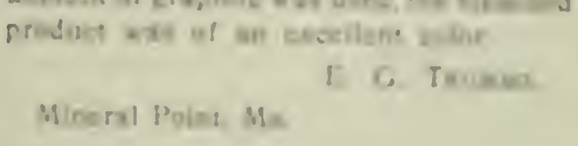
Pieces of scale which came loose from the surface of the boiler showed graphite adhering to it. My experience with graphite shows that it will work in between the scale and the surface of the metal, causing the scale to loosen and fall off. I am unable, however, to explain the apparent dissolving action of the graphite on the surface of the old scale, as there is nothing in its composition to cause this action, that I am aware of, and the amount of graphite used was very small. On account of the steam being used in bleach tanks to heat and agitate the product manufactured in this plant, the color of which must be very white to command the best prices, I was at first doubtful of the results of this point, but during the period the greatest amount of graphite was used, the bleached product was of an excellent color.

E. G. TRUMAN.

Mineral Point, Mo.

Air Chamber on a High Pressure Water Line

In the Singer Tower, New York City, the water service to the various offices was originally maintained by a single pipe line from a pump in the engine room to a tank located about [illegible] feet above the level of the pump. The outlets to the various offices were tapped directly from this line. The pressure, due to head, was so great that whenever a faucet in one of the lower floors was turned on and off a severe water hammer occurred, which was transmitted over the whole line. The natural remedy was to run a new and separate line from the pump to the tank, and to disconnect the line feeding to the faucets from the pump. Conditions were such, however, that this could not be done for some time and the following simple, but extremely effective device, was used.



SECTIONAL VIEW OF AIR CHAMBER

It consisted of a piece of [illegible]-inch pipe about 18 inches long filled with solder at one end and fitted with a cap as shown. A piece of round, medium soft rubber that easily fitted in the pipe, and about 15 inches long was placed inside. This device was then connected, in a horizontal position, with a valve and nipple to the line about half way between the pump and the tank. After this was installed no more water hammer occurred whenever a faucet was turned on or off in any part of the line, as the rubber absorbed all of the shock and relieved the air chamber entirely.

Later, when it was convenient, a second pipe was put in so that the pump delivered water directly to the tank, and the old line was used to connect the tank to the faucets. After this was done the rubber cushioning device was no longer needed, but its success demonstrated that, in a case of high-pressure heads in water lines, a rubber cushion is superior to an air chamber on the pump to absorb shocks from water hammer.

H. B. LANGE.

New York City.

Feed Pipe Scaled

The difficulties began with the packing in the boiler feed pump giving out more frequently than a good packing should. It was decided that the packing was at fault and a new brand was tried. This played out in even less time than the previous lot, so the old kind was again used, but for each renewal of packing the pump worked harder than ever.

Pump valves and check valves were carefully examined, but nothing was found amiss, except the remains of the packing. At length the trouble became more serious and it became difficult to keep enough water in the boiler.

Finally the problem was solved. The feed pipe entering the boiler was carried 5 feet inside the shell before discharging. Just outside the boiler head, an angle valve was placed to facilitate cleaning this pipe. When the bonnet was removed the 1½-inch pipe was found so badly scaled as to be reduced to ¼ inch in size.

After reaming out this feed pipe, first with a ¼-inch, then a ½-inch and finally with a 1-inch pipe with teeth filed in the end, the pump was started up and worked as smoothly as could be desired.

After this experience a special point was made at boiler-cleaning time to investigate such feed pipes and also the connections to the gage glasses.

F. H. STACEY.

Montreal, Can.

Water Coils Burn Out

What causes my 2-inch hot-water coils to burn out, and how can I remedy the trouble?

Boiler tubes, ten in number, connected with long return cast-iron ells, extend from the rear of the setting to the bridgewall, which is on a level with two courses of brick, which rest on bars, placed 32 inches from the boiler shell. The grating and bridgewall measure 5½ feet over all by 6 feet wide. The distance between the boiler shell and coil is 4½ feet.

In about four months, these coils turn up at the furnace end of the combustion chamber, the bend extending back about 3 feet.

I am not bothered with scale. I burn oil and the burners are set 2 inches above the brick, or 30 inches from the boiler shell.

The flame takes a straight line to the end of the bridgewall, and then leads up slightly to the boiler.

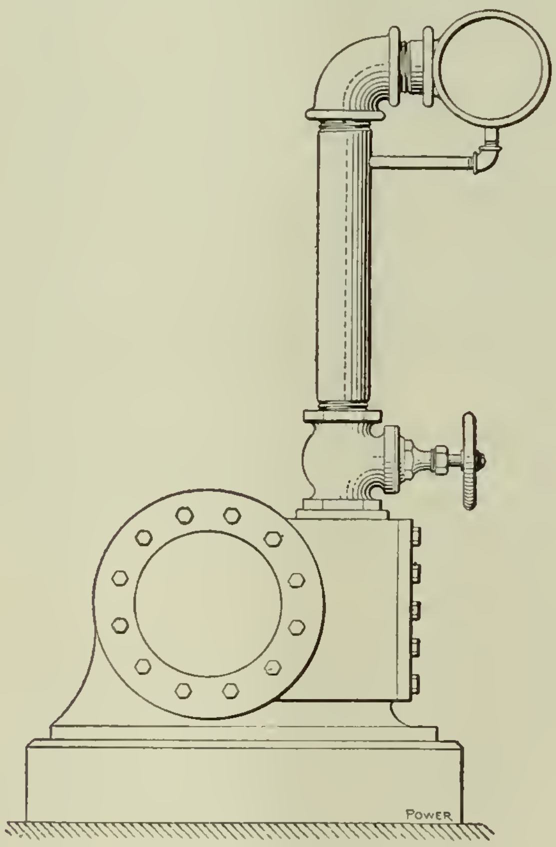
Water enters these coils from the boiler-feed pump at about 120 degrees Fahrenheit, thence to the boiler. Do these coils increase the efficiency or capacity of boiler, or both? I would like to hear from those who have had experience with coils placed beneath their boilers, in the furnace, and what advantage they have, if any, over other ways of heating the feed water.

R. A. BOOTH.

Riverside, Cal.

Steam Pipe Drips

Drips for steam mains are often neglected, and the direct drain, as shown in the accompanying sketch, is as good and safe as any plan that can be adopted. This type of drain will carry the water directly into the steam pipes leading to the



DRAINING STEAM LINE TO ENGINE CYLINDER

cylinder and consequently will drain off the condensed water above the throttle before the engine is started. This eliminates the danger of an accident to the engine. Connecting all leads to a main drip line to which many drains are led, is bad practice, as in some cases a trap is depended on to carry the extra condensation away and if it fails to operate will allow a charge of water to come over into the engine cylinder and wreck it.

When drains are carried away from the steam line leading to the engine it is best to have individual traps to carry away the surplus water rather than one trap to care for a whole line.

C. R. MCGAHEY.

Baltimore, Md.

Firing a Boiler

Most boiler attendants recognize in a general way that the economical working of a boiler furnace depends largely on the way in which the air supply is distributed and regulated and endeavor to do the best they can to comply with proper combustion conditions, but few of them can give an intelligent reason for the procedure they adopt. But a small proportion of engineers secure the best attainable furnace results and in a great many cases the matter is so imperfectly understood that there is a serious waste of fuel.

The total amount of air required for the proper combustion of fuel in a boiler furnace depends on the nature of the fuel used. With ordinary coal the theoretical minimum quantity required for combustion is about 11 pounds of air per pound of coal, but because the film of gases escaping from a burning surface interferes with the access of the fresh-air supply, it is impossible to burn a pound of coal with anything approaching so small an amount; consequently 19 to 22 pounds of air represents more approximately the quantity used under ordinary conditions, or between 8 and 11 pounds more than theoretically required. As this large quantity of air is finally expelled into the atmosphere at the chimney temperature it is desirable to keep the air supplied as low as is consistent with the efficiency of combustion. With badly designed or inefficiently worked furnaces as much as 25 pounds to 30 pounds of air is not infrequently passed through the furnace for every pound of coal burned, a fact which serves to illustrate the possibilities of economy or extravagance in connection with air distribution and regulation.

The great bulk of the air supply is drawn through the grates and the rate of flow is determined by the thickness of the fire and the draft, which is generally controlled by a damper. Under ordinary conditions the thickness of the fire does not vary very much and the air supply, if the dampers are not moved, is reasonably constant.

When the furnace receives a fresh charge of bituminous coal, the volatile gases are at first driven off very rapidly and, therefore, require a corresponding increase in the air supply just as the air flow through the grates is diminished, due to the thicker bed formed by the fresh fuel. In order to supply the necessary air the furnace doors are generally fitted with openings which the fireman can open or close at will, and in many cases the bridgewall is also arranged to admit a supplementary air supply by means of a damper operated from the furnace front.

In the hands of a skilled man the manipulation of these appliances can be made to materially contribute to the efficiency and economy of the boiler. Very often, however, the appliances are used in either an imperfect manner or are so neglected as to be almost unworkable.

Frequently the bridgewall-damper connection is so disabled that the air orifices are either permanently stuck open or closed. Air admitted through the fire door serves to better advantage than when admitted through the bridgewall because it passes the length of the furnace before mingling with the gases liberated from the fuel. Some designs of furnace door are fitted with a box from whence the air emerges into the furnace as a spray through a perforated baffle plate. Frequently these plates are removed, or burnt away with the result that the air supply is not well distributed. After the fires have been charged the ventilating grids should be opened wide and allowed to remain so for a minute or two, the length of time depending on the character of the coal and determined by the fireman from his observations of the fire and the chimney, or better still from the readings of the CO_2 recorder.

Manchester, Eng. J. F. GRESLAND.

Bonus System in the Fireroom

The efficiency of the human machine has a greater effect upon the profits of a power plant than is thought to be the case by many engineers and, in many cases, a greater saving may be made by increasing the efficiency of the men employed in a plant than could be accomplished by increasing the efficiency of the machinery.

This point is well illustrated by an experience I had in the plant of which I am chief engineer. Oil is burned as a fuel and two Mexican firemen attend to the boilers. Let me say right here that a careless fireman can waste dollars mighty fast, when burning liquid fuel. My hardest proposition was to get the firemen to do their work properly, as their only thoughts seemed to be of their *señoritas* and the next *baile*.

Some months ago I decided to try the bonus system and so offered to each man a 5 per cent. bonus of the fuel he could save over a certain specified amount. The effect was magical. The men are "on their toes" all the time and I never have to call their attention to the water level in heater or boilers, or to the condition of the fire. Each man received $3.75 bonus the first month, $2.50 the second, $3.30 the third and $7.80 the fourth month. The plant was only running half time the first three months and from all indications the bonus of each fireman will be from $7 to $10 per month in the future.

Result: In four months each man received $17.35 extra pay, and the *fuel account was benefited by a saving of* $312.30, which was *all "velvet,"* as no money had been invested by the company to accomplish the saving. The firemen are continually coming to me and, in their broken English, suggesting some new idea for saving fuel. When their suggestions are at all reasonable they are carried out at once and their interest is kept alive.

After this experience I firmly believe that this is the only way to "handle" firemen. It is simply a case of deciding whether the money is to be given to the fuel dealer, or divided between the firemen and the company.

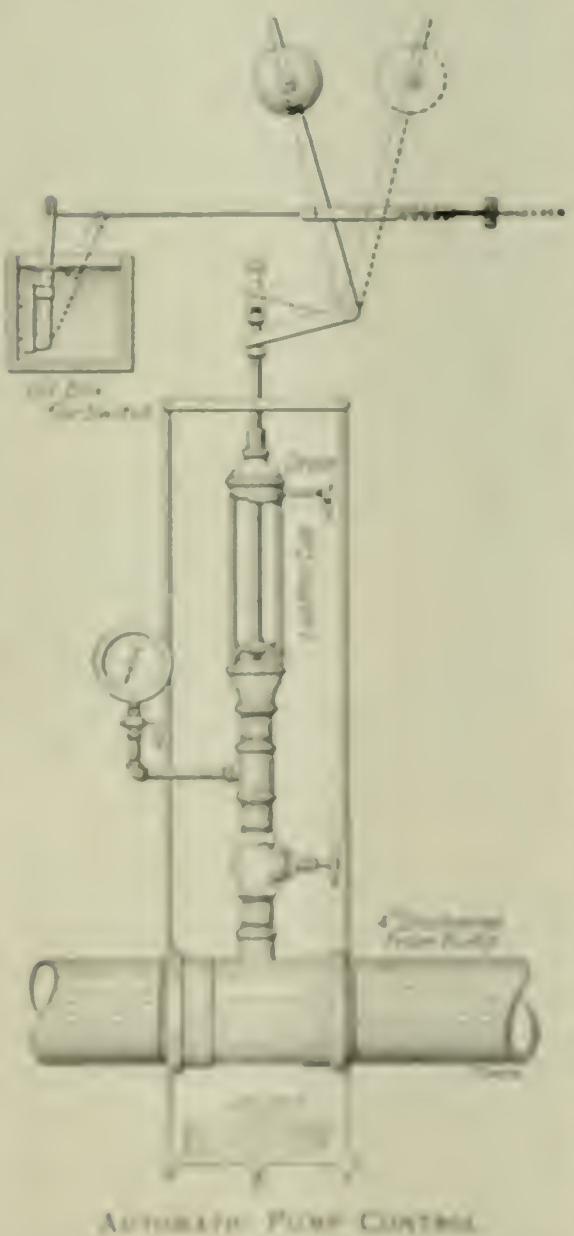
If a man is paid barely enough to keep body and soul together, he will do just as little work as he can and hold his job. If he is getting a good living wage and on top of that is receiving a share in the saving he makes, the chief engineer will soon be saying, "I have the best firemen that I ever saw."

T. P. WILLIAMS.

Brownsville, Texas.

Automatic Pump Control

The accompanying sketch illustrates an automatic pump control I built about one year ago. The motor-driven pump supplied water for a small village and worked against a [illegible]-pound water pressure.



AUTOMATIC PUMP CONTROL

The illustration shows the details of construction.

D. F. [illegible]

Glenwood Springs, Colo.

Melting Babbitted Brasses to a Bearing

The main generating unit in a small electric-light plant consisted of a high-speed engine and generator that ran at a speed of 300 revolutions per minute. The plant was operated ordinarily during the night, but at times was started up in the afternoon to furnish light for the opera-house matinée. A request was made for lights one afternoon; the engineer started up, filled the oil cups on the engine and left the plant in charge of the fireman while he went outside to do a job of wiring.

Returning to the plant about the time the show was over, the engineer found the engine room full of smoke, the engine was pounding so badly that it could be heard a block away and the fireman was frantically pouring oil on the crank pin, which had run hot, and the melted babbitt had been thrown out of the brasses.

The crank was oiled by a wiping device which would operate only with thin engine oil in the oil cup. The trouble was caused by the fireman who had made a mistake in filling the oil cup with castor oil. In one hour the engine had to be started for the night's run and it was up to the engineer to make a quick job of babbitting the brasses. They could not be babbitted in position, so a piece of shaft was found that was about the same size as the crank pin on which the brasses were babbitted. After the brasses were replaced it was found that they made a bearing on a few of the high spots only. There was no time to spend in scraping them down, so the engineer decided to try an experiment.

Oil grooves were cut in the brasses, after which they were put in position and keyed up as tight as would allow the engine to be turned with two men pulling on the flywheels. The cylinder was then warmed up, the wiper filled with oil and the oil cup set to run a stream of oil on the pin. The engine was then brought up to speed and the crank watched closely for signs of smoke. As soon as the brasses began to smoke, the throttle was partly closed to bring the engine down to a slow speed so as to prevent the melted babbitt from "freezing" to the crank pin. Oil was poured on the brasses until they stopped smoking, when the throttle was closed. The brasses were then removed and thrown into a pail of water to cool. The babbitt was found to be melted just enough on the surface to give it a good smooth bearing on the pin. After cleaning out the oil grooves the brasses were put in position, the engine started and no trouble whatever was experienced with heating when the load came on. To scrape brasses in this way the engineer must be a good guesser.

F. [illegible]

New York City.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Size of Air Chamber

In the February 21 issue, Mr. Dew describes some trouble he has had with a pump which pounds when he starts it up.

I have had some experience with pumps pounding. Every time that a troublesome pump was started the noise would be something frightful, and it was a great relief when the pump picked up the water.

One engineer told me that the air chamber was not large enough. Another told me to set the steam valves. Every man that came along had a different remedy. But none was of any value. Finally, I repacked the water plungers with fresh packing well saturated with cylinder oil and graphite. I also packed the rods at the same time. I left the packing on the water plungers quite loose. When I turned steam on, I never saw a pump work nicer, and I was surprised to see how quickly it picked up the water.

Pumps have three places in which to look for trouble: the steam valves, the water valves and the packing. Air leaks are usually pipe troubles.

O. L. Sherman.

Duluth, Minn.

In regard to Mr. Dew's air-chamber problem as described in the February 21 issue, it is my opinion that there may be a small leak at the threads in the cap which allows the air to escape and the chamber to fill with water. A threaded cap should not be used on an air chamber as it is difficult to make a tight job. A screwed flange should be put on the end of the air-chamber pipe and the latter well peened. Then, a plate should be bolted to the flange with a rubber gasket between.

A long air chamber has no advantage over a short one; it is capacity that determines adaptability.

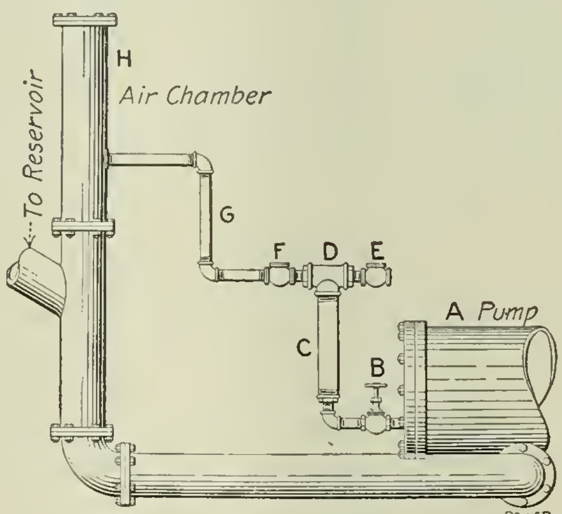
James Johnson.

Hackett, Penn.

In reply to F. A. Dew's question in the February 21 issue regarding air chambers for pumps, I will say that the proper size of the air chamber depends upon the size of the water cylinder and not upon the discharge line, if the pump is properly installed.

For ordinary double-acting pumps working against moderate pressures, and at ordinary speeds, the cubical contents of the air chamber should be not less than three times the piston displacement. For pressures of 100 pounds per square inch or more and for high piston speeds, the capacity of the air chamber should be at least six times the volume of the piston displacement. The effect of a small inlet in the chamber would be to prevent a rapid loss of air.

Under the increased pressure in the air chamber, the air is absorbed by the water and gradually passes off with it. In this way all the air will finally pass off and the chamber will be made useless if no means are provided for renewing the



Arrangement for Replenishing Air Chamber

supply. A simple device for maintaining the supply of air in the air chambers of large pumps is shown in the accompanying illustration. The piece *C* of 2½-inch pipe, about 25 inches long, is connected to the end of the pump cylinder *A* in a vertical position by means of a gate valve or cock *B*. The 2½-inch tee *D* is placed on the upper end of the pipe *C*. The 1¼-inch check valve *E* is placed on a nipple on the side away from the air chamber. This check valve opens inward. The 1¼-inch check valve at *F* opens outward.

This arrangement operates as follows: When the pump is working, the valve *B* is opened. This allows the pipe *C* to fill with water. Then, *B* is partially closed until the check valves *E* and *F* begin to click. Thus, when the valve *B* is opened the pipe *C* will fill with water during the discharge stroke of the pump. As *B* is partially closed when *C* is full, the pump, during the suction stroke, will draw part of the water from *C* and air will flow in through *E* and take its place. During the next discharge stroke more water is forced into *C*, driving the air out through *F* and *G* into *H*.

If the valve *B* is open wide all the water will be drawn out of *C* during the suction stroke and cause a slapping noise in the pump cylinder, but by properly regulating the valve *B*, a column of water is kept in *C* which acts as a piston to pump air into the air chamber *H*.

A. H. Stanfield.

Clarksville, O.

Mr. Duffy Inquires

"I am told," said Duffy, "they have made a book about that Pittsfield biler explosion. Daly says 'tis a fine book, made by the county judge."

"It is," said Doolin, "I've read it. I was over to the sugar house puttin' in tubes in the No. 18 biler an' the insurance inspector was there. He had the book in his grip an' I took it to relieve his mind from the strain of goin' through the evidence in the case. The judge is a fine man, Duffy, an' a good, plain writer. In the end ye find the pipe to the steam gage was choked wid scale an' the poor man didn't know it. With that he goes for the safety valve an' screws it down till the spring was solid an' even the huddle chamber was closed. He keeps on firin' an' chasin' B.t.u.s through the flues, worryin' all the time that he couldn't get steam enough to start. Everybody was wild to go to work an' finally some men started out to be at the ice when the engine would turn. At this instant, Duffy, the biler exploded, an' there ye are."

"Do the judge believe it was overpressure?" asked Duffy.

"There's no other cause," says Doolin, "beyond the poor man losin' his head in guessin' whether 't was the steam gage or the safety valve that wasn't right an' he has paid for that. They found the valve loaded for 225 pounds or so."

"An' I am told," remarked Duffy, "they have the best biler rules in the country up in Massachusetts. Daly says there's no doubt about it; that they have got everybody else's rules in the second division, even the U. S. G."

"Daly is right," says Doolin. "There

isn't a bilermaker but knows the Massachusetts rules is the best. An' what did ye expect else from the land of the sacred codfish an' the home of the Plymouth Rock! Sure, they know beans up there an' bilers too, for that."

"Even so," said Duffy, "the biler blew up."

"True enough," said Doolin, "but why quarrel over the rules? Mind you, those rules are new, merely a beginnin' an' a grand one, at that. Here's a terrible explosion, due to an unlooked for cause, one that had not been counted on. In a short time they will slip in a rule to cover this detail."

"An' how?" asked Duffy.

"Well, now, look at Philadelphia," was the reply. "'Tis the only place in the country where they require two safety valves on each biler. Would you believe, Duffy, if the Pittsfield man had two safety valves on his biler, that he would have took the word of the lyin' steam gage against the two valves? There is the solution of the matter. 'Tis a two to one bet I am right, as ye see. An' further, when the late George Babcock went into the biler business, he had in mind that this might occur an' so he placed two pop valves on each of his bilers. The other water-tube men, of course, did the same an' this accounts in some measure for the safety of the water-tube bilers. The next step, then, Duffy, is to pass a rule providin' for two valves set two pounds apart."

"Why not," said Duffy, "have two steam gages to each biler, one to check the other? True, in most plants ye can check the biler gage by the engine-room gage, but in the small plants, they use but the one gage."

"'Tis a grand thought," said Doolin. "If we can come back in about one hundred years an' see the bilers our gran'sons are runnin', we will see things, Duffy, that, as Bill says, are not yet conceived by mortal man. An' the Boston rules, Duffy, are doin' a great work in hastenin' the day when biler explosions will be confined entirely to the movin'-picture business. Every kicker on present conditions, every crank that takes a whack at lap-seam bilers an' lap-welded water tubes, every dreamer of a nonexplosive biler, is each mother's son a booster for better conditions an' better bilers. An' mind ye, Duffy, that Massachusetts is settin' the pace for the other States. The yeast is working an' the ferment is spreadin'. The engineers are thinkin' an' the bilermakers studyin'. The buyer in Iowa wants Massachusetts standard bilers. When, Duffy, ye get the men from the alfalfa district in line with the lads in the big cities an' then have the various societies devoted to steam engineerin', bilermakin', etc., leave, for the time bein', the discussion of who will be the next President of this bunch, an' get together for laws on biler construction, inspection and operation, ye will see every State with laws matchin' Massachusetts. In the end, Duffy, the bilermaker, the engineer, the owner and society will be benefited financially by the rigid enforcement of such laws. An' the time will come when they will take a visitor from a foreign land to a museum an' show him a lap-seam biler stuck up by a waxwork of Napoleon, Jawn L. an' other curiosities."

"An' when," asked Duffy, "will all this be?"

"I dinnae," said Doolin. "It's up to the readers of POWER."

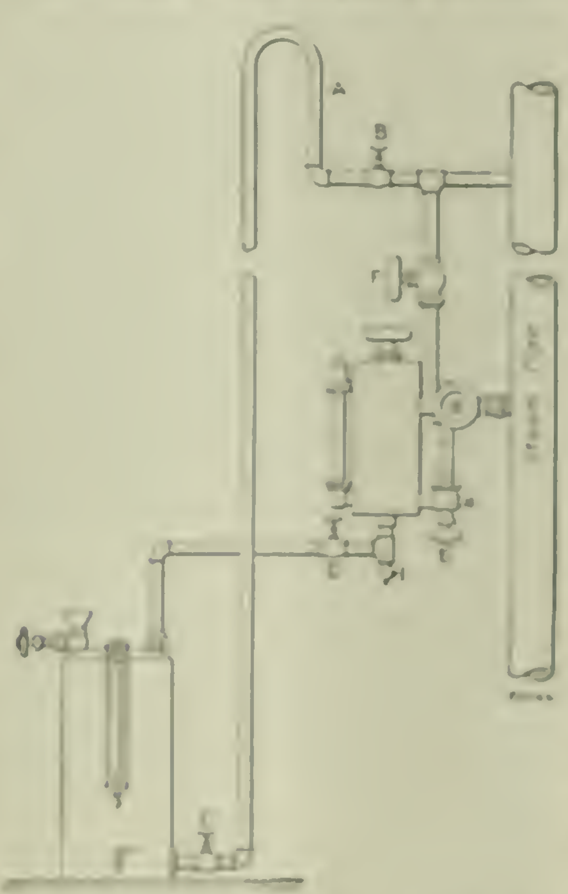
DANNY HOGAN

Punxsutawney, Penn.

Lubricator Piping Layout

In the February 21 issue, Mr. Pierce asks for a method of piping a lubricator to a reservoir. The accompanying figure shows a good method.

The reservoir can be placed anywhere



OIL RESERVOIR AND PIPE CONNECTIONS

that is convenient for filling so long as it is in no danger of freezing. The reservoir must be below the lubricator so that no water or air will be trapped. The steam pipe *A*, leading to the bottom of the reservoir, should be fairly high (20 feet is not any too much). This hight can be gained by forming a loop as shown. This will give the necessary hydrostatic pressure.

The operation is extremely simple. When using the reservoir open valves *B*, *C* and *D* and regulate the oil feed with valve *F*.

When using the lubricator alone simply close valves *B* and *D* and open valve *F*.

When filling the reservoir close valves *C* and *D* and drain off the water through the pet cock on the bottom of tank. When the water is all out close the pet cock and fill the reservoir through the funnel and strainer on top.

GEORGE H. HAMLEY.

Newburgh, N. Y.

Other contributions on this subject were received from James Bennett, Marshfield, Ore.; G. H. Wallace, Racine, Wis., and John A. Wise, Jamestown, O. These letters were much the same as the present contribution and the one published in last week's issue.

Slipping Latch Blocks

In the February 28 issue, I noticed Mr. Greer's account of his experience with latch blocks slipping and his remedy.

I have had considerable trouble myself with latch blocks slipping and wearing off at the edge. Instead of buying Novo steel and paying a dollar per pound for it, I used the common soft steel and case-hardened the plates. This method has proved to be very satisfactory.

I am using such plates on a 20 and 40 by 48-inch engine running at 95 revolutions per minute, sixteen hours per day. One set of plates has been on for eighteen months and when recently they were changed they were but very little worn.

J. R. WAMPLER.

Staunton, Va.

Leakage through a Piston Valve

The tests taken by Mr. Mitchell and published in POWER last October are valuable as they opened up a discussion on a subject which is of the greatest importance to both engine builders and buyers. This discussion seems likely to bring us nearer the truth as to the relative merits of the many types of valve at present in use.

Although these tests did not approach the accuracy of the Callender and Nicolson experiments, the results very approximately conform to the law of leakage which was established by those experimenters.

The suggestions in the letter on this subject in POWER of February 7 are sound and tests taken under these conditions should, without doubt, be readily accepted. One of the great objections to Mr. Mitchell's tests, which was not pointed out, however, is that the valve ran out of its liner, thus leaving only a narrow face for steam to leak past when the valve was at the end of its travel. This objection would be overcome by following the above mentioned suggestions.

The experiments of Messrs. Ide & Sons, described in POWER for November 8, are a striking confirmation of Messrs. Callender and Nicolson's statement that minute differences of fit of a valve do not appear to affect the amount of steam leakage past the valve to any appreciable extent, and are also a confirmation of tests taken by myself to determine the advantage of ring valves over solid valves. The results of the tests which are given by Mr. Allen in POWER for November 29 show that the leakage of a piston valve does not appear to increase much even after several years' running, thus showing that the slight wear which is bound to occur is not sufficient to make any appreciable difference in the amount of the leakage. Mr. Allen champions the piston valve and gives a category of its virtues; however, the results of the tests that he gives are slightly worse than those obtained with slide-valve and rider-valve engines in this country.

Mr. Shoemaker's letter in the January 3 issue calls for much comment. His explanations of the objections to a standing test for leakage, and of the cause of the greater leakage with valves than with pistons are certainly novel and his assertions are surprising.

To test a valve he placed it in its mid-position and turned steam on. Of course, the valve leaked badly as it had very little cover and, hence, the steam had practically no distance to leak through in order to get into the cylinder. Thus, it is not surprising that in not one of more than fifty tests was it possible to open the stop valve fully.

Let him put the valve so that it is neither over the port nor partly out of its liner, then he will obtain a very different result and one which more nearly conforms to the working conditions of the valve.

The arguments that the spectators advanced against the reliability of the tests that they were shown is just the one that is advanced, and is accepted by all engineers who consider the subject, to show why the valve does not leak to any extent when standing, although it leaks considerably when running. As he pointed out, Mr. Mitchell's tests prove that the spectators had got the wrong idea. It is stated that there was no noticeable difference between the leakage with solid valves and that with ring valves; of course there was not, because the steam in all probability had no ring to get past in the latter valves and, therefore, the leakage should be identical. Mr. Shoemaker states, "We have all heard the argument that the rings in a piston do not show excessive leakage; therefore, why should the rings in a piston valve show any more leakage? The answer to this argument is simple." It is, and surely he does not think that the answer he gives is believed by anybody beside himself. From his letter I should judge that he has seen several valves, but has he not come across any that have been working for several years in the same liners?

The information on the reputed test at Cornell University, where the piston-valve rings had to be reëxpanded after three and a half hours' run because the leakage became so great, leaves us wondering how the leakage was discovered and what the mechanical efficiency of the engine was while it was grinding the valve away so rapidly. The statement that the wear on a piston valve after a year's run will be ten thousandths of an inch or more is decidedly inaccurate if the valve has been properly designed, for there are solid valves that have been running several years that have not as much clearance as this. In this country the restrained ring type of valve is largely used, and from personal observation I can say that the wear of the rings is only about four to six thousandths of an inch in a year; in fact, some rings have run a year without wearing down to the diameter of the valve body.

Mr. Shoemaker's observations on the leakage in the slide-valve engine fitted with a pressure plate is in accordance with the results obtained by Messrs. Callender and Nicolson, and it was to be expected that it would be greater than with the piston valve as there is a greater surface over which leakage could occur. I would commend to the attention of Mr. Shoemaker the carefully conducted tests of these experimenters for consideration before he makes such emphatic statements regarding the much greater leakage of the valve after a few weeks' run; apparently he has been anxious to obtain such tests to disprove arguments that have been brought forth that both of the types of valve above mentioned do not leak steam under operating conditions, but whoever brought forward any such arguments plainly showed that he had no knowledge of the subject.

Engineers will agree with Mr. McGahey in his opening remarks upon this subject given in POWER for January 17. Material, workmanship, and care in operation are three most essential considerations in the life and efficiency of a valve, as they are in all engineering work. Engine builders do not, as he suggests, make their piston valves on the expansion principle because they have no faith in their claims that such valves are steam tight, that is, comparatively speaking, but they make them in such a manner because it is realized that some wear must occur and means for taking up this wear should be provided. In the balanced slide-valve engines the wear of the valve has been minimized by the addition of a pressure plate. This plate relieves the working face of the valve from the pressure that would be exerted on it by the steam pressure on the back of the valve and, therefore, the wear is diminished; but this gives more surface for steam leakage, so the attempt to reduce the wear on the valve is not conducive to the attainment of a tighter valve. With a pressure-plate valve it is most essential to the economy of the engine that the wear which occurs should not be allowed to become excessive; because of the greater surface for steam leakage the wear will have a more harmful effect with this valve than with a piston valve.

Mr. McGahey states that he has never been able to see but one advantage that the piston valve possesses; that is, that it runs light and is light on the governor. He overlooks the advantage of not having the piston-rod glands exposed to high-pressure steam and if he had had much experience with superheated steam he would realize the great advantage of using the piston valve instead of the slide valve for high temperatures. He recommends testing the valves for leakage in the same manner as that adopted by Mr. Shoemaker, but I would again point out that this is not representative of the actual conditions of operation and that a fairer test would be to test one end of the valve at a time with its face completely covered by the liner. Mr. Mitchell's tests were conducted on these lines, as also were those of Messrs. Callender and Nicolson.

This discussion has plainly shown the great need of further experiments. The attention which it has attracted shows the interest taken in this important matter. If one or two engineering colleges could carry out a series of tests on different valves it is possible that we should then have definite information regarding the comparative leakage of the valves and this would be of great value to engineers.

JAMES CANNELL.

Stanford le Hope, England.

Water Hammer and Other Phenomena

Of the "Topics for Discussion" in the March 7 issue by John W. Payler the first one, relating to water hammer and its possible causes, has been discussed times innumerable. Two of the theories which receive almost universal acceptance are: Water lying in the steam pipe is picked up by the inrushing steam and hurled violently against the end of the pipe, a bend in the pipe or a stop valve. Second, the steam on coming in contact with the cold water in the pipe condenses, forming a vacuum into which the steam and water are projected with violent force. I accept the former as the correct one. It is beyond dispute that water will condense in a pipe and stay there unless there be an efficient draining system or the steam line be slanted toward the engine to carry it off. If the water is not drained off the steam will throw it against the first obstruction, causing water hammer.

The correctness of this assertion seems to be borne out by various observations. Take the injector, for instance: a jet of steam will pick up a stream of water and force it into a boiler against much higher pressure. If the feed valve be closed suddenly while the injector is in operation or if it be left shut before starting the injector, a water hammer will occur, especially if the feed pipe be a large-sized one or the injector be located at a distance from the boiler.

The vacuum theory does not appeal to me because even if it were possible to create vacuum in a pipe which is presumably full of air, the only result would be an increase in the effective boiler pressure; otherwise the conditions would be the same.

As to whether water hammer is due to the contact of cold air with the inrushing steam, I will relate an experience which I had which bears on this point. I was running an air-compressor plant and dynamo for a constructing company. We ran from 2 a.m. to 6 p.m., excepting Sundays. One Monday morning I arrived at the plant, as usual, in time to warm up the engines, etc. The fireman was supposed to get there about four hours ahead of me to raise steam. On the previous day I had one of the boilers cut out for cleaning, the other one being banked. There was only one steam gage; it was connected to the steam line and there was no way of ascertaining the pressure on the boiler in which steam was being raised. The method which I usually employed was to "crack" the stop valve and give time for the pressure to equalize.

On this particular morning, there was about 75 pounds pressure on the one boiler and a very good fire under the other one. The fireman assured me that he had the fire going for at least four hours. I "cracked" the valve and later on opened it full without its giving a sign that everything was not in order. Then, I started the dynamo. In less than a minute a great rumbling sound issued from the boiler room. The sound was much like thunder and unlike what we call water hammer. Water hammer, judging from personal observation, has a distinct direction of motion. In this case there was no such thing discernible. As I rushed into the boiler room it occurred to me that there must be air confined in the boiler that I had just cut in and, although the boiler did not give a sign while the steam was at rest, it began to grumble as soon as the dynamo engine began to draw steam and the cold air to mix with the steam. I mounted the ladder to shut the stop valve, while the boiler was bucking like an unbroken bronco. As soon as the valve was closed the commotion ceased. Meanwhile, the pressure dropped to 30 pounds. The fireman corroborated my suspicions that he had got there only half an hour ahead of me and had just started the fire; consequently the boiler had just begun to get warm.

After straightening things out, I began to philosophize upon what I had just gone through. Why did not the air assert itself when I connected the boiler on which there was no pressure to the one in which there was 75 pounds pressure? I tried to satisfy this question by the theory that air being a very bad conductor objected to being heated. On second thought, this did not seem satisfactory as, after all, heating anything, no matter how bad a conductor, merely is transferring and not expending energy; the commotion that went on in the boiler required a whole lot of energy. I came to the final conclusion that heat transferred gradually will not cause any rumbling or knocking but when attempted suddenly, it will. For instance, a piece of red-hot iron when immersed in a vessel of water will cause rumbling and the water to shoot in all directions, although, if the number of heat units required to heat the piece of iron be applied to the same amount of water gradually, no disturbance would occur.

As to the second question, "Does air in pipes act as in the air chamber of a high-pressure pump, until equilibrium of temperature is established between it and the steam?" I would reply that it does. I have on several occasions raised steam in boilers without letting the air escape, to try the conductivity of the air. I let the boiler warm up until the gage showed about 15 pounds pressure, kept the pressure there for about 6 hours, then I closed the water valve on the water column and opened the blow-down valve. Air would rush out perfectly cool until the pressure dropped to about one pound and steam began to escape. This showed conclusively that cold air will not mix with steam while at rest and that it will not be heated by conduction; at least, not very quickly. Of course, if circulation be established, it would receive heat quite rapidly.

The third question was: "Is steam formed under or above the surface of the water?" I cannot conceive of steam forming "above" the surface. What is to become of the space between the surface of the water and "above"? The water nearest the heating surface receives heat first. In receiving the heat it expands and rushes to the surface, establishing circulation. This is continued as long as heat is applied. Water, like anything else, is subject to the laws of gravity. The hottest water, being the lightest, always rushes to the surface where, I should say, steam is formed. This seems to be true with the exception of cases where defective circulation exists, when steam is formed at the heating surface. This condition is manifested by priming or a violent motion of the water level in the gage glass.

The fourth question was: "How, and by what means, is a very rapid production of a large volume of steam produced after a violent and destructive boiler explosion?" If in a boiler carrying, say, 100 pounds pressure and containing one ton of water, a sudden reduction of pressure takes place, caused by the opening of a stop valve or a rupture of a defective plate, a corresponding drop in the temperature will result, liberating, per pound of water contained in the boiler, 108 B.t.u. which would instantly be available to turn some of the water into steam. This sudden formation of a large quantity of steam would hurl the water surrounding it against the shell, causing a violent and destructive explosion.

VICTOR BONN.

New York City.

The Benefit of Organization

I read POWER—have read it ever since 1887—and have distributed many copies of it through the State in which I live. I have seen it make many good engineers by a careful study of the experiences of other engineers. But I must differ with Mr. Gotstein in the March 14 issue.

Organization will not secure more salary; the engineer's work is different from any other calling or trade; he is appreciated for just what he is worth. His value is estimated not from the amount of laborious work he does, but from the money he saves in the plant's operation.

His end of the establishment is often the maker or breaker of the firm's financial standing; often either bankrupts or saves money, depending on whether he is what his name and calling indicate or simply a coal passer and oiler—a stopper and starter.

When any man gets the idea in his head, as evinced in Mr. Gotstein's letter, that he is worth more money than his employer pays him, let him get out; if he is competent and muscular enough to perform the work and has the abilities to keep up a better establishment—there are other places. Men of abilities are always wanted, and the pay is proportioned to the abilities displayed.

I know of a man that believed he was worth more than his firm paid him; he said so, he sought another position, he did not seek long; he is drawing $6000 a year today.

I know of many who are drawing good salaries. I have seen men in organizations cut wages more than any other men. It was each for himself and "the devil take the hindmost."

My forty years' of experience has taught me to lead up, look up, help up, to learn all that one can and one will earn more and positions will come his way without depending on organizations. He best helps himself who leads another up.

T. D. WALLACE.

Duluth, Minn.

"What did you do with the steam gage?" asked the superintendent of the lumber mill.

"Oh!" replied the darky engineer. "Do you mean that thar ole clock? I taken it off an' throwed it away. It wasn't keep time no how."

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Split Condenser Tube

If a tube in a surface condenser should split, how could it be temporarily repaired so as to keep on running?

S. C. T.

A surface condenser tube may be cut out of service by stopping the ends with soft-wood plugs. The splitting of a single tube would not have any appreciable effect on the operation of the condenser or on the vacuum.

Bare Tube Sheet

Why can the upper tube sheet of a vertical boiler be left bare without the danger of burning?

B. T. S.

Because the hot gases in passing through the lower part of the tubes give up so much heat that they cannot overheat the upper portion of the tubes and the head to the danger point.

Saturated and Superheated Steam

What is the difference between saturated steam and superheated steam?

D. W. S.

Saturated steam of a given pressure has the temperature at which water will boil under that pressure. It may be moist, may carry unevaporated water along with it as mist in which case its quality is designated by the percentage of the mixture which is steam. Thus steam containing 2 per cent. moisture and having the temperature at which water boils under its pressure is "saturated" steam having the quality 0.98. When the last trace of moisture is dried out the steam is "dry saturated." Further application of heat will raise the temperature of the steam above that due to its pressure when it is said to be "superheated." If moisture is introduced into superheated steam, the superheat (that is to say, the heat above that necessary to make it dry saturated) will be taken up by the water, so that normally superheated steam will be dry.

Temperature and Pressure

Are there other means than the steam gage and safety valve for determining the pressure in a boiler?

F. F. P.

Yes, a thermometer may be used.

Effect of Rocker on Eccentric

What effect has a rocker on the setting of the eccentric?

E. R. E.

It changes the position of the eccentric with regard to the crank. Without a rocker the eccentric leads the crank; with one it follows it.

Effect of Broken Spring

If the spring in a centrifugal governor should break, what effect would it have on the speed of the engine?

E. B. S.

The centrifugal effort of the weight is opposed by the tension of the spring. If this tension is removed by breakage or otherwise the weight will move outward and reduce the speed of the engine.

Location of Lap Crack

Where should search be made for a lap crack in a horizontal tubular boiler?

P. L. C.

A lap crack usually occurs in the outer or overlapping sheet near the row of rivet heads. It is covered by the inside lap and cannot be seen until it extends through the plate. Search will not reveal it as it can be found only by unmaking the joint.

Morrison Flue Collapsing Pressure

What is a Morrison furnace flue? Give the rule for determining the allowable pressure, and the rule for determining allowable pressure on riveted boiler flues.

M. A. D.

A Morrison furnace flue is one with consecutive annular corrugations throughout its length.

For corrugations 1½ inches deep the pressure of collapse is found by the formula

$$\frac{t^2 \times 1200}{D \times \sqrt{L}} = p$$

in which

t = Thickness of tube in thirty-seconds of an inch;
D = Greatest external diameter in inches;
L = Length of tube in inches;
p = Pressure in pounds per square inch.

For the strength of butt-strapped flue joints the English Board of Trade prescribes the formula

$$\frac{90{,}000\, t^2}{(L+1)\, d} = p$$

and for lap-riveted joints

$$\frac{60{,}000\, t^2}{(L+1)\, d} = p$$

in which

p = Collapsing pressure in pounds per square inch;
L = Length in feet;
d = Diameter in inches;
t = Thickness of plate in inches.

Latent Heat

What is latent heat?

L. H. S.

It is heat that is absorbed by a substance when changing from one form to another without any increase in temperature, as when ice changes to water or water to steam.

Boiling Point of Watar

Is it possible to heat water above 212 degrees at atmospheric pressure?

B. P. W.

If water is entirely freed from all dissolved air it may be heated to about 260 degrees before ebullition takes place. It then flashes into steam with an explosive effect, which fact has been used in some instances in attempts to account for certain boiler explosions.

Piston and Cylinder Clearance

What is meant by piston clearance in a steam engine?

C. C. P.

Clearance in a steam-engine cylinder means all of the space not swept through by the piston. With the piston at the end of the stroke, the space between the cylinder head and the face of the piston and the volume of the ports constitutes the clearance. It is reckoned in terms of percentage of the piston displacement. The term piston clearance is sometimes used in reference to the distance between the piston and cylinder head when the engine is on the center.

Full-weight standard pipe should be used for pressures up to 125 pounds, and full-weight extra-heavy pipe for pressures above 125 pounds. Cast-iron standard fittings should be used only for pressures below 100 pounds, medium extra heavy for pressures from 100 pounds to 150 pounds, and extra heavy over 150 pounds.—*Ex.*

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Contents

POWER

The Control of the Coal Supply

The power-plant owner will sit up nights to figure how he can save ten per cent. in the cost of power production. He will invest money in expensive engines and search for boilers of the maximum efficiency; he will buy indicators and CO_2 recorders and strive to save the last redeemable fraction of a pound of coal per horsepower or kilowatt-hour.

And then he will sit supinely by and see a group of men grab all the coal in sight, and watch its price go up to "what the traffic will bear."

We will not presume to assert that the beneficent storing of the energy radiated to and absorbed by the earth in past ages was designed for the benefit of all mankind, but we think that the fact is sufficiently evident that the many would have profited at the expense of the few if the founders of the Republic had had such a prevision of the coming importance of the coal deposits to the industries of the country as to have kept their ownership and control in the hands of the people.

What has been done is done, and the growing conflict between the rights of property and the rights of man must drag out its slow and tedious course. But we can stop piling error upon error and sacrifice upon sacrifice. All of the coal and oil and mineral wealth has not been ceded, and the people, through the national and State governments, still retain control of much of the undeveloped water power. A few earnest far-seeing men are trying to call a halt upon the wholesale surrender for all eternity of this control and of the rights of the people in their inheritance. Have you attached any more than a political significance to their effort? Have you done anything to hold up their hands? Have you manifested any disapproval when those in high places have blocked their progress, kept alive the hopes and encouraged the machinations of the grabbers?

The far-seeing business man, the educated and thinking engineer, can realize the possibilities of the next half century in this direction as few legislators can. A general attitude of protest upon their part against the continued giving away of the people's property to individuals that they may sell it back to the people at baron-making profits will make their representatives think twice before continuing the process of public depletion and private enrichment. An attitude of openly expressed approval of the efforts of those who are working for new and better ideals and practices in this respect will encourage those who are giving of their time and effort and money for the general good, and discourage those who are reaching after the public property for their individual gain, and the officials who are inclined to help them to get it.

Place the Responsibility

In the matter of boiler explosions, which are rare in England as compared with the United States, a very different course is pursued from that in vogue here. Whenever a power-plant accident occurs the owner is held accountable and primarily responsible until an investigation by the commission of the Board of Trade places the responsibility and fixes the punishment. In this country it seems that the effort on the part of those chosen to fix the responsibility is, if possible, to find someone who was killed on whom the blame can be placed. This, if successful, is usually followed by a "whitewash" of those who may possibly be considered by the public to be even remotely connected with the accident, and the incident is closed.

Last summer a thermal storage tank in a south of England city failed along the head flange, killing two men and doing considerable property damage. The investigation which was conducted by the engineers selected by the commission revealed the fact that the head plate was cracked by the use of a hydraulic riveter in forcing the cold head-plate flange and the shell together. When the evidence was all in, the commission which sat on the case assessed a fine of two thousand dollars against the company that built the tank, a fine of two hundred and fifty dollars against the manager of the company for allowing the tank to go out of the works, two hundred and fifty dollars against the chief engineer of the power plant for allowing the tank to be installed and one hundred and fifty dollars against the operating engineer of the plant for not cutting out the tank when the leak was first noticed.

It would seem that such a glowing handling of a few cases of morally criminal carelessness in this country would have a salutory effect and perhaps tend to reduce the rate at which explosions occur. In 1909 there were five hundred and fifty. The complete reports for 1910 are not yet available but it is thought that the figures for that year will closely approach those of the one before. For the first eighteen days of 1911 there were twenty-four, which rate, if kept up for the rest of the year, will fetch the total to five hundred and forty-seven, a number far beyond the really unavoidable. If the English method had been applied to some of the recent American explosions the beneficial effect would have been felt all over the land, for not a boilermaker, owner, operator or inspector cares to go down in his pocket for funds to pay for the privilege of taking a gambler's chance on the safety of a manifestly unsafe boiler.

Preventing Power Plant Losses

The problem of keeping down the cost of operation confronts every steam-plant owner, and the methods employed in solving this problem are many.

Purchasing cheap supplies is doubtless the means most commonly used. For some reason or other, many operators seem to believe they can get as good an article cheap as they can by paying a higher price. As a result, the repair bills run up to a much higher figure than the sum saved by purchasing cheap supplies.

In other matters men use good business sense. Not one of the purchasers of cheap supplies would think of purchasing a suit of clothes for fifteen dollars and imagine that they would wear as well as a fifty-dollar suit.

Cheap oil is used and journals heat and burn out. Poor coal is put into the furnace and the fireman is blamed because he burns more coal per horsepower developed than the man across the way.

A good engineer working for a low wage can make a good fight to keep things going, but there are conditions that will get the better of him, and one way to bring them about is to supply him with inferior equipment and maintenance supplies.

Is it cheaper to put a packing in the stuffing box of an engine that will last a few weeks or to use a packing costing twice as much that will last years?

Which is the more profitable way of running an establishment: to pay out hundreds of dollars in unnecessary repairs, or to use better and more costly supplies, and avoid frequent repair bills?

How it makes the careful manager squirm to see good coal in the ash pile, yet he has no compunction against running the engine year after year with leaky piston rings and steam valves. He has no idea how much steam is leaking into the exhaust pipe without doing work. The loss is there, although it cannot be seen. And that is the point: the losses that cannot be seen are given scant attention. It is a case of "don't know, don't care." These unseen leaks cost money, however, and these invisible losses eat up profits. The visible losses generally force the management to remove the cause.

In many instances gross neglect can be seen in the management of the power plant. In one instance a steam plant furnishes steam and power for a manufacturing concern, but of all the numerous steam pipes that emit steam hardly one discharges into a trap, although such an arrangement is feasible.

Out in the yard a new Corliss engine has lain all winter exposed to the elements with no pretense of protection and there is seemingly no anxiety on the part of the owners as to its condition or to the extra expense that will doubtless be entailed in getting the engine in proper condition to run when it is finally put on its foundation in the engine room.

On the other hand, a member of this same company reported one of the engine-room attendants because he had been seen eating a portion of his lunch before lunch time—a horrible waste of time and a financial loss to the company.

Why not be consistent regarding these things? If a watch is kept to guard against the company's losses, why not make it thorough and not stop with the man eating a little lunch before time, while out in the yard an engine costing several thousands of dollars is being injured by exposure to the elements? It is better to look after the source of real losses rather than to waste time reporting petty trifles which in a year's time would not save the renowned "thirty cents."

Explosion on the "Delaware"

Elsewhere in this issue appears a summary of the findings of the board which inquired into the cause of the boiler explosion on the battleship "Delaware." There appears to be no question as to the direct cause of the explosion, as all evidence points to a condition of low water. In this type of boiler, the burning of the lower part of the rear headers would indicate that there was no water whatever in the drum; furthermore, as stated in connection with the report, that water which did flow into the boiler probably passed directly into the inboard headers and tubes. Considering the slow rate at which the boiler was steaming, it would have taken at least half an hour for the drum to have been emptied completely and the question immediately arises: What was the water tender doing all this time?

It is possible that the connections to the gage glass may have been obstructed, although an examination after the accident failed to reveal any obstructions. Even if such were the case, the gage cocks would have shown that the water was leaving the drum. We are told that the water tender was an experienced man and, as such, much confidence was placed in him; nevertheless, the boiler exploded and the water tender should have known that there was practically no water in it. Just why he was not aware of it will probably never be known, but the fact remains: Had less dependence been placed upon the human element and a low-water alarm and fusible plugs been used, it is probable that the low water would have been detected before any damage was done.

The effect of vacuum upon the steam consumption of a turbine is strikingly shown by the reports of a recent test on a one thousand-kilowatt machine in which the consumption increased forty per cent. with a decrease in vacuum from twenty-nine to twenty-one inches.

It is conceded that specialization to the exclusion of general knowledge is a bad thing; nevertheless it is always well to know a little more than the other fellow about some particular subject. This knowledge carries with it a certain amount of independence.

The easiest way to find out whether you are right or wrong is to get down to basic principles and work up from them to the question at issue without thinking about preferences, hobbies or personal interests.

The man who uses his fingers to test the possibilities of a dangling piece of insulated wire belongs in the same ward with the idiots who rock boats and point unloaded guns at people.

Gas-engine lubrication by "splash" from the crank case is in the same class with hot tube ignition, the old tallow cup on steam engines and the high-wheel bicycle.

Have you thought of the engineer as a mechanic who must know more, work longer hours, carry more responsibility, and have much more expected of him than of any other ordinary mechanic, and still get a smaller sum on pay day?

The fireman's temper is one of the best indications of the quality of the coal and the condition of the fire.

Oil is purchased by your company to lubricate bearings of various kinds, not to pour on the floor.

It's rash to wish all the fools were dead. Some of our best friends would be missing and lots of us who remained would have to move down several notches in the scale of merit.

An engineer with a chew of tobacco in his mouth and wearing a full-dress suit doesn't synchronize.

Boiler Explosion in Georgetown, S. C.

On March 4, 1911, boiler No. 3 in plant No. 1 of the Atlantic Coast Lumber Corporation at Georgetown, S. C., exploded, killing three persons and injuring four others. The boiler plant consisted of ten horizontal tubular boilers set in one battery, eight of the boilers being in the boiler house proper and the other two boilers immediately adjoining the boiler house. As a result of the explosion, the center sheet of No. 3 boiler was torn bodily from the boiler and several boilers nearby were displaced and damaged to a greater or less extent. The roof of the boiler house, which was made up of structural-iron trusses covered with corrugated iron, was almost a total ruin. Boilers Nos. 3, 4, 5 and 6 were practically ruined. The side walls of the boiler house, which was a building approximately 93x70 feet, were ruined to a greater or less extent, some of the wall being thrown down bodily, and much of the wall that remained standing must be taken down and rebuilt. A number of pumps, heaters, conveyers, engines, belting, etc., together with a very complete supply of operating materials in the engine room, were destroyed.

Fig. 2. Damage to Steelwork and Stacks

The investigation as to the cause of the explosion appeared to show, according to sworn evidence of a number of witnesses, that the stipulated pressure of 100 pounds had not been exceeded. This fact was also corroborated by the record made by the recording steam gage which showed a pressure of [illegible] pounds at the time of the accident. There was no evidence of burned sheets or of low water. Several pieces of the metal in the boiler were tested by being bent double while cold and showed no sign of fracture. The boiler failed at or near one of the longitudinal seams. Practically all of the fracture or break was not (as is usually the case) through rivet holes, but through the solid metal. There was, however, one section about 3 inches long, torn through the rivet holes. It is possible that there may have been a hidden crack at this point, and this appears to be the only reasonable cause of the accident. This boiler having been built in three courses with two sheets to each course, caused the longitudinal seams to be below the top of the tubes; consequently, it was practically impossible for an in-

Fig. 1. Ruins of Georgetown Explosion

spector to discover a hidden crack in the seam from the inside of the boiler and it was equally impossible to discover the crack from the outside on account of the wall being close to the longitudinal seam.

All of the boilers at the plant had been internally inspected during the Christmas holidays of 1910 and inspections were carefully and conscientiously made, according to sworn statements of the chief engineer and foreman boilermaker at the plant, both of whom were with the inspector during the time the inspections were made.

The boilers were insured with the Ocean Accident and Guarantee Corporation, of 59 John street, New York City, who promptly paid $25,000 in settlement of the loss to property caused by the explosion.

Court Findings in Boiler Accident on "Delaware"

Through the courtesy of the Babcock & Wilcox Company, we are enabled to publish the accompanying summary of the finding of the court of inquiry which investigated the accident to one of the boilers of the U. S. S. "Delaware."

From the short note previously published in POWER, it may be remembered that the accident occurred about 9:15 a.m. on January 17, while the "Delaware" was bound for Norfolk, Va. The ship was proceeding under easy steam, but on account of poor draft the fire rooms were closed and working under an air pressure of ¼ inch. This, under the circumstances, was not more than good natural draft, so that the rate of combustion was about 18 pounds of coal per square foot of grate. The boiler is one of the well known Babcock & Wilcox marine type, with 4425 square feet of heating surface and 103 square feet of grate surface, there being 14 boilers in all. On trial, the "Delaware" developed nearly 30,000 horsepower, so that this boiler when worked under forced draft has a capacity of over 2000 horsepower.

The damage was confined to boiler "O" and the extent and nature thereof are set down in the findings in considerable detail. It is also to be noted that the structure of the vessel was not injured at all, thus emphasizing again the fact that an accident to a water-tube boiler involves the minimum of damage. The boiler was repaired while at Norfolk with some headers and new tubes, most of the work being done by the engineering department of the ship.

There is one point in the finding which needs just a word of explanation to make it perfectly clear. The court finds that only the outboard half of the boiler was damaged. It might seem at first glance as though it would be impossible for one-half of the boiler to be injured and the other escape. The explanation, however, is very simple. The feed water enters the boiler in the steam and water drum, which is above the front headers and connected to them by nipples, and is discharged through an internal feed pipe perforated with holes on its lower side. This pipe extends from the check valve at the inboard end of the drum to a short distance past the center of its length. As long as the water in the drum was above the tops of the nipples mentioned, it would not, of course, make any difference where the feed water was introduced, as it would naturally find its level. In case of low water, however, due to inadequate feed, there might be under moderate combustion, just enough water to save the inboard half of the boiler, where the water would go directly down the nipples, while only a few headers and associated tubes on the other side would get any. This appears to be the explanation of the salvation of the inboard side of the boiler.

With this general statement of the surrounding conditions, the finding of the court should be entirely clear, and it would seem that the court is to be congratulated on the very careful analysis which it has made of all the circumstances of the case, so that the reasons for its conclusion that the accident was due to low water are perfectly evident and convincing.

Finding of Court

"In compliance with the request contained in your letter of February 24, and with the approval of the department, the bureau submits for your information the following general statement of the finding and opinion of the court of inquiry appointed to inquire into the accident to boiler 'O' of the 'Delaware':

"(*a*) An explosion occurred in boiler 'O' January 17, 1911, by which three rear headers Nos. 8, 9 and 10 were blown bodily out of the boiler.

"(*b*) These headers were found severely bowed, their tube faces were bulged, and the metal showed signs of overheating. All the back headers of the outboard half of the boiler, 13 in number, were more or less bowed, the degree of distortion diminishing toward the outboard side of the boiler.

"(*c*) The inboard half of the boiler was uninjured, and consequent comment refers only to the outboard half.

"(*d*) The 4-inch tubes next the fire were all more or less bowed near the back ends, and showed signs of having been burned; and the majority of the 2-inch tubes were more or less distorted, while a number showed signs of having been white hot.

"(*e*) The front headers were in good condition.

"(*f*) The superheater tubes and manifolds showed a red color, and the 4-inch tubes through the first and second passes showed the blue color characteristic of overheating.

"(*g*) On two of the headers blown out were found scores and dents made by the headers striking obstructions. The character of the scores and dents, and the blue color of the metal in the scores, indicated that the metal of the blown-out headers was in a softened condition, due to heat, when they struck.

"(*h*) The three headers showed unmistakable signs of having been very hot. They showed the characteristic blue color following overheating, and the tube face of each had been bulged out by internal pressure, possible only when the metal is heated to a condition approaching redness.

"(*i*) The greatest heat appeared to have existed at about the width of the hight of the header, but the effects of overheating were manifest in all the back headers of the outboard half of the boiler, diminishing either way from the zone of greatest intensity of heat, which appeared to exist opposite the headers that were blown out.

"(*j*) A number of 2-inch tubes of the blown-out headers gave evidence of having been white hot. The surface of these tubes, near the back ends, appeared burned, and was covered with a coating of black oxide of iron. Signs of overheating were also in the outboard half of the drum, from which much of the soot had been burned off.

"(*k*) From a consideration of the preceding facts, the court concluded that the explosion was due to the lack of a sufficient quantity of water in the boiler, and that the water tender on watch at the time was responsible for this condition. This opinion was strengthened by the fact that it was possible to enter the fire room with safety a very short time after the explosion occurred, which would not have been possible had the boiler contained the normal quantity of water.

"(*l*) All testimony showed that the boiler was in good condition prior to the accident, and that the regulations regarding the care and preservation of boilers had been carried out; that other boilers which had been subjected to the same use were in good condition; and that the overheating noted in the injured boiler would have produced the results observed by the court after the accident, no matter how perfect the boiler.

"(*m*) From some testimony before the court, the conclusion was reached that the reading of the water gages was misleading, although the gage glass fittings are recognized as simple and reliable; other testimony, however, led to the opinion that the opening of the feed check valve had been increased shortly before the accident occurred.

Very respectfully,

R. S. GRIFFIN,

Acting Chief of Bureau."

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

The Kennicott Water Weigher

A device for automatically recording the weight of water fed to boilers and correctly ascertaining the evaporation, is the Kennicott water weigher, which is manufactured by the Kennicott Company, Chicago Heights, Ill.

As shown in Fig. 1, the Kennicott water weigher consists of a shell, the lower part of which is divided by a partition into two measuring or weighing compartments. A siphon in each compartment discharges the water when the full-unit charge has been received. A tipping box composed of two halves, which alternately fill with water, serves the double purpose of furnishing a sufficient quantity of water to start the siphons and to shift the supply from one compartment to the other. This tipping box is balanced on pivots, is mounted directly above the weighing compartments, and is operated by floats, one in either compartment.

Fig. 1. View Showing Interior of the Kennicott Water Weigher

Water enters the inlet and passes to the tipping box, where a small portion of it is intercepted, the remainder passing directly to the weighing compartment below. When this compartment is nearly filled, the float tilts the tipping box, thereby automatically spilling the water contained in the tipping box into the compartment, thus completing the unit charge and starting the siphon which discharges the unit charge, while the entering water passes to the opposite half of the tipping box and to the opposite compartment which fills and empties in a like manner.

Fig. 2. Weigher Arranged to Discharge into Storage Tank

A counter registers each double unit charge developed by the weigher, and is so arranged that it cannot be tampered with by unauthorized persons.

This weigher has no valves in its mechanism to leak and cause unreliable records and it has no pistons or revolving disks.

The weigher can be placed to receive water from any source and deliver it in unit charges of uniform weight into any available storage tank or hotwell and, when weighing boiler feed water, the feed pumps take the water from the storage tank. This arrangement is shown in Fig. 2.

This weigher is also furnished complete with storage tank and balanced pressure inlet valve, as shown in Fig. 3. The balanced pressure valve is controlled by a ball float in the storage tank which automatically regulates the supply to meet the varying demands of the plant,

Fig. 3. Weigher and Attached Storage Tank

and insures that the storage tank is always full of water.

Each weigher receives an individual test and calibration. The unit charges are accurately weighed on platform scales, and a certificate of accuracy and capacity is sent with each shipment. The weigher is guaranteed to record the correct weight of water to within one-half of one per cent. of absolute accuracy.

Besides weighing boiler feed water, this weigher will accurately weigh or measure any free-flowing liquid, hot or cold.

Automatic Engine Stop

This mechanism has been designed to prevent flywheel accidents due to the engine racing or running away, and also enables the possessor to stop the engine from any desired point in the shop.

It consists of a valve of the Corliss type which is so balanced as to be practically frictionless. Fig. 1 shows a front head of the valve on which is mounted a solenoid, a valve lock or disengaging arm and a valve lever. Fig. 2 shows an interior view of the valve when it is in its open position. The face of the valve is turned on one center and the stem on which it rotates is offset so that the valve does not touch the face of the seat except when it is closed. By means of this eccentric motion of the valve, in relation to its seat, friction between the valve seat and face has been eliminated, and there is no chance of the valve sticking and refusing to operate. Fig. 3 shows the automatic spring-switch trip arrangement, and Fig. 4 is a wiring diagram.

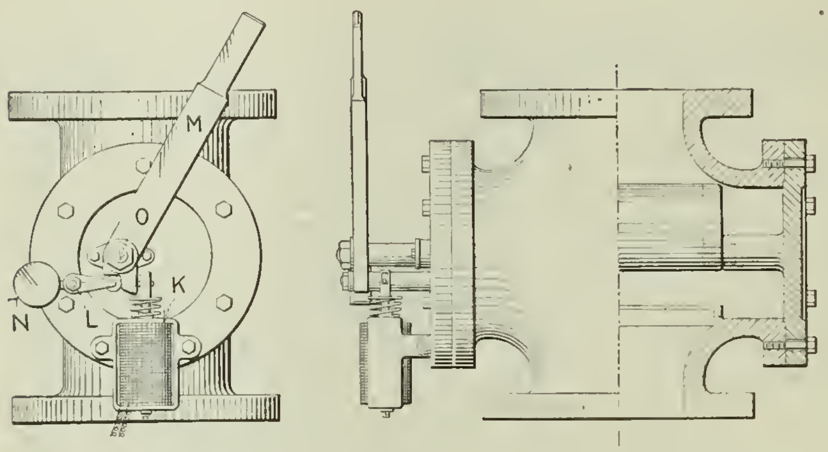


Fig. 1. End and Side View of the Detaching Device

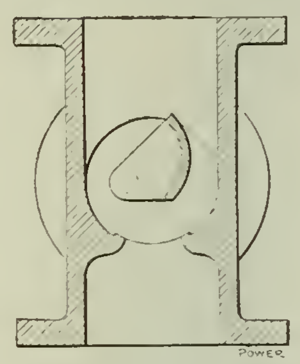


Fig. 2. Sectional View of Valve and Seat

Either batteries or regular line current can be used if desired.

The operation of this mechanism is as follows: *P*, Fig. 4, is the solenoid mounted on the front head of the valve; *R* is the automatic spring switch and *S S S* are shop switches for emergency use.

Referring to Fig. 3, *B* is a bracket fastened to the engine shaft *A* and supports the weight arm *C*, which turns on the pin *D*. The centrifugal force exerted by the shaft turning in the direction indicated by the arrow will throw the arm *C* out and away from the shaft. The distance this force will cause the arm to move out is regulated by the resistance of the spring *E*. At normal speed the spring is set to hold the arm *C* tight against the shaft *A*, but any increase of speed will cause the centrifugal force to overcome the spring resistance and allow the arm to move out so that the point *F* will describe a larger circle until it comes in contact with the pin *G*, forcing it down and thus releasing the spring knife switch *J*. This closes the electric circuit, as will be seen by glancing at the wiring diagram in Fig. 4.

When the circuit is closed, either by the increased speed of the engine or by throwing in one of the shop switches, the solenoid *K* is energized, which causes it to draw the plunger down, hitting the disengaging arm a hammer blow, causing it to turn on the pin *L* and disengaging the roller, shown in Fig. 1, from con-

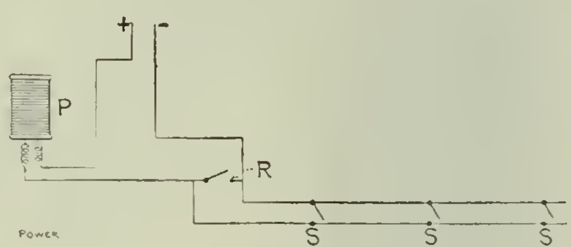


Fig. 4. Diagram of Wiring

tact with the nose of the lever *M*. This disengaging arm is afterward brought back to its normal position by the counterweight *N*. The valve lever *M* is attached to the valve stem *O* and when one of the switches is closed the valve and lever will drop, shutting off the steam and stopping the engine.

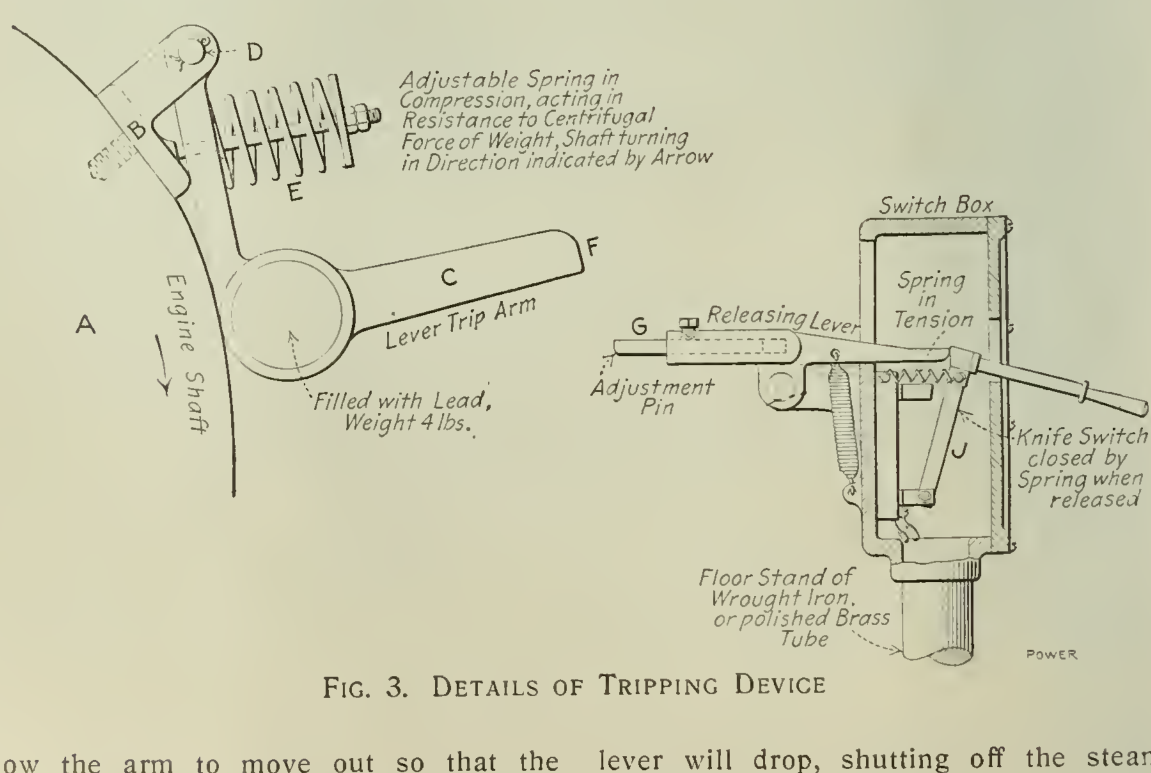


Fig. 3. Details of Tripping Device

This apparatus is made by the Automatic Engine Stop Company, Sheboygan, Wis.

A Vacuum Ventilator

As the name implies, the principle upon which this ventilator operates is due to a vacuum formed in the hollow ball of the ventilator. This ball is placed on the top of a vertical outlet and serves the purpose of drawing out the foul air, gases, etc., from the room to which it is attached.

In operation, the wind strikes the ball, which has an opening as shown in Figs. 1 and 2. As the wind passes over this opening it sucks out the air which is in the ball and causes a partial vacuum. The air in the building or room below, being under normal pressure of the atmosphere, is forced up to take the place of that which has left the ball, the process becoming continuous, and results in a strong, steady updraft as long as there is any movement in the outside atmosphere.

Fig. 1. How it Works

Fig. 1 shows how this is accomplished. The wind velocity is represented by the figure. Air is blown against the ball and the particles shown in the tube between the stand and the ball represent the upward current of the air. Fig. 1 represents a model that has been made for the purpose of demonstration. A person blowing against the ball is able to draw particles of paper, fine cloth or anything that is of a light material up through the tube and out through the opening in the ventilator head.

Fig. 2 shows a sectional view of the ventilator. It will be noted that the head is made in the shape of a sphere and the rounded surface is presented to the wind no matter from what quarter it blows and divides the current of air which passes over the outlet space with the result described.

The hood is provided with a shield which protects the vertical outlets and keeps rain and snow from getting into it and also keeps the ventilator free from downdrafts. It is so situated that the offset is enough to allow free egress of the heated air and free and easy access of the wind to the outlet.

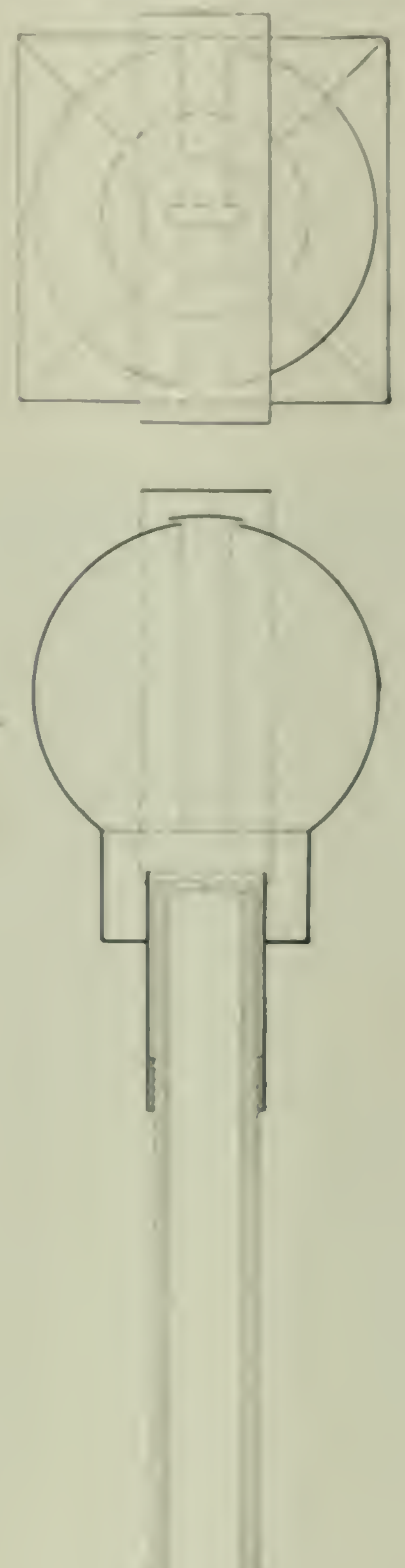


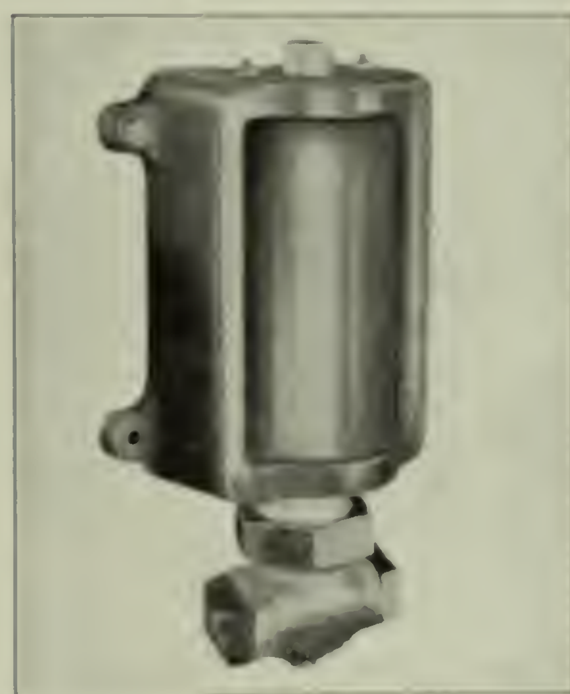
Fig. 2. Details of Construction

These ventilators can be placed in such position that the wind has full sweep around them, or they may be so located that the wind will come directly down on top of them. Either arrangement will give satisfactory results.

There are only four parts which enter into its construction: the barrel or neck, the diameter of which determines the size of the ventilator, the two hemispherical shells, between which are the vertical outlets and the shield. There are no mechanical parts or movements to get out of order. It is made by the Vacuum Ventilator Company, 84 Purchase street, Boston, Mass.

Solenoid Operated Valve

There is usually considerable difficulty in attempting to start a double-acting compressor because of compression and it is in the function of an unloader that the new solenoid-operated valve recently developed by the Cutler-Hammer Manufacturing Company, of Milwaukee, has found employment. The arrangement consists of a bypass automatically operated by this solenoid valve, which permits the pressure to be released from the compressor cylinder, thereby preventing compression. When the desired speed has been reached the bypass is automatically closed, allowing the loading of the compressor.



Solenoid-operated Valve

It will be noted by referring to the accompanying illustration that the construction is such as to permit placing the solenoid plunger inside the piping system, thus eliminating entirely stuffing-box friction. The energizing of the magnet coil, for which only a small current is required, lifts the solenoid plunger through a short free travel, operating the valve by a hammer blow. After the valve is started the pressure becomes nearly balanced. The coil circuit can be run wherever desired so that the valve can be operated from any location or series of locations, according to the arrangement.

These devices are also applicable for many functions in hydraulic or pneumatic systems; with self-starters, for remote control of valves used for setting the brakes of a pneumatic-brake control set.

tem, etc. When arranged with a thermostat in a heating system they can be made to automatically control the flow of steam as desired. In signal systems where air-operated whistles are used these valves save piping and enable the ready control from a central location.

Four standard sizes of valves are built: ⅜, ½, ¾ and 1 inch, threaded for standard iron pipe and having an area of opening approximately equal to that of pipe of the same rated size. The solenoid coils used are wound for voltages of 115, 230 and 500, being the standard Nos. 3, 5 and 6 Varley coils.

Boiler Explosion at Augusta, Ga.

By S. Kirlin

A 40-horsepower upright boiler used for pumping out a cofferdam and operating a pile driver on the work being done on the Southern Railway bridge at Augusta, Ga., exploded at about 4:30 a.m. on March 23, instantly killing two negroes and fatally injuring two white men.

The body of one of the negroes was blown to atoms and no part of it has been found. The other one was almost completely blown to pieces, but was found later in the cofferdam. W. A. Vowell, the superintendent of the work, from Columbia, S. C., was badly crushed and scalded and is thought to be fatally injured. D. C. White, night foreman, was scalded all over the body and it is not thought that he can recover. He was standing on the platform on which the boiler was set and was blown over into the cofferdam, from which he was removed shortly after the explosion occurred.

All of the men were working around the boiler at the time and it is said that they were trying to get the injector started. It is supposed that the water was low in the boiler and that the explosion occurred when they succeeded in getting the injector to working. Not a trace of the boiler or engine can be found, so that it is impossible to form any correct idea as to the exact cause of the explosion. It is said that a part of the boiler was blown several hundred feet into the air, passing over the top of the bridge and falling into the river below.

The accident seems to have been very similar to the one with the same type of boiler which exploded in the Ideal laundry at Verona, Penn., a description of which was given in the issue of March 14.

A fire in the plant of the Cohannet Silver Company, Taunton, Mass., on March 22 caused considerable damage in the boiler room. The fire started in another part of the building and caused a total loss of about $45,000.

Peat Society Meeting

The New York section of the American Peat Society held its regular quarterly meeting on Tuesday evening, March 21, at the rooms of the Chemists' Club in West Fifty-fifth street, New York City. Dr. Charles F. McKenna, chairman of the section, introduced Prof. Charles A. Davis, peat expert for the United States Bureau of Mines, who gave one paper entitled, "Late Developments in the Peat Industry" and another, entitled, "Drainage of Peat Deposits."

By way of introduction, Professor Davis spoke briefly of the work of the Bureau of Mines in connection with the development of the peat industry. Up to the present time the work has been largely educational. This has been the result of the lack of facility for accomplishing material progress in experimental work.

In his first paper, the Professor described in outline the various processes of digging and preparing peat that so far have been employed.

In his second paper, he told of the ways in which peat bogs are drained, of the difficulties to be contended with and of the difference in drainage requirements of bogs yielding peat for fuel and those yielding peat for filler and other purposes.

National secretary Julius Bordollo announced that the annual convention of the society would be held in Kalamazoo, Mich., late in September. An interesting program is being prepared.

Steam Pipe Explodes in Amoskeag Mills

On March 27 the blowing out of the "dead end" of a 12-inch steam pipe in the new power plant of the Amoskeag Manufacturing Company, of Manchester, N. H., killed two men and seriously injured seven more, according to reports published in the daily press. Full particulars will be given in an early issue.

PERSONAL

David Moffat Myers, consulting engineer, New York City, has moved to larger offices in the New Whitehall building, 17 Battery place.

George Alfred Goodenough, for many years associate professor of mechanical engineering of the University of Illinois, has been promoted to be professor of thermodynamics.

Bernard L. Walsh, chief engineer for the Woonsocket, R. I., Electric Machine and Power Company, has tendered his resignation. He will be succeeded by Everett Read, of East Bridgewater, Mass.

Cornelius T. Myers, formerly assistant secretary and assistant treasurer of the Wisconsin Engine Company, of Corliss, Wis., has now opened consulting-engineering offices at Racine, Wis.

John B. Perkins, president of the John B. Perkins Company, of Boston, and F. P. Sheldon, M. E., of Providence, left on Saturday, March 25, for a visit to Cuba, Jamaica, Porto Rico and the Bermudas.

Prof. W. F. Schaphorst, of the mechanical-engineering department of the New Mexico College of Mechanic Arts, has resigned his position there to become a technical writer on the staff of A. Eugene Michel, advertising engineer, New York City.

Charles Russ Richards, dean of the college of engineering of the University of Nebraska, has been appointed professor of mechanical engineering in charge of the department at the University of Illinois, effective September 1, 1911. Professor Richards has been identified with the University of Nebraska in various capacities for the past 20 years and has been largely instrumental in organizing and equipping this university for mechanical-engineering study.

George A. Orrok, of the New York Edison Company, visited the University of Wisconsin on March 16 and addressed the student section of the American Society of Mechanical Engineers on the subject of "The Utilization of Blast Furnace Gases, with Especial Reference to Gas Engines." Mr. Orrok dealt with the problem of the blast furnace involving the utilization of its waste gases, and showed the historical development of different means of utilizing these gases. The latter part of the lecture included a brief description of the latest types of blast-furnace gas engines, and was very copiously illustrated by lantern slides.

SOCIETY NOTES

The American Institute of Steam Boiler Inspectors annual meeting and election of officers will be held at the Parker house, Boston, Tuesday, April 25, at 8 p.m.

Under the auspices of the power-transmission section of the National Electric Light Association, a public conference will be held in the United Engineering Societies building, New York City, on Saturday, April 8, to consider the important subject of the relation of the National and State governments to the conservation and utilization of water powers. This subject is one, not only of vital concern to the central-station industry, but affects in many ways the conditions of engineering, the employment of labor and capital, and the welfare of the public. Two sessions will be held, afternoon and evening, and papers and addresses will be delivered by several well known men.

On March 16, the New York Electrical

Society celebrated its three hundredth meeting. F. O. Blackwell lectured on "Hydroelectric Development in Mexico." In opening the lecture, Mr. Blackwell gave an interesting sketch of the causes which have led up to the present conditions in Mexico, giving to the enlightened and progressive policy of President Diaz, the credit for the wonderful developments in hydroelectric installation effected in recent years. The society had a short business meeting, at which reports of committees were received. The treasurer reported that the heavy load of debt which the society had incurred during the last few years, in its endeavor to develop its work and increase the advantages of its membership, has been paid off, and the finances are now in a prosperous condition. Twenty-eight members and thirty-two life members were elected. The society now has over eight hundred members.

NEW PUBLICATIONS

Scientific American Cyclopedia of Formulas. Compiled and edited by Albert A. Hopkins. Published by Munn & Co., New York City, 1911. Cloth, 1000 pages, 6½x8¾ inches; 200 illustrations. Price, $6.50 net.

This is the latest and probably by far the most complete work of this kind issued. It was compiled by the query editor of the *Scientific American* and contains some 15,000 recipes, formulas and processes selected from a collection of nearly 150,000. There are chapters treating upon soldering, soap and candles, preserving, painting and photography; lapidary art, leather and lubrication; confectionery, glass making and metal working, beverages, alloys and amalgams, beside some hundreds of other topics, many of which are of the odd, out-of-the-ordinary type, relating to little known technical products. A complete index prepared by professional librarians makes it an easy matter to find any subject desired.

"The Strength of Oxyacetylene Welds in Steel," by Herbert L. Whittemore, has just been issued as Bulletin No. 45 of the engineering experiment station of the University of Illinois. This bulletin gives the results of an extensive series of tests to determine the strength which may be developed in welded joints made by fusing thin steel plates together by means of the flame of an oxyacetylene blowpipe. It was found that with careful manipulation such a welded joint may be expected to have about 85 per cent. of the strength of the plate material. Considerable information as to methods of manipulation of the oxyacetylene blowpipe and the proper regulation of the gases is also given in the bulletin. Copies may be obtained gratis upon application to W. F. M. Goss, director of the engineering experiment station, University of Illinois, Urbana, Ill.

OBITUARY

Charles Wallace Hunt, president of the C. W. Hunt Company, of Staten Island, N. Y., and former president of the American Society of Mechanical Engineers, died at his home on March 27. He was born at Candor, Tioga county, N. Y., in 1841. He studied at Cortland academy, Homer, N. Y., and subsequently received instruction in mechanics and higher mathematics under a private tutor. At the time of the war between the States, he joined the army on the Northern side and served from 1862 to 1865, chiefly in Virginia, undergoing hardships from which his health, for a while, considerably suffered.

The Late C. W. Hunt

Entering readily into mechanical pursuits, he engaged, in 1872, in the manufacture of special machinery on Staten Island, N. Y. His plant has since attained great importance in its province—appliances for handling materials in large quantities. There was such novelty in this branch of mechanics when he took it up that his work partook of a pioneer character. The various special devices he put out were designed to meet actual, definite exigencies. The patents of the business run into hundreds and its ramifications extend to conveying and hoisting machinery for ore, coal, etc., cableways, industrial railways, manila rope and kindred lines.

Mr. Hunt was president of the American Society of Mechanical Engineers, 1897 to 1898, having been for several years before that time chairman of its Committee of Publications. He was also a member of many other societies, such as the American Institute of Mining Engineers; New York Electrical Society; Engineers' Club, of New York; National Science Association, and New York Chamber of Commerce. He had been president of the Staten Island Chamber of Commerce and of several manufacturing companies both auxiliary to his main business, the C. W. Hunt Company, and otherwise.

William Carpenter Woodward, for the past 18 years electrical engineer of the Narragansett Electric Lighting Company of Providence, R. I., died in that city Saturday afternoon, March 25, as a result of cerebral hemorrhage. He had been in poor health since last August and had not worked since that time. Mr. Woodward gained his first experience in electrical work with the General Electric Company, and later with the Standard Electric Company, of Boston. He had entire charge of the electrical-engineering department of the Narragansett company, and it was he who adapted the high-voltage system now in use in Providence. He was born in Roxbury, Mass., about 50 years ago. A son will be graduated from the Naval Academy at Annapolis this year.

The power equipment of the M. S. Novelty Company's factory in Providence, R. I., was destroyed by fire on March 22. The fire started in some chemicals near the engine room, and Engineer B. T. Edwards barely had time to open the injector and fire doors of the boiler and shut off the gage cocks and get out of the building. The equipment included a 35-horsepower Nagle engine and an upright 35-horsepower boiler.

The boiler room of the Woonsocket, R. I., Dye and Bleaching Company's mill was damaged to the extent of about $500 by a fire on Thursday night, March 9.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

POWER GENERATOR. William J. Neilson, Elmhurst, N. Y., assignor to himself, and Leland H. Kimball, Salt Lake City, Utah. 987,158.

CONSTANT-PRESSURE INTERNAL COMBUSTION APPARATUS. Edward P. Noyes, Winchester, Mass. 275,861.

ENGINE. Daniel R. Scholes, Chicago, Ill., assignor to Aermotor Company, Chicago, Ill., a Corporation of Illinois. 987,177.

OIL ENGINE. Hermann Bowyer Leech, Halifax, England. 987,246.

COMPOUND ROTARY ENGINE. Lucas K. Sivertson, Carrington, N. D. 987,264.

ELASTIC-FLUID TURBINE. Berthold Wolff, Berlin, Germany. 987,336.

ROTARY EXPLOSIVE ENGINE. James C. Peterson and Robert T. Peterson, Gleichen, Alberta, Canada. 987,486.

WINDMILL. John O'Toole, Colegrove, Cal. 987,645.

WINDMILL. William P. Bennett, Woodstock, Ohio. 985,131.

POWER WHEEL. Walter H. Fierce, Atlantic City, N. J. 985,152.

ROTARY ENGINE. Stephen E. McGann, Cleveland, Ohio. 985,192.

INTERNAL COMBUSTION ENGINE. Alden E. Osborn, New York, N. Y. 985,198.

INTERNAL COMBUSTION ENGINE. Andrew Betts Brown, London, England, assignor to William Albert Hickman, Pictou, Canada. 985,507.

ROTARY ENGINE. Reece Williams, Albany, Western Australia, Australia. 985,562.

ROTARY ENGINE. David N. Green, Sunbury, Ohio. 985,584.

ROTARY ENGINE. David Newton Green, Sunbury, Ohio. 985,669.

INTERNAL COMBUSTION ENGINE. Henry Joseph Podlesak, Chicago, Ill. 985,703.

BOILERS, FURNACES AND GAS PRODUCERS

MECHANICAL STOKER. Wilfred Rothery Wood, London, England, assignor to the American Stoker Company, Erie, Penn., a Corporation of New York. 987,661.

BLACK-OIL BURNER. James Warren Elder, Visalia, Cal. 987,617.

BOILER. George Peterson, Duluth, Minn. 985,281.

LIQUID-FUEL BURNER. Henry W. Schoff, River Forest, Ill. 985,291.

FURNACE. Henry E. Wallis, Terre Haute, Ind. 985,480.

LIQUID-FUEL BURNER. John Jay Vallier, Oakland, Cal. 985,644.

POWER PLANT AUXILIARIES AND APPLIANCES

FLUE PLUG. Silas Adams, Cleveland, Ohio. 987,099.

COMBINED WATER, VACUUM AND PRESSURE GAGE, AUTOMATIC REGULATOR AND SAFETY DEVICE. William T. Fowden, Chester, Penn. 987,125.

VALVE MECHANISM FOR INTERNAL COMBUSTION ENGINES. Alden E. Osborn, New York, N. Y. 987,164.

STUFFING BOX. John Hahn, Los Angeles, Cal. 987,296.

VALVE. William J. Theis, Chicago, Ill., assignor to Manufacturers Equipment Company, a Corporation of Illinois. 987,334.

STAY BOLT FOR STEAM BOILERS. Patrick J. Connors, Greenville, Penn., assignor of one-half to Frank Disler, Greenville, Penn. 987,431.

BOILER-FLUE CLEANER. William Eichelberger and De Los E. Hibner, Dubois, Penn., assignors to the Vulcan Soot Cleaner Company, of Pittsburg, Penn., Dubois, Penn., a Corporation of New Jersey. 987,450.

VALVE. Edward Dwyer, Clymer, Penn. 987,447.

VALVE. Robert Charles Green, Winchester, England. 987,571.

PRESSURE AND DAMPER REGULATOR. John B. Bischoff, Mount Clemens, Mich. 987,610.

AIR-LIFT DISPLACEMENT PUMP. Frank S. Miller, Indianapolis, Ind. 987,679.

VALVE. Vincent F. Bernesser and Joseph J. Crotty, New York, N. Y. 985,134.

VALVE. Axel Valdemar Clorius, Copenhagen, Denmark. 985,146.

SAFETY VALVE. Nelson Goodyear, New York, N. Y., assignor to Maine Development Corporation, a Corporation of Maine. 985,160.

VALVE. Willard A. Speakman, Wilmington, Del. 985,220.

STEAM TRAP. Joseph B. McKeown, Union Hill, N. J. 985,362.

VALVE. Franklin M. Patterson, Philadelphia, Penn., assignor, by direct and mesne assignments, to Patterson-Allen Engineering Company, a Corporation of New York. 985,444.

VALVE. George W. Hammond, Philadelphia, Penn., assignor of one-half to John H. Michener, Jr., New York, N. Y. 985,526.

PACKING FOR VALVES. Caspar W. Miller, Wallingford, Penn. 985,618.

ELECTRICAL INVENTIONS AND APPLICATIONS

ALTERNATING - CURRENT ELECTROMAGNET. David L. Lindquist, Yonkers, N. Y., assignors to Otis Elevator Company, Jersey City, N. J., a Corporation of New Jersey. 987,146.

ELECTRIC IGNITION SYSTEM FOR EXPLOSION ENGINES. Oliver B. Thompson and Carl R. Moeller, Buffalo, N. Y. 987,188.

ELECTRIC SWITCH. Oliver B. Whipple, Saginaw, Mich. 987,200.

ELECTRICAL SYSTEM OF DISTRIBUTION. Albert S. Hubbard, Belleville, N. J., assignor to Gould Storage Battery Company, a Corporation of New York. 987,301.

ELECTRIC INDUCTION FURNACE. Wilhelm Rodenhauser, Volklingen-on-Saar, Germany, assignor to the Grondal Kjellin Company, Ltd., London, England. 987,404.

ELECTRIC WATER HEATER. Herbert N. Riche and William Ruth Ray, San Francisco, Cal., assignors to Thomas B. Gray, San Francisco, Cal. 987,493.

SNAP SWITCH. Samuel Korf, Chicago, Ill., assignor to the Wi-Ko Electric Company, Chicago, Ill., a Corporation of Illinois. 987,581.

ELECTROLYTIC CELL. Victor E. Goodwin, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 987,622.

PRIMARY BATTERY. Charles B. Schoenmehl, Waterbury, Conn. 987,647.

TUNGSTEN INCANDESCENT LAMP. John J. O'Brien, Shamokin, Penn. 987,483.

ELECTRIC HEATER AND STERILIZER. Johann G. Wallmann, Oakland, Cal. 987,658.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City. Spring meeting in Pittsburg, May 30 to June 2.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York. Next meeting in New York City, May 29 to June 2.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Commander U. T. Holmes, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., O. P. Chamberlain; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill. Meeting first Wednesday of each month.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., Walter Riddle; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Pres., R. P. Bolton; sec., W. W. Macon, 29 West Thirty-ninth street, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio, September 12-15, 1911.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June 5-10, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting at Detroit, Mich., January 15-19, 1912.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION.

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May 23-26, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

POWER

NEW YORK, APRIL 11, 1911

THERE are many kinds of pessimist (which is the parlor substitute for such terms as "croaker," "calamity howler," "grouch," etc.)

First, there is the amateur. His case is seldom hopeless if treated properly in the early stages. The primary cause is usually a languid liver or some other temporary physical failing. When a person is troubled in this way, even a slight run of hard luck may serve to put him in the dumps of despair. But, a liver pill or a spring tonic soon re-establishes his mental equilibrium and he gets safely over his distemper.

Then, there is the professional—the chronic kicker. You can depend upon him to ferret out an excuse for complaint every time and to make the best possible use of it when he does. To express it mildly, the habitual howler is a nuisance and sometimes even a positive danger.

The amateur pessimist usually thinks that the trouble is with himself; the professional is positive that it is with the world.

If you tell old "Steady Grouch" of some pet project you have in mind or of some ambition you hope to be able to realize by dint of hard work, he will see instantly a thousand things to thwart you and will knock a lot of enjoyment out of telling you how impossible it is for you to realize your "dreams" as he probably would call them.

Optimism is an asset. Perhaps faith is a better name for what we mean—faith in ourselves, in our own ability, in our friends, in our assistants and in the man "higher up."

During the late lamentable "financial stringency" one of the "foolish" papers "did" the cleverest thing. Just at the time when all of us were dragging our weary selves around with the fear of rank ruin written in every wrinkle of our faces, *Judge* came out with a full-page cartoon which "hit off" the condition of the business world to the "queen's taste." The picture showed a group of men standing about looking at a cake—a circular doughnut, to be perfectly frank with you. One member, rotund and jovial, was urging the others to keep their eyes on the doughnut and not to mind about the hole. Good, wholesome advice, that, and well worth practising right along.

It doesn't do anyone a bit of good to think so hard about the hole in his cake that he forgets to eat and enjoy the cake itself. Not only is such practice bad for the man himself but it also has a bad effect upon those with whom he comes in contact. Deny it though you may, the fact remains that all of us are strongly influenced by our companions and our environment.

By the same token, then, each of us has his influence on his companions. Keeping this in mind, is it not more profitable to be a "booster" than a "knocker"? We guess yes.

After all, this is a good old world and right down in our hearts we're glad we're here. This being so, why not mention the fact now and then to someone who seems to have forgotten it temporarily?

Gas Engine Waste Heat to Turbine

By Edwin D. Dreyfus*

> *The economies to be effected by running low-pressure steam turbines in connection with gas engines are considered, as influenced by investment as well as by heat recovered. The turbine may be designed to use steam of two pressures, a primary supply at from one to three atmospheres generated by the heat of the gases and a secondary lower pressure supply derived from the jacket water and introduced at later stages.*

Composite power plants containing independent sections of steam turbine and gas-engine generating equipment have heretofore been shown to establish a very economical arrangement for the production of electrical energy from stores of latent heat. As observed, this plan would prove of advantage for swinging loads and low load factors—the gas-power division to be operated constantly near normal capacity and the fluctuation and peaks absorbed by the steam installation.

It is patent that gas engines rapidly decline in efficiency on loads less than 50 per cent. of their rating and, moreover, their greater first cost generally demands a large output to reap commensurate returns on the investment.

The high thermal efficiency of the gas engine is well known, but the large steam turbine has also developed remarkable economies so that the internal-combustion motor only excels in the moderate and small units.

When the combining of turbines and gas engines in a single station was first proposed, it was with the intention of using high-pressure steam, requiring the installation of boilers, stokers and additional coal-handling machinery, which entails greater labor expense and standby losses. It was suggested at that time, however, that the gas-engine waste heat be applied to the feed water of the steam section.

Since the advent of the low-pressure turbine, it has become feasible to economize the waste heat of the gas engine in exhaust heaters and utilize the energy directly in the turbine without the introduction of high-pressure boilers and coal-burning furnaces in the plant. Furthermore, the heat so conserved may be stored in large tanks, analogous to the system outlined by A. M. Hunt in the April, 1910, *Proceedings* of the American Institute of Electrical Engineers, for high-pressure operation in emergency stations, and used in bulk for peak demands.

Based upon the actual performance of the component elements of such an amalgamated plant, the following results may be readily achieved:

For Continuous Operation

(*a*) Employing the exhaust heat only, 6 to 8 per cent. heat saving over the existing economy of the gas engine.

(*b*) Abstracting heat from both the engine exhaust and jackets, 10 to 14 per cent.

For Peak Load Operation

(*a*) Storing heat from the exhaust over periods several times the duration of the peak, enables heavy overloads to be sustained, resulting in appreciable reduction in investment for the maximum demand, 15 to 30 per cent. normally, in addition to the fuel saving.

(*b*) Operating with intermittent storage, the variable swings may be loaded on the turbine and the engine and producers operated under the most favorable conditions. Ultimate improvement about 15 per cent. in heat consumption and a reduction of 12 per cent. in investment. Moreover, the auxiliary low-pressure turbine would act as a reserve unit to relieve, partially or fully, any temporary embarrassment of the engine.

*Commercial engineer of the Westinghouse Machine Company.

Heat Storage

If a widely changing load should be experienced, providing a *low loading factor*, the installation of the auxiliary plant for continuous operation may likely prove inadvisable, as the fuel expense may bear only a small relation to the total cost. But by accumulating the primary waste heat in a storage system and utilizing it in a simple and comparatively inexpensive low-pressure turbine auxiliary, this arrangement will lend itself to reducing the burdensome capital charges.

The conditions where the auxiliary low-pressure turbine may be profitably installed, may be divided mainly into two classes:

Case I. Low-pressure turbines operating continuously with uniform load on the plant, as exists in most industrial works.

Case II. Widely varying load on the plant, with the low-pressure turbine in conjunction with a heat-storage system, serving only the peak swings of the load. (a) Fixed peaks, as in central lighting stations; (b) irregular peaks, such as occur on an interurban railway with infrequent service.

Uniform Plant Load

The value of a waste-heat power installation for steady service may be readily appreciated; and the accompanying general layout, Fig. 1, shows the principal elements of the plant.

From a practical standpoint, it would not be warrantable to employ for *continuous operation* a smaller low-pressure turbine auxiliary system than 150 kilowatts, which would serve a 1400-kilowatt normally rated engine plant.

The low-pressure turbine system will cost $45 to $60 per kilowatt installed, the smaller size naturally being the larger in unit cost. A four-unit gas plant would represent an investment of $130 to $140 per kilowatt with units 300 to 500 kilowatts in size. The entire plant unit cost will be reduced about 6¾ per cent., which will, in itself, not greatly affect the cost of a kilowatt-hour generated.

Where the price of fuel is a serious factor in a plant, such an installation as that outlined may commend itself.

Peak-load Operation

Gas engines have very limited overload capacity in addition to suffering greatly in economy on the light loads. Their initial costs also produce high fixed charges on low load factors. This auxiliary system, using heat storage, should prove decidedly beneficial if not a complete panacea for these ills. A tank is provided as indicated by dotted lines in the lower left-hand corner of Fig. 1 and as no use would ordinarily be made of the jacket heat in this case the low-pressure boiler *D* of the first case would be eliminated. Obviously, the size of the low-pressure turbine unit would be affected by the extent and duration of the station peak.

On the basis of employing the exhaust heat only, and figuring storage efficiency at 85 per cent., the loss being due to radiation, the percentage of overload that may be obtained above the normal rating of the plant, is plotted in Fig. 3 a. For example, if a three-fourths hour peak is to follow six hours full-load operation, the overload capacity the plant would be capable of sustaining would be 60 per cent.

As it is unusual in commercial operation for full load to obtain for a period of six hours preceding the time of maximum demand on the plant, Fig. 3 b has been included so the approximate entire overload capacity for varying average fractional-load operation may be

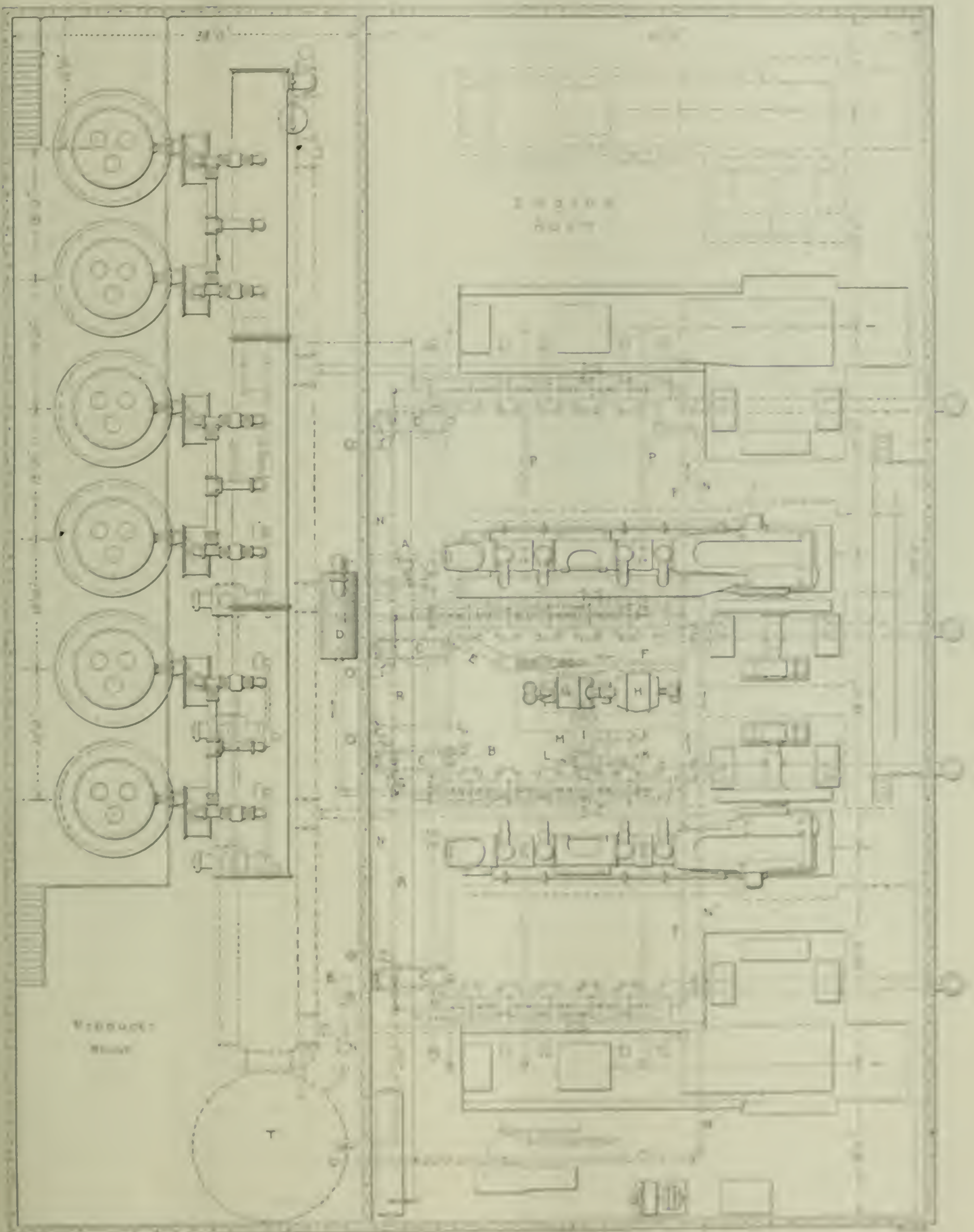


Fig. 1. General Layout of a Waste-heat Power Installation

A. Jacket water circulating pump.
B. Exhaust boiler feed pump.
C. Cast-iron exhaust header.
D. Low temperature boiler.
E. Secondary steam line.
F, [illegible] and G. [illegible]
H. Low-pressure turbine.
M. Generator.
L. Jet condenser.
N. Condenser injection pipe.
S. Condenser discharge pipe.
R and [illegible]
P. Jacket-water circulating system.
T. Storage tank.

readily derived graphically from Fig. 3 a. For illustration, if the plant had been running at three-quarters load for six hours and was to sustain a three-fourths hour peak, it will be found from Fig. 3 a that 60 per cent. overload could be sustained by the turbine. Taking, then, the 60 per cent. vertical ordinate and extending it horizontally to the 75 per cent. load diagonal, Fig. 3 b, 55 per cent. is obtained—this value including the 10 per cent. overload capacity of the gas engines. For other conditions, manifestly the same course is to be pursued. It is to be observed that the percentage of peak to be determined in each case represents the average of the period over which the low-pressure turbine operates. The maximum will therefore undoubtedly exceed the values given, especially if the maximum swing occurs during the first half of the time so that the tank temperatures will not be too low to operate the turbine on overloads. For peak-load conditions, plants as small as 500 kilowatts in engine capacity, may well include the byproduct power system.

These charts, therefore, facilitate the predicting of possibilities for any combination of conditions, but each individual case should be treated specially to definitely prove its merits.

The actual gain in fuel economy in this system will depend upon the true nature of the load curve. Where a peak of steep character and of very short duration occurs frequently and at indefinite times, the improvement in operation may be 15 to 25 per cent., as the engines will not have to be run underloaded normally so as to sustain the heaviest swing. With a widely changing load, as in some interurban railway systems, sufficient time may not elapse for adequate heat storage between peaks.

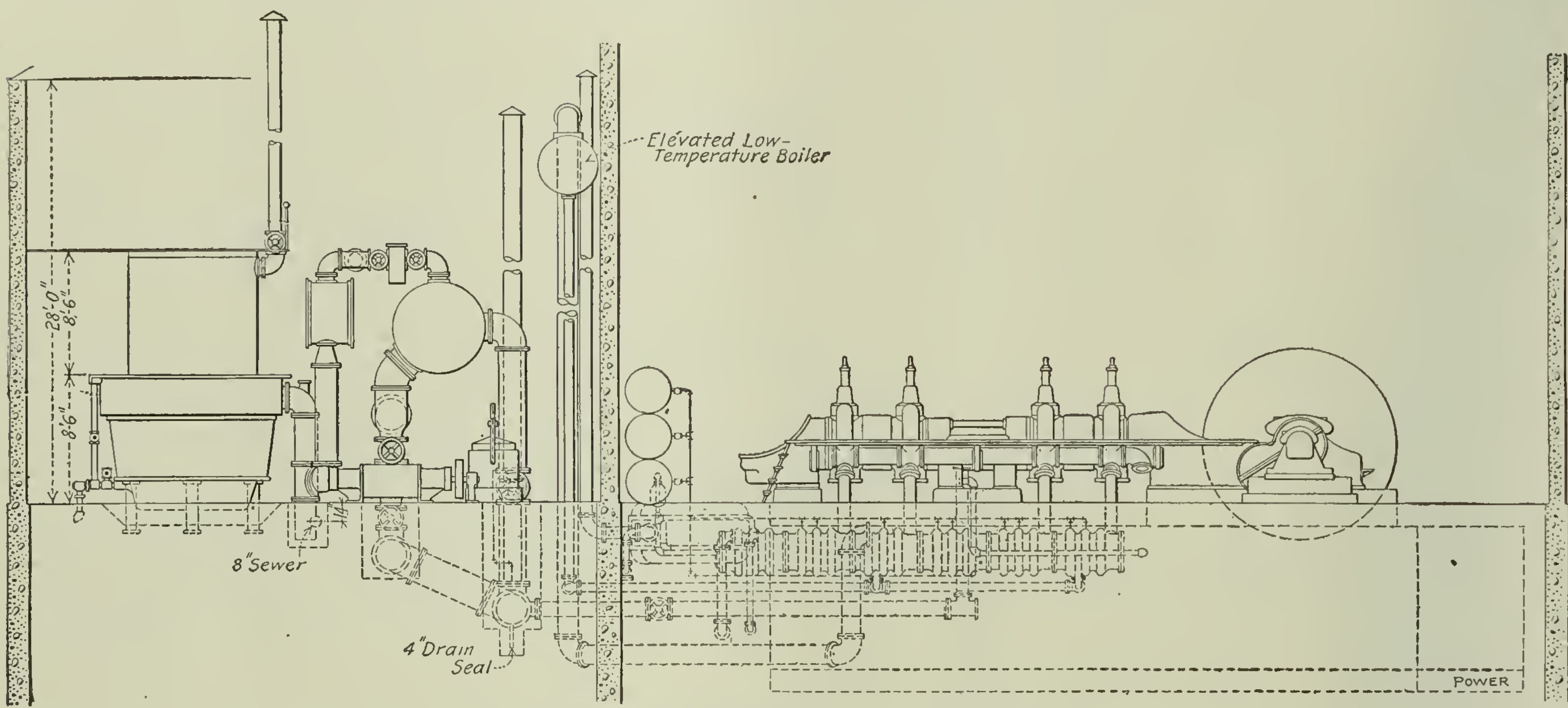


Fig. 2. Sectional Elevation through Plant

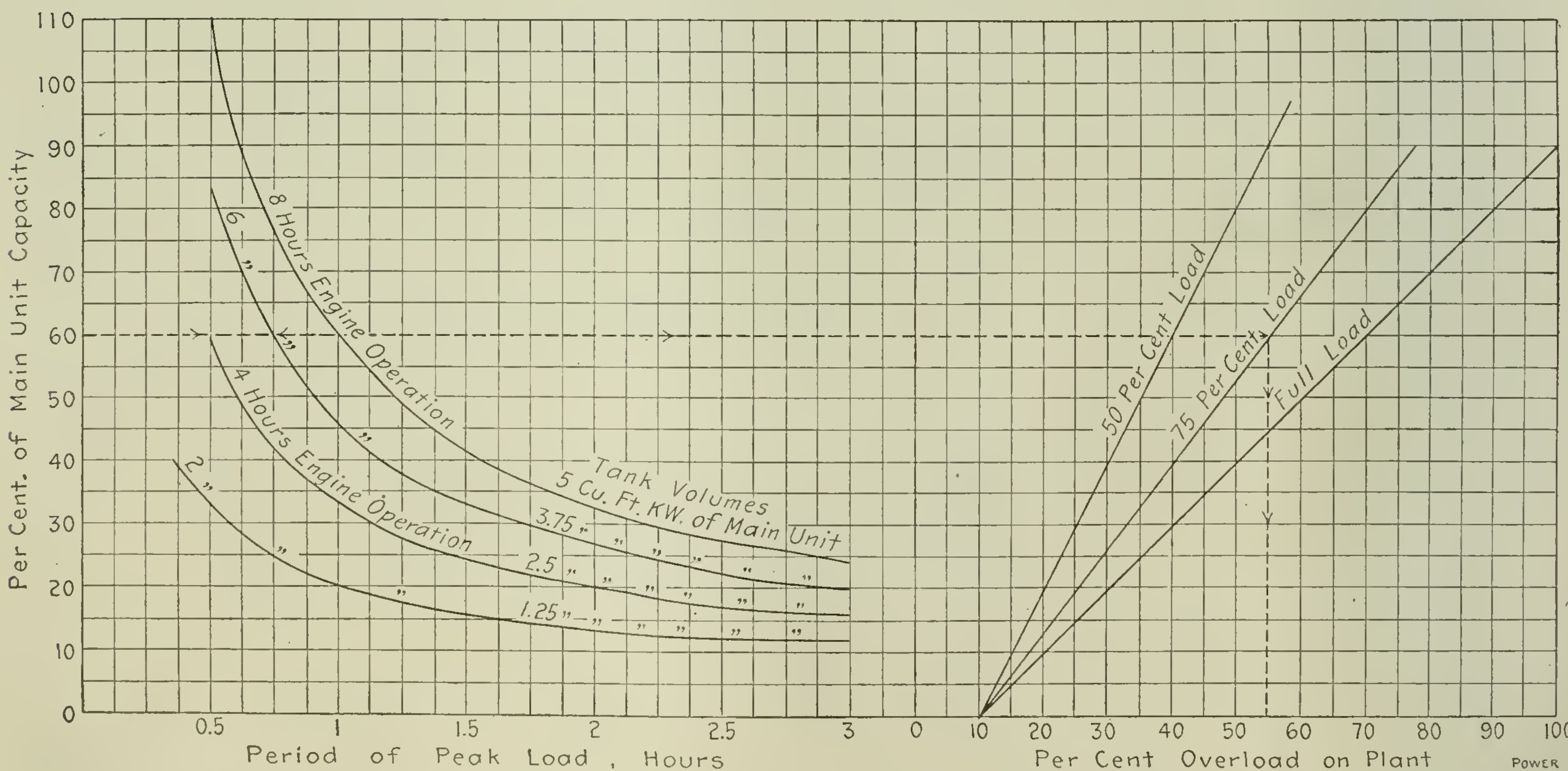


Fig. 3a. Percentage of Main Unit Capacity Available from Low-pressure Turbine Operating on Gas-engine Waste-heat Storage System. For Full-load Operation Preceding Peak

Fig. 3b. Chart for Obtaining the Percentage Overload Capacity of Gas Plant and Low-pressure Turbine from Fig. 3a for Fractional-load Operation Preceding Peak

The influence on costs works out in an interesting way. A four-unit gas plant, aggregating 1200 kilowatts, or more, will require an investment of approximately $135 per kilowatt, including buildings and plat. An installation of a low-pressure turbine system with condenser, tanks and piping, would approximate $45 per kilowatt. Therefore, if the station is to carry a 50 per cent. peak, of which 40 per cent.

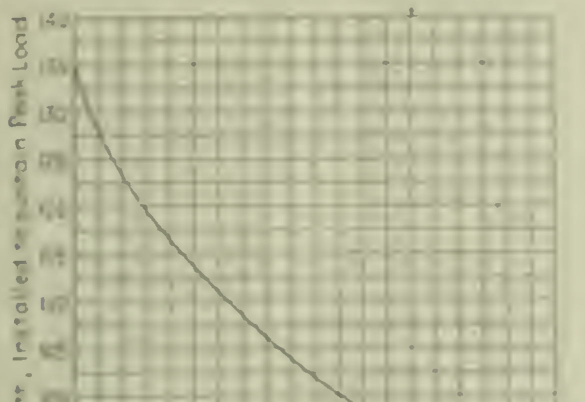


FIG. 4. DECREASED COST PER KILOWATT, DUE TO INSTALLATION OF LOW-PRESSURE TURBINE

is taken by the low-pressure turbine and 10 per cent. by the engines, the average cost becomes,

$$\frac{135^*}{1.10} \times \frac{110}{150} = 90$$

$$45 \times \frac{40}{150} = 12$$

$$\$102$$

This average corresponds to a reduction of $20.75 per kilowatt, or 16.9 per cent. For convenience, a number of values for other ratios have been determined and are given in Fig. 4.

If the low-pressure turbine is to be operated to supply peak loads only, but must be in operation continuously to absorb any sudden load increase, it will probably be warrantable to utilize the jacket heat to supply the no-load losses, as well as pump and condenser auxiliary power. The no-load steam consumption of a turbine is from one-fifth to one-sixth that of full load. As one-third of the work is obtained with the jacket heat, as brought out in the first case, the installation of a secondary system will contribute materially toward decreasing the power losses of the turbine running idle. In this manner, the low-pressure turbine system would be analogous to a storage battery floating on the line. The plant arrangement would be one which would combine the features of Cases I and II.

POSSIBLE SAVING

To demonstrate the value of this combination of gas engines and low-pressure turbines, studies of specific cases are included. For one example, a typical central lighting station load has been considered. Where central-station development is properly conducted, the character of the load curve should be more or less similar for the average city, and a form of load curve as given in Fig. 5 has been chosen. As previously shown, at least 7 per cent. of the gas-engine output may be obtained in the low-pressure turbine. To cover all contingencies, 6 per cent. has been used for this particular example.

Integrating the entire load chart and determining a peak-load area (6 per cent. of the area representing the gas-engine output) the portion of the load that the turbine may carry is indicated by the cross-hatched area. This shows that three 500-kilowatt gas engines and one 500-kilowatt low-pressure turbine may be installed in place of four straight gas-engine equipments. The gas plant, including building and real estate, would cost, at $135 per kilowatt, $270,000. A low-pressure turbine and auxiliaries, including low-temperature boiler, may be added without increasing the building or land cost and may be set up at about $50 per kilowatt, or, with the three gas engines, the entire plant would represent only $227,500 investment, a difference of $42,500. At 11 per cent. fixed charges* (5 per cent. interest, 4.5 per cent. depreciation—18 years' annuity—and 1½ per cent. insurance and taxes), the decreased yearly capital expense would be $4675.

As regards fuel saving, 6 per cent. would be conserved from the exhaust heat. The engine load factor must be improved, saving fully 4 per cent. additional. There would obviously be few producers standing by for peak load, and it may be safely estimated that a further saving of 5 per cent. may be secured from the elimination of a greater part of the standby losses. Thus the total improvement in fuel economy should equal 15 per cent. For such a plant-load curve as that shown in Fig. 5, the load factor for the winter months is 50 per cent., and for the summer months 30 per cent. The average should be over 40 per cent. where the winter months predominate. Therefore, the 2000-kilowatt plant at 40 per cent. load factor would generate (2000* × 8760 × 40 per cent.) 7,008,000 kilowatts per annum. The approximate coal curve for a four-unit plant, where the units would be placed in and taken out of service to correspond as closely as possible with the load variations, and including auxiliary-power losses, is given in Fig. 6. At 40 per cent. load factor, the average coal consumption per kilowatt-hour becomes about 2.8 pounds. This represents

$$\left(\frac{7{,}008{,}000 \times 2.8}{2000}\right) = 9{,}811$$

tons per annum, which, at $2.50 per ton, delivered, amounts to $24,528. By reducing the fuel consumption 15 per cent., the saving would be $3679. The total decrease in annual expense would be $4675 plus $3679, or $8354, regardless of labor. Capitalized at 11 per cent., this represents a decrease in investment of $75,900, which is about three times the cost of the turbine equipment. Or it might be stated that the low-pressure turbine system, if adopted for the fourth unit, would pay for itself in three years by the saving produced over and above the investment and operating cost of a fourth gas-engine unit.

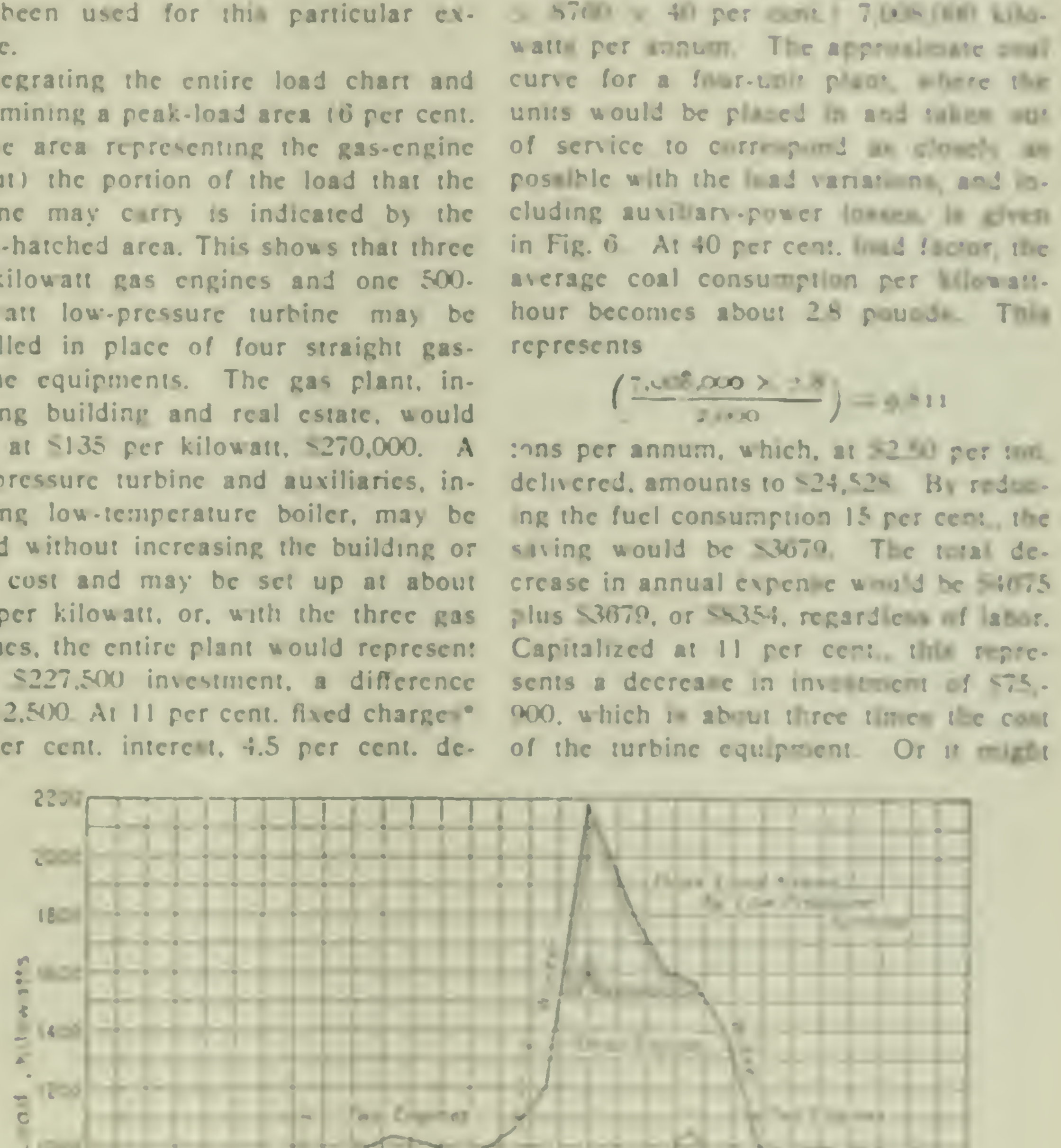


FIG. 5. TYPICAL CENTRAL-STATION LOAD CURVE. EXHAUST HEAT ONLY UTILIZED

Fig. 7 is an illustration of what may be accomplished with a swinging load, as in interurban-railway service, the curve being an actual one taken from a

*Reducing to cost per kilowatt, maximum rating, $122.75.

*This would be greater if allowance were made for depreciation.

*The classification, load factor is based on the normal rating of the plant.

station log. Engines would be improved 10 per cent. in economy, 9 per cent. would be saved by using the exhaust and jacket heat, and probably 3½ per cent. in the producer, totaling 22½ per cent. By carrying a 35 per cent. overload, the investment cost would also be lowered about 12 per cent. A curve of temperatures is plotted in this figure, showing the variation in the storage tank with load throughout the day.

It is understood that in Germany, particular activity has been displayed in this direction, and the possible gains which have been herein portrayed, have there become a matter of fact in actual installations.

Operating Conditions

In the preceding calculation, ample supply of condensing water at an average temperature of 70 degrees is assumed. With lower water temperatures, the results would obviously improve. On the other hand, if either the natural water supply is warmer or cooling towers are demanded, the attractiveness of this type of plant rapidly diminishes, which is emphasized by the theoretical water-rate curves, Fig. 8, for varying vacuum. This is essentially true for Case I, while Case II may show warrant for existence even under this condition.

All estimates are purposely made conservative in order that the advantages assumed may be realized in practice. Improvements in the detail apparatus may follow and refinements be introduced which will produce greater benefits than have been indicated.

The application of an amalgamated generating equipment of this nature will, it is believed, be confined to stations of 10,000 kilowatts aggregate capacity and less, due to the low fuel, labor and investment costs of the large turbine plant.

To facilitate a working understanding of the details involved in developing a combined gas-engine and low-pressure turbine equipment, the fundamental factors have been discussed at length below.

Power Developed in the Low-pressure Turbine

For all practical purposes, the heat distribution in the internal-combustion engine may be considered evenly divided between mechanical conversion (and radiation), the exhaust and the jackets. With an engine consuming about 10,000 B.t.u. per brake horsepower-hour at full load, the exhaust heat (33⅓ per cent. of the total) applied in a low-pressure boiler, with 70 per cent. efficiency, will produce, roughly, two pounds of atmospheric-pressure steam.

To facilitate a ready understanding of the accompanying deductions, the ideal water rates of steam motors, based on the Rankine cycle for different initial temperatures and vacua, are given in Fig. 8.

Expanding from atmospheric pressure to a 28-inch vacuum, the theoretical steam consumption is 15.2 pounds per horsepower-hour. A small steam turbine may be designed with a conversion efficiency of 65 per cent., hence would actually require 23.4 pounds per brake horsepower-hour at its normal rating. Consequently, the two pounds of steam generated from the engine exhaust may be applied in the turbine to develop $\frac{2}{23.4}$ or 8.54 per cent. of the power produced

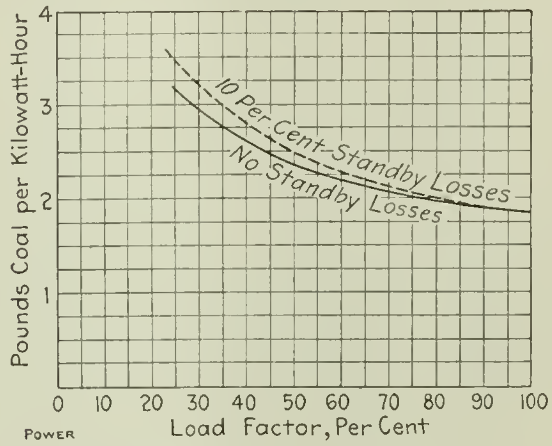


Fig. 6. Effect of Load Factor on Coal Consumption of Four-unit Gas-engine Plant

in the main engine. This percentage would be practically correct where a turbine of 500 kilowatts capacity may be used, and obviously smaller and greater, respectively, for corresponding sizes of turbines.

There is an equal amount of heat available in the jacket at a lower temperature head, and with consequently less potential energy above the condenser pressure.

The problem of utilizing this low-tension steam and obtaining it conveniently from the jacket water is not a difficult one. It is entirely feasible to extract the heat from the jacket water in the form of steam by circulating the discharge through a vessel in which a pressure is maintained lower than the steam tension corresponding to final jacket-water temperatures. The water, in passing through the low-temperature boiler, will be partly evaporated until the whole body is chilled to the low temperature. There would even be a tendency for this action to take place violently in the boiler. This can be obviated by a proper design in which the water passing through is divided into sheets, or sprays, so that steam may be released with the minimum amount of resistance.

In ordinary practice, the jacket- and piston-water temperature averages about 150 degrees. Allowing a working range of 20 degrees for the jacket water, secondary steam may be supplied to the final turbine stages or rows, at 130 degrees. Between 130 degrees (4½ pounds absolute) and 102 degrees (28 inches vacuum), the ideal water rate is approximately 50 pounds, and with a Rankine cycle efficiency of practically 65 per cent. in the lower last row of blades, the actual water rate becomes 77 pounds per brake horsepower-hour. With 33 per cent. of the heat being absorbed by the jackets, 3300 B.t.u. become available when the engine is at full load; 1018.7 B.t.u. are required to evaporate one pound of steam from and at 130 degrees and hence $\frac{3300}{1018.7} = 3.24$ pounds of steam available per engine brake horsepower-hour at 4½ pounds absolute pressure. This is then equivalent to producing $\frac{3.24}{77} = 4.21$ per

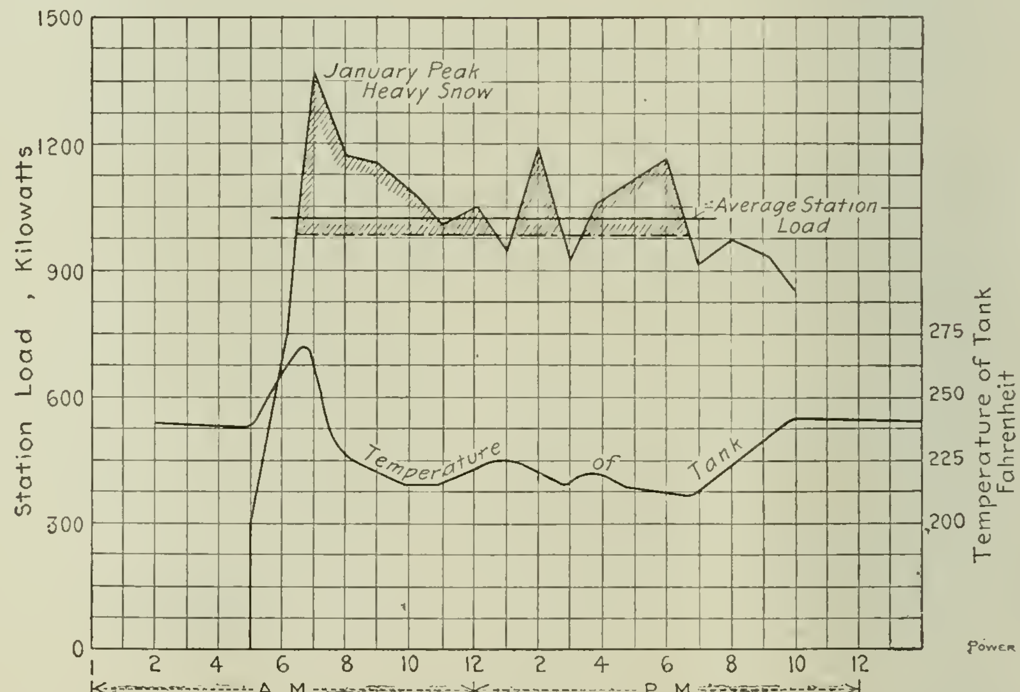


Fig. 7. Load Curve of Interurban Railway System. Jacket and Exhaust Heat Utilized

cent.* of the gas-engine output, which, added to the power from the exhaust heat, amounts to 12.75 per cent. In the smaller plants, this may not be greater than 11.75 per cent. Evidently these quantities represent the gross gain by

*Temperatures of 150 degrees Fahrenheit have been considered for the jacket and piston water. Should the temperature be raised to 200 degrees Fahrenheit as found in some foreign plants, the power that may be developed from the jacket heat would be doubled. The advantage will probably inspire this practice.

the operation of a low-pressure turbine; and to determine the net benefit that may be obtained, the power consumption of the auxiliary condenser and pumps must be deducted. As a close approximation, it may be assumed to be 1 per cent. for every 6 pounds of steam consumption of the main unit; in other words, 2½ per

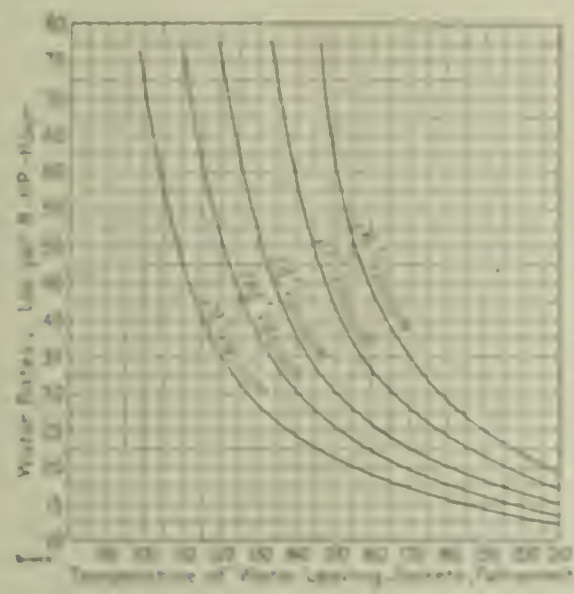


FIG. 8. IDEAL WATER RATES

cent. for 15 pounds steam consumption per brake horsepower-hour, 5 per cent. for 30 pounds, 12½ per cent. for 75 pounds, etc.

Furthermore, a small allowance must be included for radiation and friction, say 2 per cent. The following establishes a fair estimate of the true improvement:

$$8.54 \times (1 - 0.04) \times 0.98 = 8.04\%$$
$$4.21 \times (1 - 0.1283) \times 0.98 = 3.595\%$$
$$11.635\%$$

The smaller plant would, in proportion, be about 10.5 per cent. The coal consumption of the plant would be lowered 10½ to 11½ per cent. by the installation of the low-pressure turbine using both exhaust and jacket water. If operating only on exhaust heat, the reduction would be but 7 to 7½ per cent.

For the purpose of designation, the steam obtained from the exhaust-gas heat, being predominant in available energy, may be correctly termed the "primary" steam, and that obtained from jackets the "secondary" steam. While the percentages expressed above were for full-load conditions, they may be safely applied, to an extent, to fractional loads, it being noted that the engine declines in efficiency at somewhat greater rate than the turbine and auxiliaries, and thus a fairly uniform percentage should obtain over a wide range in load.

In addition to the saving above shown, the sensible heat of the gas leaving the producer may be absorbed in an economizer placed between the producer and the scrubber, and the steam thus generated consumed in the low-pressure turbine. This item has been neglected, however, as it represents but a small percentage of the heat which may be conserved, and as a producer with an integral vaporizer has been considered, this extra apparatus seems unwarranted.

Some brief data on turbines and exhaust boilers may be appropriate for reference.

DISTRIBUTION OF HEAT AT AVERAGE LOAD

The characteristic performance of the gas engine is exemplified in the Norton tests which form a part of volume No. 29 of the American Society of Mechanical Engineers *Proceedings*. Based on brake-horsepower output, the items divide as follows:

Useful work	24.86
Electrical losses	[illegible]
Friction and pump work	4.38
Jacket absorption	34.22
Exhaust and radiation* (by balance)	36.54
Loss in producer	[illegible]

TURBINES

Results of series of tests under conditions of varying vacuum, conducted two years ago on one of the first double-flow, reaction, low-pressure turbines, are presented in Fig. 9. While it is to be understood that they are not typical of the improved economies secured with later designs, they are very complete and are to be found instructive in this study.

The efficiency obtained then was 65 per cent. on a 2000-brake horsepower turbine. A like efficiency is probable in a turbine such as that discussed in this paper.

In some research work undertaken by The Westinghouse Machine Company, a low-pressure turbine designed for an initial pressure of 2½ pounds absolute and 1 pound absolute back pressure produced the results plotted in Fig. 10. The experience that was gained from the operation of this very small machine justifies the assumptions made above for the large units, which would also benefit from more recent knowledge of the requirements.

EXHAUST BOILER

A countercurrent, cast-iron exhaust boiler under test exhibited the amount of steam that could be practically generated from the engine exhaust. Fig. 11 shows that, regardless of rating, 30 per cent. of the heat input to the engine may be converted into steam.

It is important that the exhaust heater be placed close to the engines to reduce the length of the exhaust piping and consequently the radiating surface. As it is impracticable to lag the exhaust piping with nonconducting material owing to the heating and trouble at the engine that would result, it becomes desirable to water-jacket this piping, either as shown in Figs. 1 and 2, with special cast pipe or perhaps with a less expensive method of small coils wrapped around the pipe. The primary steam mains pass through the exhaust header, which secures a small superheating effect.

LOW-TEMPERATURE BOILER

Recovering heat from the jacket water in the form of steam is almost ideally accomplished. The apparatus consists merely of an elevated cylinder, shown in Fig. 2, through which the jacket water is allowed to flow. Water entering the drum or cylinder will be approximately at the temperature at which it leaves the engine jackets. It is thus only necessary that a pressure be maintained in the chamber corresponding to the temperature of the water leaving the boiler, and that the water travel at a sufficiently low rate to

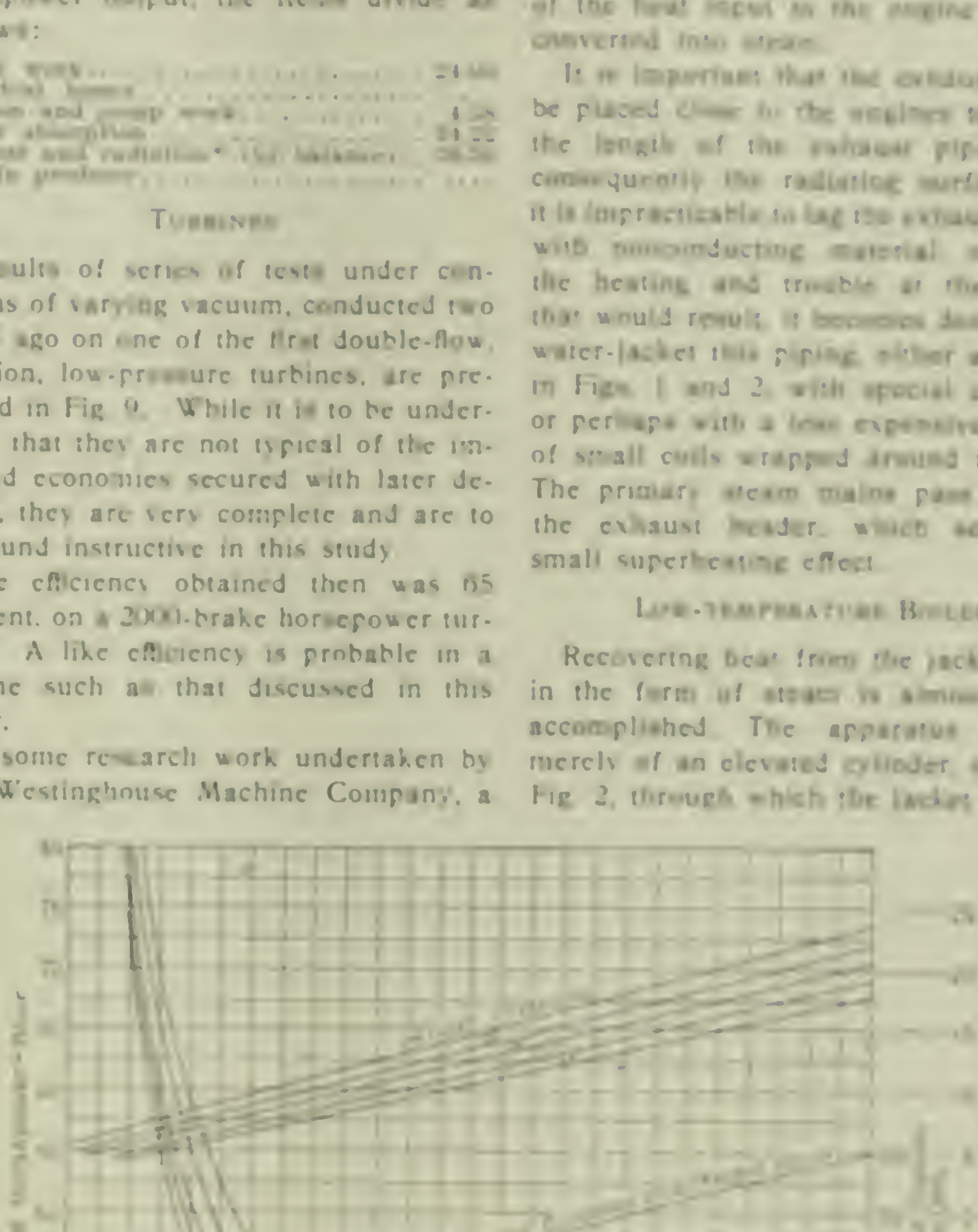


FIG. 9. RESULTS OF ECONOMY TEST OF 2000 BRAKE HORSEPOWER LOW-PRESSURE TURBINE

*Radiation, which is included with the exhaust by balance, should be credited the remaining the available heat for economy.

allow proper disengagement of the steam. The boiler is elevated to avoid operating the jackets and water lines under vacuum and to prevent the formation of steam pockets which otherwise would be liable to be injurious to the cylinders. Regardless of the fact that all the heat is transferred from the jacket to the steam, the boiler cannot be considered 100 per cent. efficient. To effect the interchange, the temperature must be lowered, which reduces the available energy in the steam. Thus its efficiency may be only from 60 to 80 per cent.

Storage Tanks and Insulation

Guide or baffle plates may be used in the tank to facilitate circulation, which will manifestly depend upon the rate at which the energy may be withdrawn from the tank.

Owing to the large tanks that are essential, it is advisable to maintain the working temperature and pressure above atmosphere. This obviates the expense of providing tanks to resist the collapsing tendency under a vacuum and prevents air leakage. On the other hand, while it is desirable to have as high a temperature elevation as practical to confine the heat storage to a small body of water, there are obviously natural limitations in the exhaust heater. Present calculations show that from 45 pounds absolute (274 degrees) to 15 pounds absolute (a range of about 64 degrees Fahrenheit) best suits the conditions. The amount of water necessary to absorb the heat available from the gas engine is a definite quantity, depending upon the temperature range worked through and the time during which the heat is supplied; in other words, the hours of engine operation preceding the peak load.

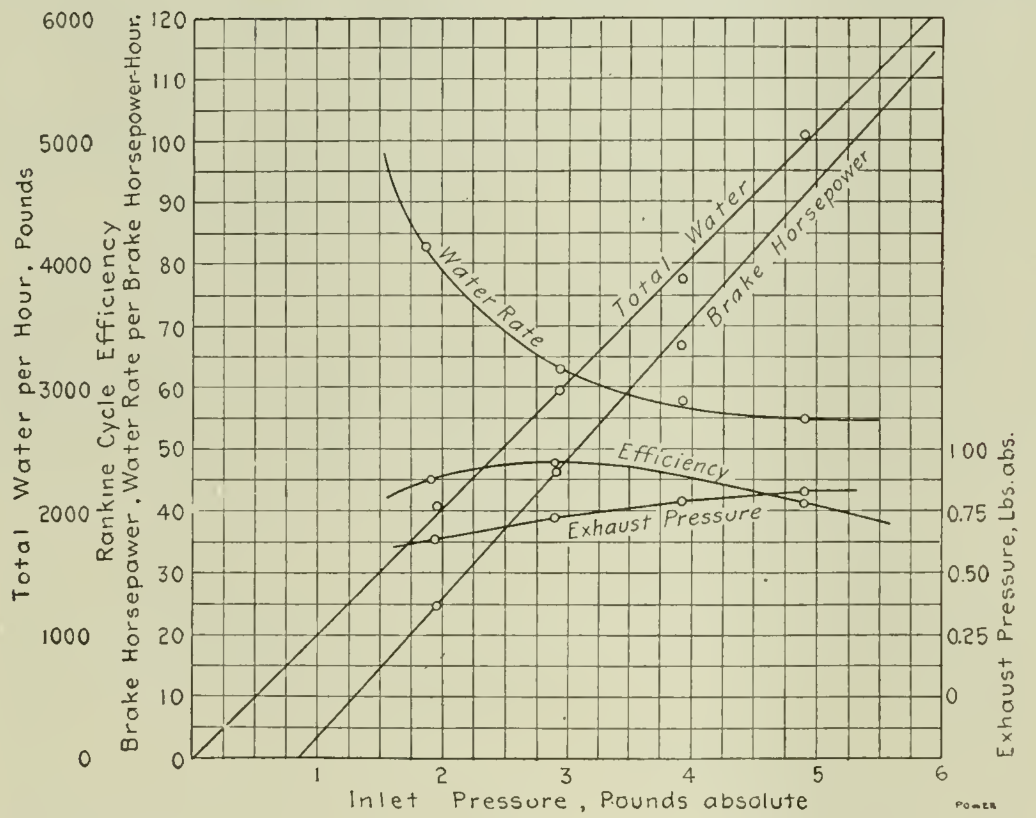


Fig. 10. Results from Test of 20-horsepower Low-pressure Steam Turbine

The curves, Fig. 3, have all been plotted on the basis of 64 degrees Fahrenheit temperature drop, and it therefore follows that the curves of constant period of engine operation preceding the peaks are also lines of constant tank volume. Thus for a period of four hours engine operation at full load previous to the peak, 2.5 cubic feet per kilowatt of gas-engine capacity are necessary; for 6 hours, 3.75 cubic feet; 8 hours, 5 cubic feet, etc. For a 2000-kilowatt plant, this corresponds to a tank volume of 5000 cubic feet. If the peak is to last three-quarters of an hour after four hours storage, 840 kilowatts, or 42 per cent. of 2000 kilowatts, are available from the low-pressure turbine. Proportioning the tank allows considerable latitude. The area of the surface of the water, or disengagement of the steam, may be determined by employing a disengaging velocity of the steam varying from 1½ to 5 feet per second. Thus the dimensions of the tank may be accommodated in a large measure to the plant layout. The tank should be equipped with burners or grates and fire tubes, at relatively low cost, such that a byproduct plant could be made self-contained in an emergency.

Losses from radiation and conduction may be made very small items. Low temperatures are used, and consequently the rate of transfer, depending upon the temperature difference, will be correspondingly low.

Radiation loss from the heat-storage system is an extremely low percentage of the low-pressure power available. Authorities on the subject of "Conduction and Transmission of Heat" differ somewhat in opinion as to the rate of heat dissipation from cast-iron and sheet-steel surfaces; 2.5 B.t.u. per hour per degree difference in temperature per square foot of bare surface is about the accepted average.* With 85 per cent. covering efficiency, the actual loss per square foot is 0.375, or ⅜ of a B.t.u. With approximately 180 degrees average temperature difference, the hourly loss per square foot would be 67.5 B.t.u. As 37,500 B.t.u. are, roughly, required to develop a kilowatt-hour in a low-pressure turbine,

$$37{,}500 \div 67.5 = 556$$

square feet of exposed surface would

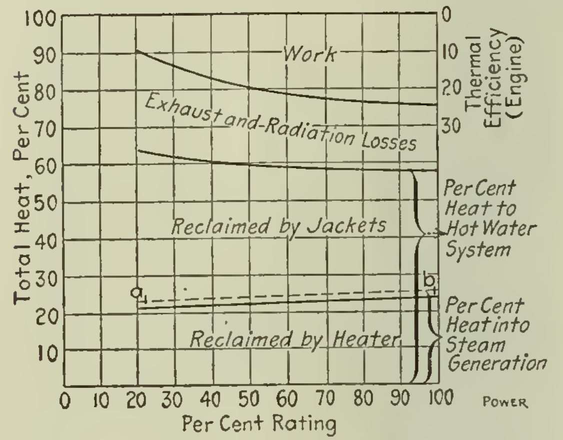


Fig. 11. Heat Balance from Test of 200-horsepower Gas Engine and Heater with 134 Square Feet of Heating Surface

represent a loss of one kilowatt in an hour. In case of the 2000-kilowatt plant results, a tank 15 feet in hight and 28 feet in length, would be required, providing 20 per cent. steam space. Together with the connecting pipe, the radiating area would be in the neighborhood of 2500 square feet and the loss per hour would be

$$2500 \div 556 = 4.5$$

kilowatts. For four hours operation preceding the one-half hour peak of 840 kilowatt,

$$4.5 \times 4 = 18$$

kilowatts would be lost. This amounts to only $\frac{18}{840}$, 2.15 per cent. of the power required. These radiation losses have been more than conservatively covered in the accompanying results.

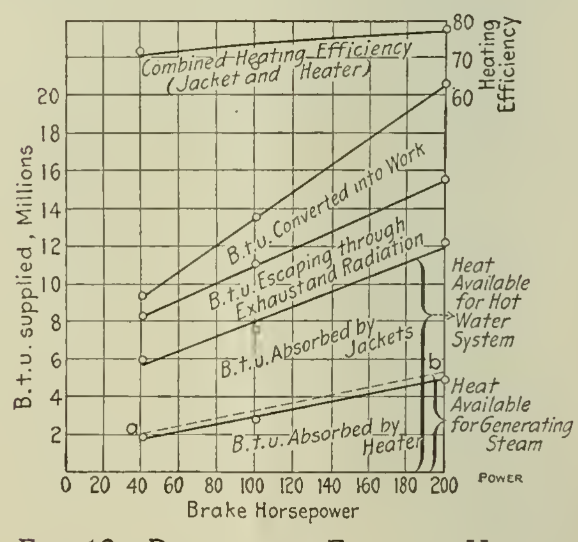


Fig. 12. Results of Exhaust Heater Test

Addendum on Heating Systems

The utilization of gas-engine waste heat was attempted very soon after the gas engine assumed commercial importance, over twenty-five years ago, effort

*Steam-heating engineers use a lower value.

being applied to divert as much of this heat for steaming and industrial purposes as possible.

The amount of heat to be obtained in the form of steam or hot water is given in Figs. 11 and 12. Two facts have operated against a more general adoption of gas-engine waste-heat systems. First, the steel boilers that were employed at the outset were very seriously corroded by the sulphurous-acid gas and the moisture present at the low temperatures. The introduction of cast-iron heaters should revive the use of waste gases. Only 1½ per cent. of the jacket water* may be evaporated by the exhaust heat, and the use of the jacket water in a hot-water system involves several disadvantages, and more complicated and costly installation. Secondly, where the ratio of heating requirements to the power demanded in isolated industries or buildings is large, the noncondensing steam motor is obviously superior. Probably in a southern latitude, or where the power consumption is large in comparison with the heating to be done, sufficient heat may be obtained from the gas engine.

ACKNOWLEDGMENTS

The author is indebted to the Westinghouse Machine Company for permission to use these data, and to A. T. Kasley for fruitful suggestions in the arrangement of details of the installation.

*Equal to 16½ pounds jacket water per brake horsepower hour.

Safety Valves and Their Application

By John S. Leese

The limitations and uses of the different types of safety valves and the necessary computations for setting one of the ball and lever type.

All steam boilers should be fitted with two safety valves, one of these valves to blow off for high steam pressure, and the other for both high steam pressure and low water. The former is generally of the dead-weight or direct spring-loaded type. Where springs and weighted levers are used, the lever and the weight should be such that the valve will open at blowing-off pressure when the weight is at the extreme end of the lever. This prevents overloading, due to slipping of the weight, although unscrupulous attendants may adopt the dangerous and often criminal practice of hanging more weights on the lever. There are other points to be noted in connection with the choice of a lever-type safety valve; for instance, if guide forks are fitted to the lever, they must be open at the top so that the lever cannot become wedged; also, iron to iron contact should not be permitted for the lever pins on account of rust. If the valve is of the closed type the "iron to iron" remark applies also to the valve spindle passing through the cover. Dead-weight valves are not permissible on marine, portable or locomotive boilers, owing to the vibration and swaying, but the direct spring-loaded type is not affected in this way.

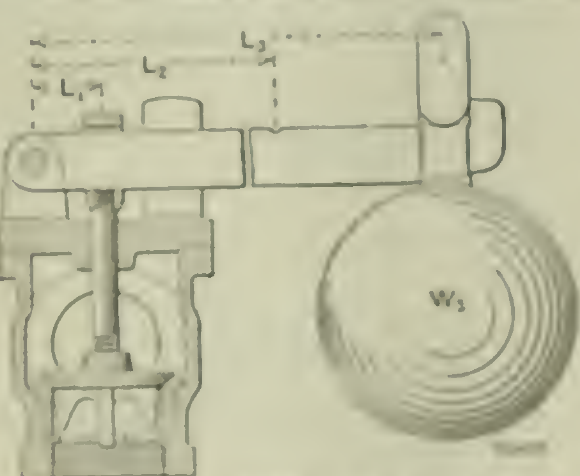
The second safety valve is often connected to a float in such a way that it will open when the water sinks to a certain level; this type is known as the "low-water safety valve." Preferably it should open for high steam pressure as well.

On many portable boilers, especially those that have been in service for many years, lever safety valves, loaded by spring balances, are used. It should be made impossible to lock these by screwing up the thumb nut on the balance, as an unskilled attendant may ignorantly cause disastrous results. The readings on the spring-balance scale should indicate "pounds per square inch" by a suitable proportioning of the valve area and the length of the lever to the pressures. Neglect of these precautions has led to many explosions, owing to the attendant being ignorant of the existing pressure.

Where the use of dead-weight safety valves is prohibited, there appears to be no reason why direct spring-loaded valves should not be used. They are much preferable to the lever-spring-balance type.

Safety valves should never have a diameter less than two inches, the relation of diameter to lift being a much debated point. In the writer's opinion neither extreme, that is, high lift and small diameter or small lift and large diameter, is desirable, but rather a mean might be reached between the two.

In many cases the valve is so formed



BALL AND LEVER SAFETY VALVE

that the reaction of the steam blowing through it increases the lift, thus insuring the full area of opening. The use of a lifting gear arranged so that the safety valves may be operated by hand from the floor of the engine or boiler room, may be decidedly advantageous in cases of emergency.

Referring to the sketch, let

W_1 = Weight of valve;

W_2 = Weight of lever;

W_3 = Weight on end of lever;

L_1 = Distance from fulcrum pin to center of valve;

L_2 = Distance from fulcrum pin to center of gravity of the lever;

L_3 = Distance from fulcrum pin to center of weight;

A = Area of safety valve, in square inches;

P = Steam pressure at which valve will blow off, in pounds per square inch.

Then,

$$P \times A \times L_1 = W_1 \times L_1 + W_2 \times L_2 + W_3 \times L_3$$

and,

$$P = \frac{W_1 \times L_1 + W_2 \times L_2 + W_3 \times L_3}{A \times L_1}$$

The miter of a safety valve should not exceed one inch.

Electrical Engineering Exhibition

The third triennial exhibition of electrical engineering and machinery is to be held at Olympia, London, this year, from September 23 to October 21. It is to be international in character and is a manufacturers' exhibition, promoted by the large electrical manufacturers of England, through their association, the National Electrical Manufacturers' Association. All the exhibiting firms will participate in the profits, if any, arising from the exhibition, although their liability is limited to their space rental, which is advertised not to be in excess of those of any similar exhibition.

The forthcoming exhibition, it is stated, will be the largest event of the kind which has ever been held in England, and perhaps in any other country. The fact that this event will take place in the coronation year, it is urged, is also strongly in its favor, as there will be a large number of colonial buyers visiting in London, who will embrace the opportunity of visiting such an important undertaking, in which many of them will be keenly interested.

It is suggested that if any manufacturers of the United States contemplate participating in this exhibition, it is important that they make inquiry early as to space, because a large percentage of the ground floor and a very large proportion of the galleries have already been engaged.—*Daily Consular and Trade Reports.*

Friction Clutches and Their Use

By H. A. Jahnke

Reasons why the use of clutch pulleys and cutoff couplings makes for economy. Suggestions in regard to the selection of suitable clutches. General description of some clutches of well known make.

In most manufacturing plants changes and improvements are constantly being made in the machinery for the sake of effecting greater economy. But, strangely enough, in many plants, although they are equipped with modern machinery, there exist inefficient means of stopping and starting line and countershafting. Aside from the independent, electric-motor drive, there is nothing better for this purpose than the friction clutch. The use of clutches permits the shafting to be so divided that it is only necessary to run the machinery, countershaft and line shaft which are actually in use. Thus a machine, countershaft, line shaft or whole department may be shut down without interfering in any way with other departments or equipment. This results in a saving of power and time and should be appreciated by every engineer and

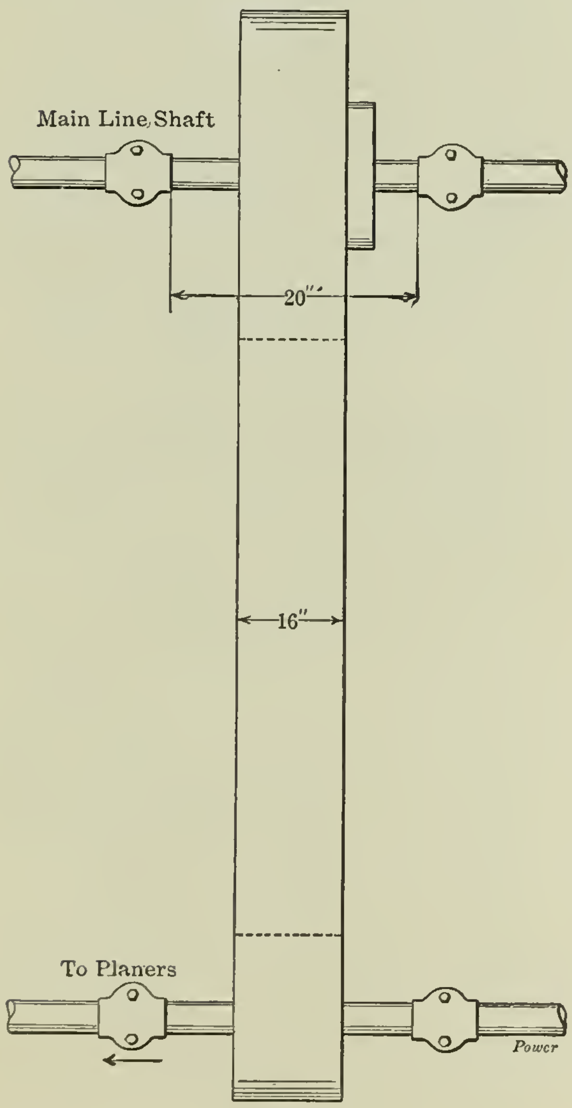


Fig. 1. Use of Friction Clutch to Economize Space

power-plant owner who perhaps has seen a whole plant shut down, the men standing idle and production stopped, all due to the breaking of a belt, rope or pulley. Where friction clutches are in use this trouble can be overcome. Of course, to equip a whole power-transmission system with friction clutches is quite expensive, but it should prove to be cheaper and more efficient, in the long run, than the use of tight and loose pulleys. With friction clutches, the loads may be picked up slowly while the driving shaft is running at full speed. Further, clutches act as safety devices and eliminate strains upon machinery and belting. The slippage in starting and stopping is taken up by the clutch instead of the belt.

If it is desired to place friction clutches in line of shafting so as to make parts of the shaft independent units, this can easily be done by removing shaft couplings at convenient points and in their place putting friction-clutch cutoff couplings. By the use of a split type of friction-clutch cutoff coupling such a change can be made without much expense or trouble.

A large percentage of the unnecessary cost of running line shafts and countershafts can be saved by arranging the shafting and machinery so that parts can be stopped by means of friction clutches when not in use.

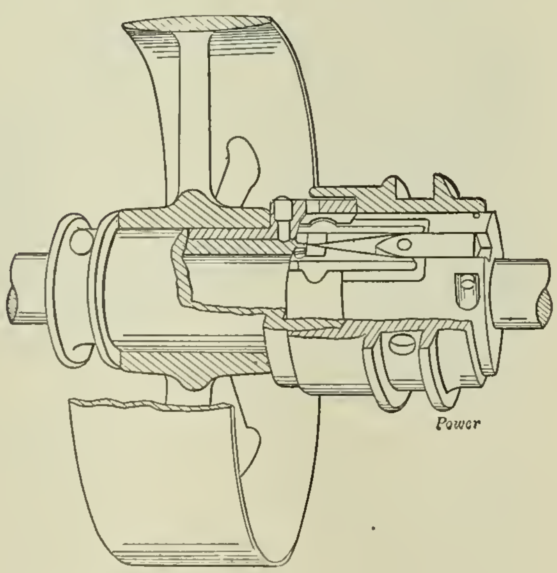


Fig. 2. Johnson Clutch, Engaged

Often, slight changes in transmission conditions save a great loss of time. Take, for example, the following case of a machine which is driven direct from the line shaft by means of a 4-inch belt. In order to start or stop this machine the belt has to be shifted from tight to loose pulley or *vice versa*. Should the belt tear or need tightening during the time when the machine is in operation, the line shaft has to be stopped before adjustment can be made. Often, this results in shutting down other departments. This would not be the case if there was a friction clutch on the line shaft; all that would be necessary would be to disengage the clutch and any repairs could be made without interfering with other parts of the transmission equipment. Friction clutches save wear and tear on the belts. With a tight- and loose-pulley arrangement, when the belt is shifted from one to the other, the stress in the edge of the belt is considerable. This results in the burning of the belt and the opening of the laps at the edges.

In a certain plant, a line shaft, used for driving planers, had been driven for many years by a 10-inch double leather

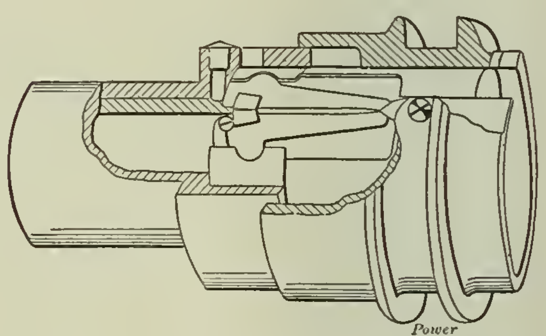


Fig. 3. Johnson Clutch Disengaged

belt from the main line shaft. The planer line shaft was arranged with a tight and loose pulley to permit the stopping of this shaft during the noon hour and at night when machinery in other parts of the factory was worked overtime. A few years ago it became necessary to install a larger belt to drive the planer line shaft, due to the installation of more machinery. A 16-inch belt was necessary. Had it been necessary to use the tight- and loose-pulley system with the larger belt, considerable work would have been required, for the new pulleys would have required 32 inches and this would have necessitated the shifting of the bearings. By the use of a clutch, however, this was obviated, as shown in Fig. 1.

For economy of space and convenience in subdividing transmission systems into separate parts, any of which may be taken out of service without disturbing the others, friction clutches find extensive use. It may be well, therefore, to consider the design and operation of some clutches in general use.

Clutches may be divided into two general types, the ring type and the disk type. In the former, the friction surfaces bear on a ring which is concentric with the shaft. In the latter, the surfaces bear on a disk which is normal to the shaft.

In most clutches one contact surface

is composed of wood while the other is made of cast iron. The advantages consequent to the use of these materials are: High coefficient of friction; uniform contact due to the wearing of the wood shoes; low cost of renewing wood shoes; negligible amount of wear of cast iron in contact with the wooden sur-

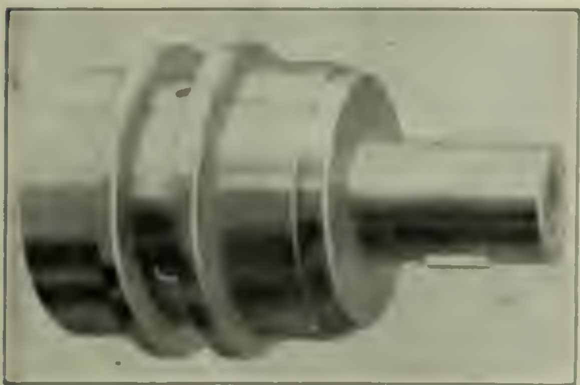


FIG. 4. EXTERIOR VIEW OF JOHNSON CLUTCH

faces; the fact that wood can be used without lubrication, and freedom from danger of the surfaces seizing.

In purchasing a friction clutch great care should be taken to select the right size of clutch to transmit a given horsepower and due consideration should be given to the character of the work which is to be performed. Especially is this so if the clutch is to be used in connection with an electric motor. Where the motor is capable of carrying perhaps 50 per cent. or more overload that clutch should be selected which has a horsepower rating at least 50 per cent. in excess of that of the motor.

A clutch which is frequently thrown in and out will be subjected to more wear and tear than a clutch which is operated infrequently. A clutch will carry a uniform load more easily than a variable load. Greater satisfaction will be secured if a clutch is selected with a capacity in excess of the work required of it. Overloaded clutches are the source of much of the difficulty that users of friction clutches usually experience.

In placing a friction clutch on a line shaft it is advisable to put it as close to a bearing as is possible, because when the clutch is thrown in there is a heavy strain on the shaft. Friction-clutch pulley service, with its frequent stopping and starting, picking up and dropping a full load, is very hard on pulleys and it is advisable to use a substantial pulley for this service.

A friction clutch must receive good care if it is to do its work right. The bearings should be well lubricated and all friction surfaces kept free from dirt, oil and grease. Never allow a clutch to slip, for, ultimately, slipping will ruin a clutch.

THE JOHNSON CLUTCH

Figs. 2, 3, 4, 5 and 6 show the Johnson clutch. This clutch has few parts and is very compact. A body fastened to the shaft carries a split ring in which are inserted a pair of levers. A curved-shaped wedge which is made a part of the slipper sleeve, forces the levers apart, extending the ring and thus bringing its outer surface into frictional contact with the inner surface of the friction cup, the hub of which is made to suit requirements. The leverage is so compounded that it requires but slight pressure to operate the clutch.

This type of clutch is used in many plants in place of a countershaft for driving machines direct from the line shaft, as shown in Fig. 5, as they operate smoothly at any speed without bang or clatter and have no projections to catch anything. By using the double clutch, Fig. 5, on a countershaft with two pulleys, one carrying an open belt and the other a crossed belt, the machine can be run either in the forward or in the reverse direction. This form of clutch is especially convenient for running machines which require a reverse motion.

To adjust this clutch, all that is necessary is to give a single screw a fraction of a turn, or more if necessary, to

FIG. 5. JOHNSON DOUBLE CLUTCH

the right or left. This screw can be reached through the hole in the friction cup. The Johnson clutch is manufactured by the Carlyle Johnson Machine Company, Manchester, Conn.

THE HILLIARD CLUTCH

Figs. 7 and 8 show the Hilliard clutch. In this clutch all toggle mechanisms have been avoided, as will be seen in the part sectional view, Fig. 7. Two friction plates are drawn against a friction ring, which contains a number of hardwood inserts, by means of screws operated by spiral gears which are turned by the spiral racks attached to the sliding collar. Ball thrust bearings are provided for the spiral gears so as to reduce the effort necessary to engage the clutch. It will be seen that as long as there is space between the hub, or body, of the clutch and the sliding collar, the clutch can always be thrown in tighter, and readjustment is not necessary until these parts come together.

This clutch is particularly valuable for controlling delicate machinery, especially

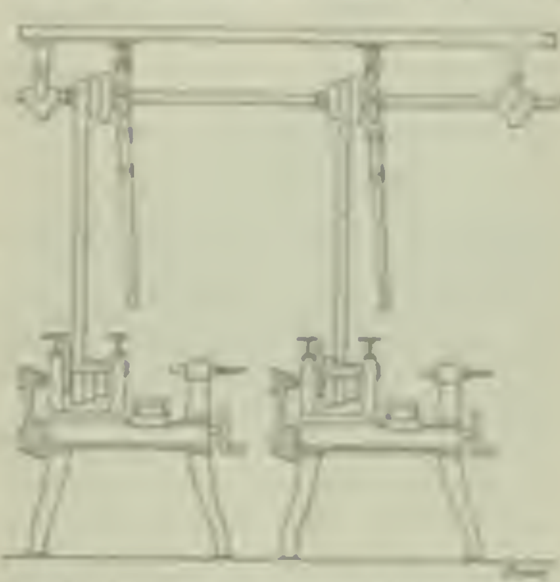


FIG. 6. DRIVING MACHINERY DIRECT FROM LINE SHAFT WITH JOHNSON CLUTCH

in textile mills where a sudden shock in starting may cause much damage, as the screws can be turned slowly, thus applying the friction gradually and picking up the load smoothly.

When the clutch needs adjustment this can be done by removing a nut which allows the sliding collar to be drawn out, taking the spiral racks out of mesh with the gears. By turning each gear the same number of teeth to the right the friction plates are drawn up the same amount on all sides. This clutch is especially free from bolts, nuts and fastenings and cannot easily get out of adjustment. The Hilliard Clutch and Machinery Company, Elmira, N. Y., manufactures this clutch.

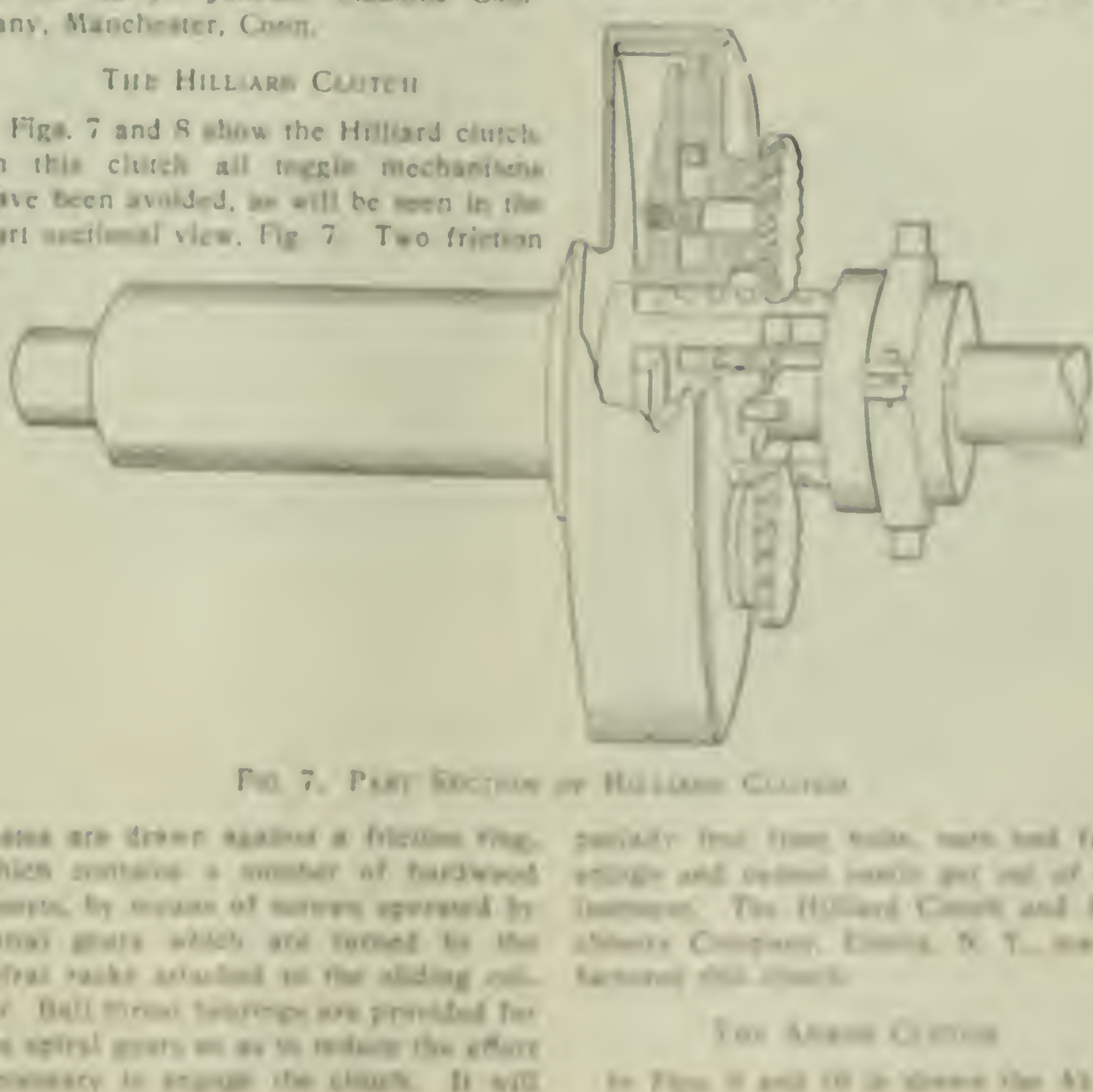


FIG. 7. PART SECTION OF HILLIARD CLUTCH

THE [illegible] CLUTCH

In Figs. 9 and 10 is shown the [illegible] clutch, which is of the disk type. The construction of the Akron clutch is extremely simple, as a little study of the sectional view in Fig. 9 will show. The

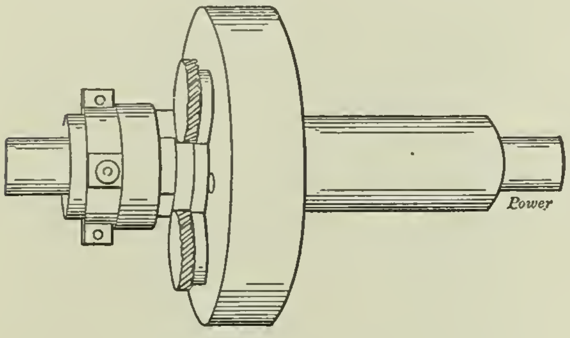


Fig. 8. Outline of Hilliard Clutch

drum *A* carries a hub or sleeve to which a pulley, gear or sprocket wheel may be keyed. The head *T* of the drum is separate. Within the drum are arranged two cast-iron friction plates *C* which the keys *H*, sunk into the fixed, or driving, member *B*, force to rotate with the shaft. The disks *C* are free to move laterally on the keys *H*. The clutch depends for its power-transmitting capacity upon the friction between the disks *C* and the corresponding friction surfaces of the drum *A* and

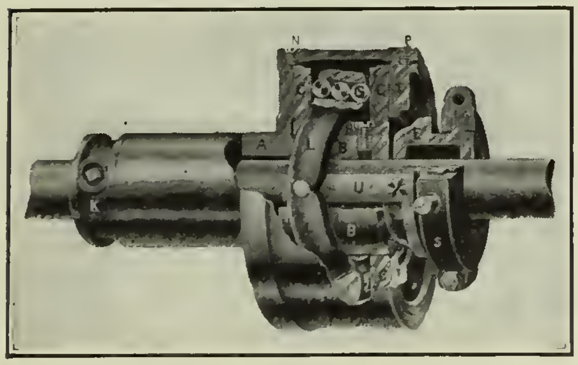


Fig. 9. Sectional View of the Akron Clutch Coupling

the cover *T*. The clutch is engaged by forcing apart the friction disks *C* into contact with the drum heads by means of the toggle mechanism, the latter being connected by steel links *U* to the sliding sleeve *E*. Regular shifter forks attached

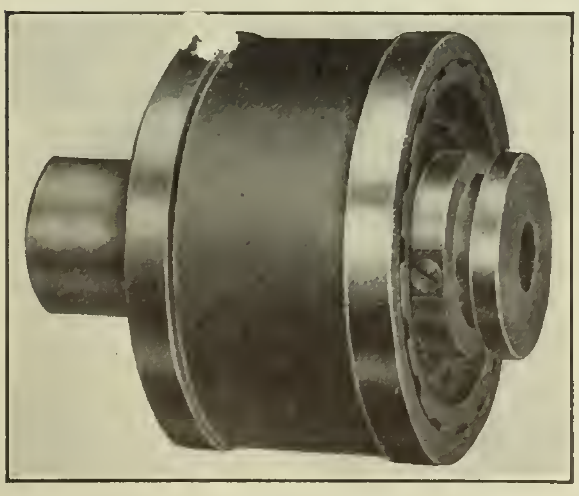


Fig. 10. Exterior of Akron Clutch Coupling

to the yoke *S* are used to disengage and engage the clutch. The roller toggle is a novel feature of this clutch; it consists of two forked liners *L* with chilled holes through them in which are lodged three hardened tool-steel rollers. When the levers *L* are perpendicular to the shaft, the center line of the three rollers is perpendicular to the faces of the friction disks, and the latter are pressed apart into contact with the friction surfaces. The design of the improved shifter ring *S* is such that the oil is retained while dust and dirt are excluded. The ring is made of cast iron and lined with babbitt.

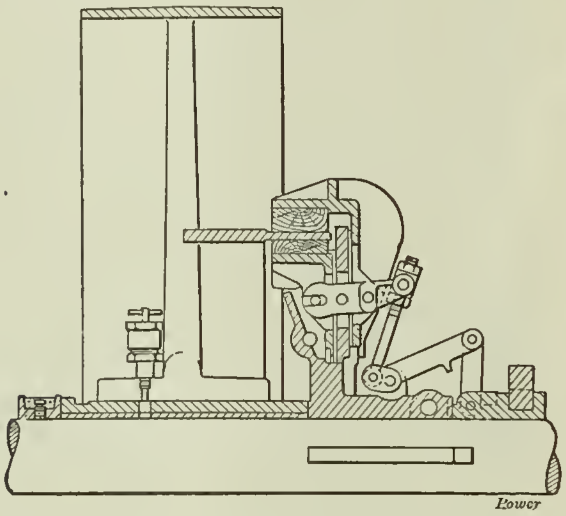


Fig. 11. Section of One-half of Hill "Smith Type" Clutch

The Akron clutch requires no attention other than the occasional renewal of oil in the case through the oil hole *N*. The cover *T* serves to retain the oil.

The clutch is adjusted by means of the head *T* which is screwed into the drum *A* and provided with notches in

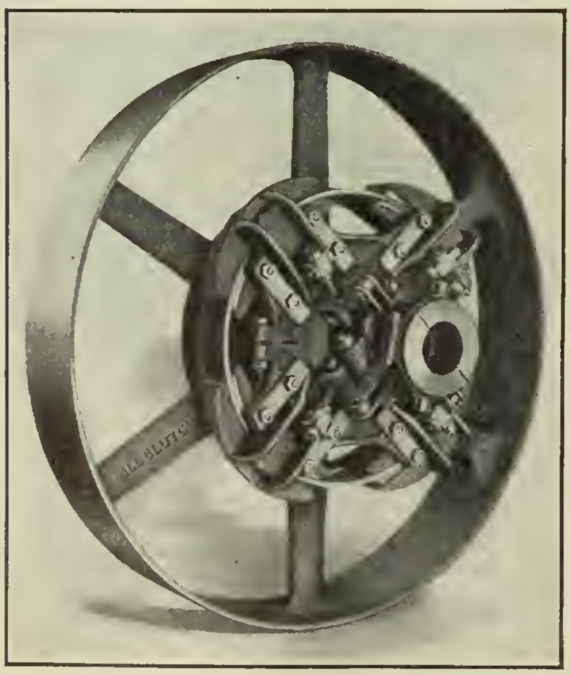


Fig. 12. Hill "Smith Type" Clutch

which the point of the locking screw *P* engages. The pitch of the screw and number of the notches are so proportioned that one adjustment of one notch corresponds to a lateral movement of 1/200 of an inch between the friction surfaces. The Akron clutch is made by the Williams Foundry and Machine Company at Akron, O.

The Hill "Smith Type" Clutch

The new Hill "Smith type" friction clutch is shown in Figs. 11 and 12. In this clutch the positive release feature is new, and eliminates the use of springs formerly used for disengaging the fric-

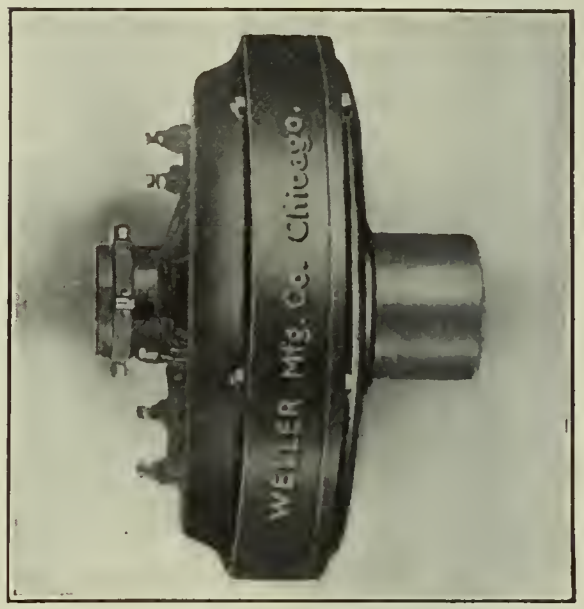


Fig. 13. The Weller Compound Clutch

tion jaws. As an examination of Fig. 11 will serve to show, the continuous toggle connection from the cone to the jaws positively releases the ring when the clutch

Fig. 14. Side View of Weller Compound Clutch

is thrown out. This new clutch is distinguished by improvements in the design which allow any working part to be removed parallel to the shaft from the

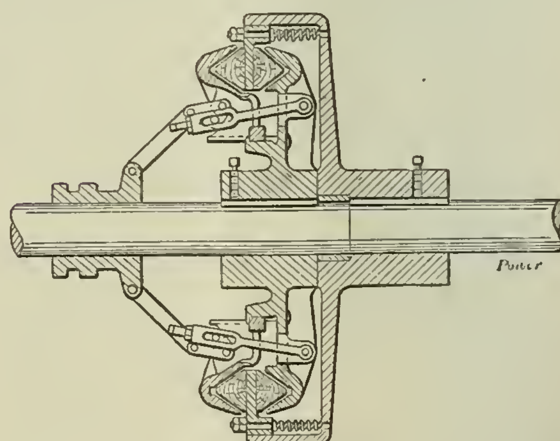


Fig. 15. Details of the Weller Clutch

mechanism side without removing the main spider casting. On account of the rigidity of the construction, the clutch is self-protective; if the clutch is loaded beyond the limit set by the jaw adjustment, slippage ensues instead of breakage.

This clutch is manufactured by the Hill Clutch Company, Cleveland, O.

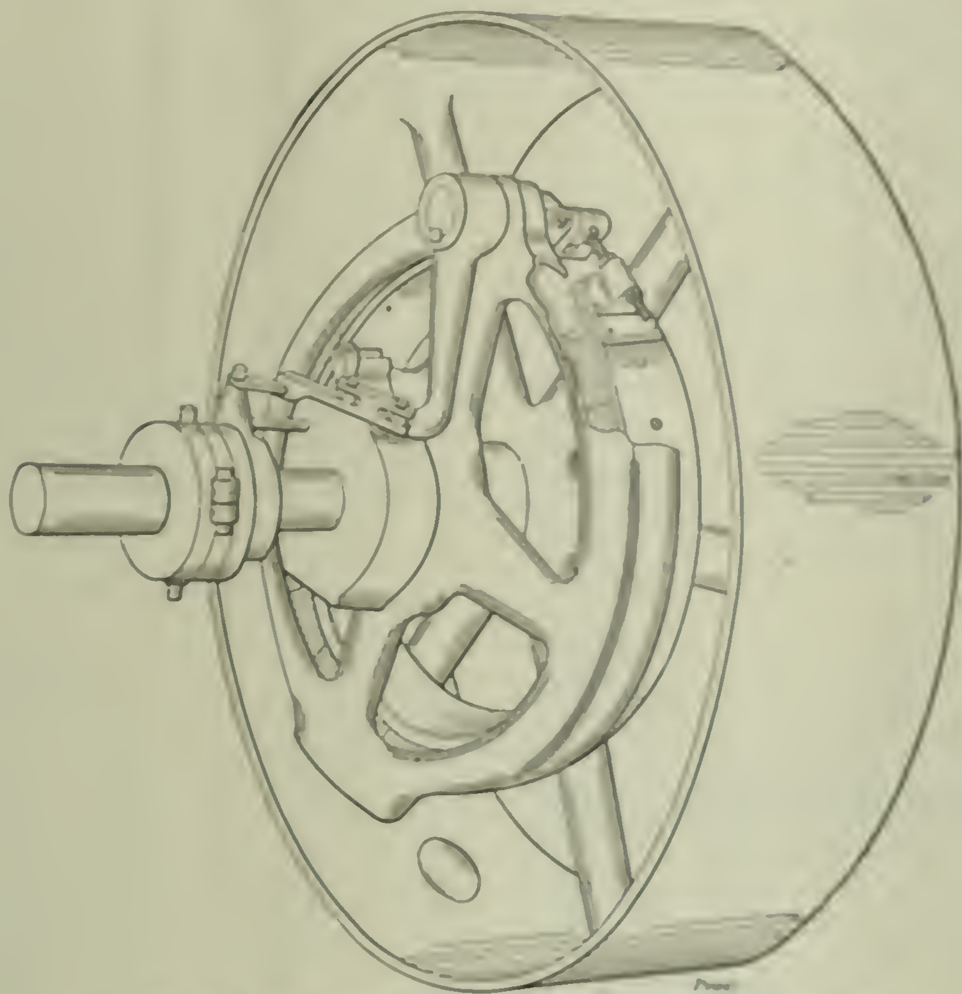


Fig. 16. Caldwell Clutch Attached to Pulley

The Weller Compound Clutch

Figs. 13, 14 and 15 show the Weller compound clutch, designed for high speeds and large powers. The clutch is made with two sets of wedge- or V-shaped wooden shoes extending around its entire circumference. When used as a cutoff coupling, the V-shaped construction of the wooden shoes and iron friction ring or grips which engage the latter helps to keep the shaft in line. The ring or plate to which the wooden shoes are attached is dovetailed into the drum of the clutch and acts as a universal joint when the shafts are out of alinement.

The Weller Manufacturing Company, Chicago, makes this clutch.

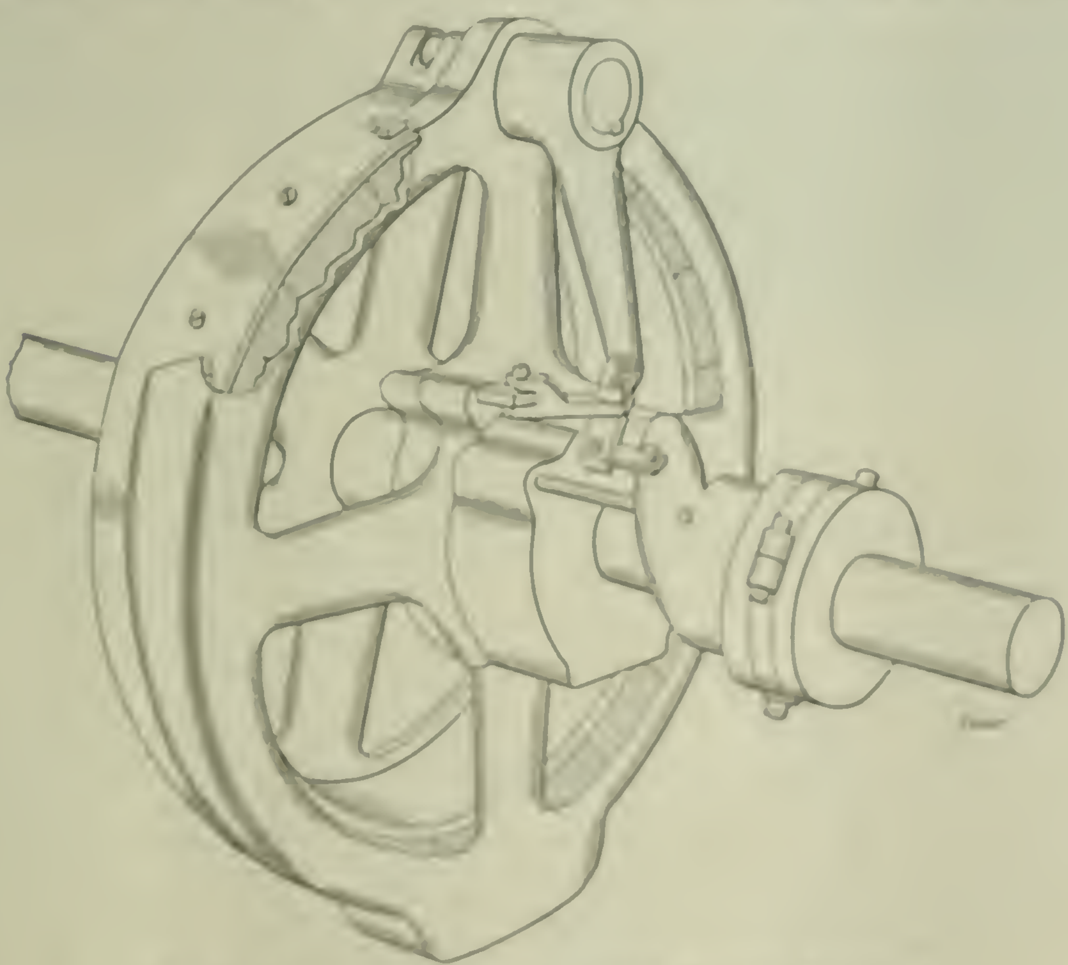


Fig. 17. Caldwell Friction Clutch Cutoff Coupling

The Caldwell Clutch

The Caldwell clutch, shown in Figs. 16 and 17, can be attached to a pulley or used as a friction-clutch coupling. The principal features of the Caldwell clutch are large friction surface, simplicity and small number of parts. A steel friction band is lined with hardwood friction blocks and when the clutch is engaged contact is obtained entirely around the friction surface, distributing the strains equally on all parts of the friction mechanism.

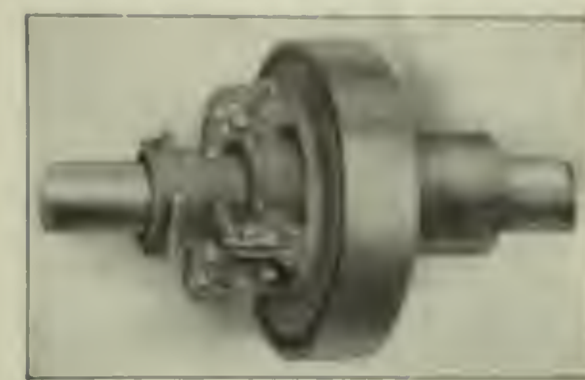


Fig. 18. Universal Giant Friction Clutch Cutoff Coupling

This clutch is manufactured by the W. E. Caldwell Company, Louisville, Ky.

The Universal Giant Clutch

Figs. 18 and 19 show the Universal Giant clutch. This clutch is of compact design, strongly built, easy to apply and readily adjusted. It is designed so that the outer rim covers and protects the friction disks from dust and dirt. The friction surfaces, which have a large area, are wood and iron. Selected hardwood blocks are fitted into the friction disk so as to present two end-grain surfaces which come in contact with the two iron surfaces of the friction plates when thrown into or out of engagement. The friction disk and follower plates adjust themselves with the clutch.

Fig. 19. Universal Giant Clutch Attached to Pulley

The Universal Giant clutch is made by the T. B. Wood's Sons Company, Chambersburg, Penn.

Other clutches will be described in an early issue.

Underground Pipe Covering

By Charles H. Herter

The modern tendency to distribute heat from central points makes it necessary to lay steam pipes underground more frequently than ever; consequently, information on this subject should be appreciated by those who are expected to do underground pipe work in an uptodate manner and at moderate cost.

The essential features of a successful underground conduit conveying steam, hot water, cold brine, ammonia, etc., are now recognized to be perfect insulation and protection. These can only be obtained when the outside of the pipe is always dry. The importance of dryness is only realized fully when it is remembered that the transmission of heat from a steam pipe to surrounding quiet air is from 2.1 to 2.8 B.t.u. per degree Fahrenheit temperature difference per square foot of pipe surface per hour and that proportionately greater losses result when the best possible conditions are not maintained.

Any type of wooden inclosure is subject to decay, sooner or later, and should, therefore, be avoided, for there is available now material which is proof against water, fire, acid and time. A conduit which has been used in many important installations within the past fifteen years is one which is specially prepared for underground service. It is made from stoneware and fireclay, passed through hydraulic presses, vitrified and glazed inside and out. This pipe in form is similar to ordinary bell and spigot sewer pipe, except that, after burning in the kiln, it is split into duplicate numbered halves, for which purpose two downward diagonal grooves are cut along the interior wall, leaving at least one-half of the thickness rough for cementing. Care is taken to cement the same halves together on the job as when mending a broken plate. The conduit comes in 3-foot lengths and in diameters ranging from 6 to 30 inches. There should always be a distance of not less than 3 inches between the wall of the conduit and the nearest steam pipe. One or more and different sized pipes can be inclosed in the same conduit.

About every 15 feet a special supporting tee with the branch set downward and inclosing pipe supports concreted in this base is provided. These supports are provided with rollers, permitting the pipes to expand and contract freely without imposing the least strain upon the conduit. Clamps with anchor bolts embedded in concrete in a blind pit or a manhole are used for anchoring the steam pipes at suitable points, especially where the direction or elevation of the line changes. Expansion is provided for by expansion joints, arranged in water-tight manholes at proper intervals. Where the line enters a building or a manhole, or inside building walls, a shutter is built of 4 inches of concrete on lattice work spread over the opening of the conduit to prevent the passage of vermin from one building to another, and to seal the conduit. Sleeves of suitable pipe covering about a foot long and wired with a waterproof jacket or of the next larger size pipe, are put on each pipe to act as a stuffing box allowing pipes to slide without injury.

For brine and ammonia pipes the conduit can be packed with fine, regranulated cork, say 8 pounds for each cubic foot of space filled. For steam, hot-water pipes, etc., H. W. Johns-Manville Asbesto-Sponge filling has proved to be very efficient, 7½ pounds being required per cubic foot. Its insulating value is exceptionally high and the material does not deteriorate under the heat and moisture met with in practice.

The approved method of laying this conduit is to dig a trench about 20 inches wider than the conduit and of proper depth and grade. As in any first-class work, it is essential to first of all lay an underdrain of sewer pipe in a narrow subtrench, the joints being laid open and not cemented. This underdrain, which is surrounded with broken stone, serves to lead away any water which might otherwise remain in contact with the conduit, absorbing heat much faster than dry material would. Connection to this underdrain can be made with the manhole pits, draining them of any drippings from valves or expansion joints. A clean gravel should ultimately extend up above the side joint of the conduit. Next, the lower halves of the various tile sections, unions and supporting tees, are assembled and cemented, and roll frames to carry the pipes concreted into bases of supporting tees. An opportunity is now presented to thoroughly test the whole pipe line for leaks, after which the upper halves of all conduit sections are cemented exactly in place, one by one, and packed with insulating material. Then the hub joints of the top halves are cemented up.

This type of conduit has been tested in the field by George H. Barrus and others, and found in the case of steam pipes to reduce the loss of heat to the extent of from 89 to over 94 per cent. of that suffered with bare dry pipe. Very few pipe coverings approach and retain this high insulating quality. The cost is little more than for wooden covering and much less than for a pipe tunnel.

Test of Zoelly Turbines

The accompanying table, taken from a recent issue of the *Zeitschrift für das Gesamte Turbinenwesen,* shows the results of a series of tests at different loads on four turbines of the Zoelly type, built by the firm of Escher, Wyss & Co., of Zurich. These turbines are extremely short and show especially good results.

TEST OF NEW ZOELLY TURBINE.

Rating of Turbine.	Kilowatts Developed.	Admission Steam.		Vacuum, Inches.	Steam Consumption, Pounds per Hour per Effective		Thermodynamic Efficiency, Per Cent.
		Gage Pressure.	Temperature, Degrees Fahrenheit.		Kilowatt.	Horsepower.	
4000 kw.	4189	165	556	28.75	13.3	9.25	68.7
	3092	169	557	28.85	13.82	9.50	66.2
	2199	162	518	29.20	14.55	9.71	63.2
	1138	167	520	29.35	16.15	10.00	59.9
2000 kw.	2052	180	586	28.4	13.05	9.10	70.5
	1514	182	563	28.6	13.75	9.40	67.2
	1026	178	566	28.75	14.55	9.67	65.2
	510	172	544	29.00	17.40	10.58	58.8
1700 kw.	1641	206	669	28.00	13.10	8.8	69.7
	1366	203	672	28.20	13.80	9.10	66.5
	851	206	842	28.60	15.55	9.70	61
	457	209	642	28.40	18.95	10.52	57.1
1200 kw.	1235	163	450	28.40	15.40	10.62	67
	949	165	460	28.6	16.05	10.95	62.8
	606	167	424	29.00	17.15	11.35	59

Central Station Will Have to Show 'Em

No. 2, of Missouri, National Association of Stationary Engineers, St. Louis, is sending out to its members a very complete power-plant report blank. This is being done to encourage the engineers to keep a system of records.

The report is a four-page leaflet. On the first page, blank forms are to be filled which call for power-plant investment, total output, capacity of plant, cost per kilowatt-hour, total costs and credits for each month of the year, and other data of a leading character.

The second and third pages are devoted to daily, weekly and monthly costs, including fixed charges, wages, materials, repairs, service of plant, service outside of plant, lamps furnished and credit and bills under control. The fourth page is the daily log.

The report is one of the most completed of its kind that has come under our inspection, and if given the attention it deserves, the members will be better engineers and in addition they will have data that should forestall any encroachment of the central station.

Methods of Testing Boiler Steel

By Guy Wise

A description of the machine used in testing specimens of boiler plate with directions for preparing the test piece and conducting the test.

The formula for calculating the safe working pressure of a steam boiler is

$$\text{Safe working pressure} = \frac{\left(\begin{matrix}\text{Ultimate}\\\text{tensile}\\\text{strength}\end{matrix}\right) \times \left(\begin{matrix}\text{thickness}\\\text{of plate}\end{matrix}\right) \times \left(\begin{matrix}\text{efficiency}\\\text{of joint}\end{matrix}\right)}{\text{Radius of boiler} \times \text{factor of safety}}$$

Before this formula can be used, however, it is necessary to know what value to assign as the ultimate tensile strength of the plate.

It is almost universal practice for large users of steel plate to inspect and test all material bought, in order to make sure that it conforms to the specifications; also, this information, in connection with the results given by the material in actual service, is of great value in determining the requisites that are essential to good service so that these qualities may be specified and secured in future orders. Furthermore, it is common practice for the manufacturers of steel plate to make tests of samples of their entire output so as to know at all times the qualities of their product.

The machine generally used in this work is shown in Figs. 1 and 2. The specimen to be tested is represented by *A*, one end of which is held by the jaws in the upper or fixed head *B*, while the other end is similarly gripped in the lower or movable head *C*. The load is applied to the specimen by the downward movement of the head *C*, at the rate of about one inch per minute, trains of gears being used to drive the screws which draw the head downward. The load to which the specimen is subjected is sustained by the head *B* which, in turn, transfers it through the columns *D D* to the weighing table *E*. Inserted in the lugs on the lower side of the weighing table are hardened-steel pins which rest on the hardened-steel knife-edges of the main weighing levers *F*, which are fulcrumed on the base of the machine. The load is transmitted through the intermediate lever *J* to the graduated weighing beam *G* which carries the screw-driven poise *H*.

The specimens to be tested are sheared from the plate, trimmed to the overall size and then milled to the standard form

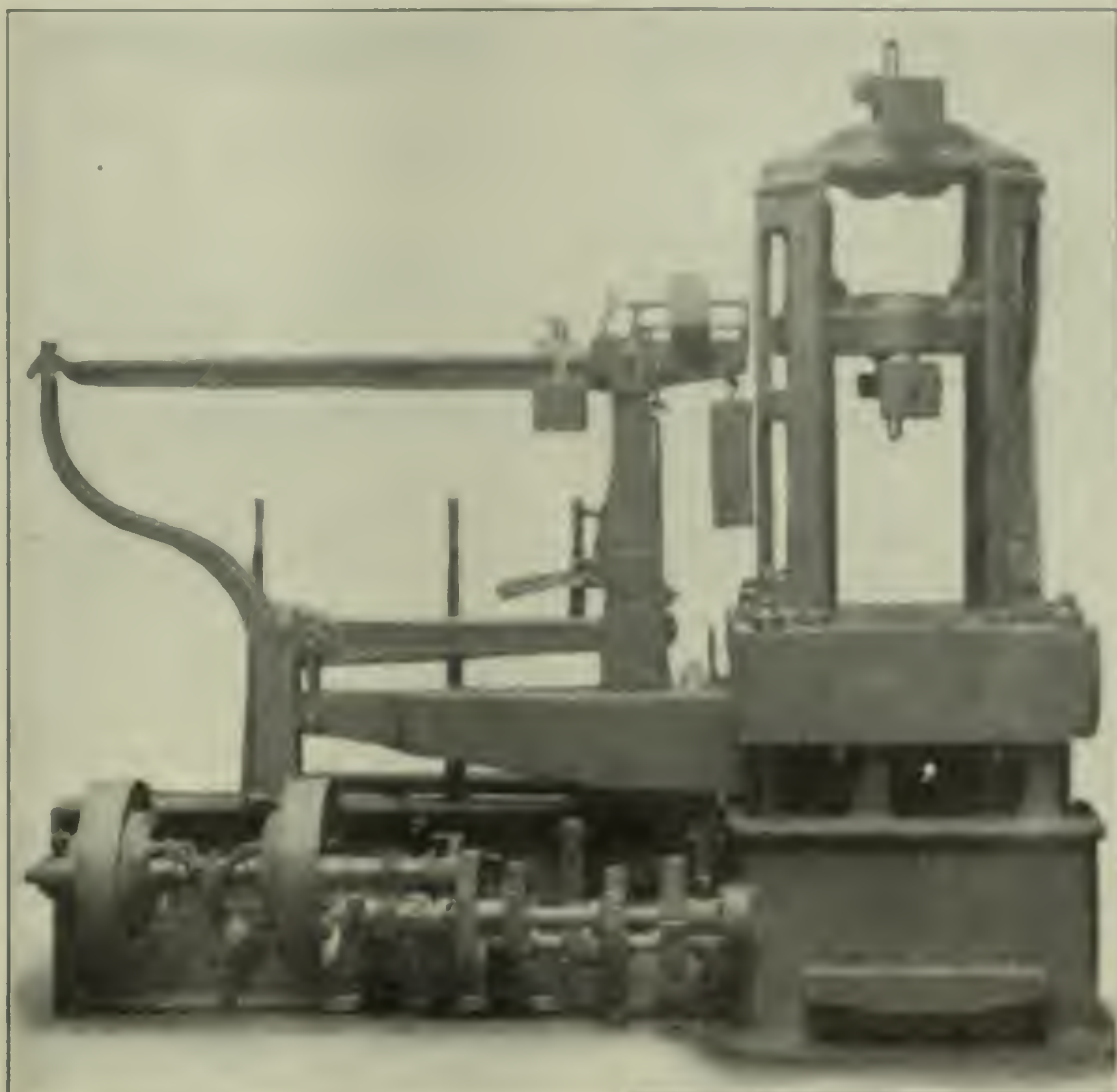


Fig. 1. Testing Machine Showing Driving Gears

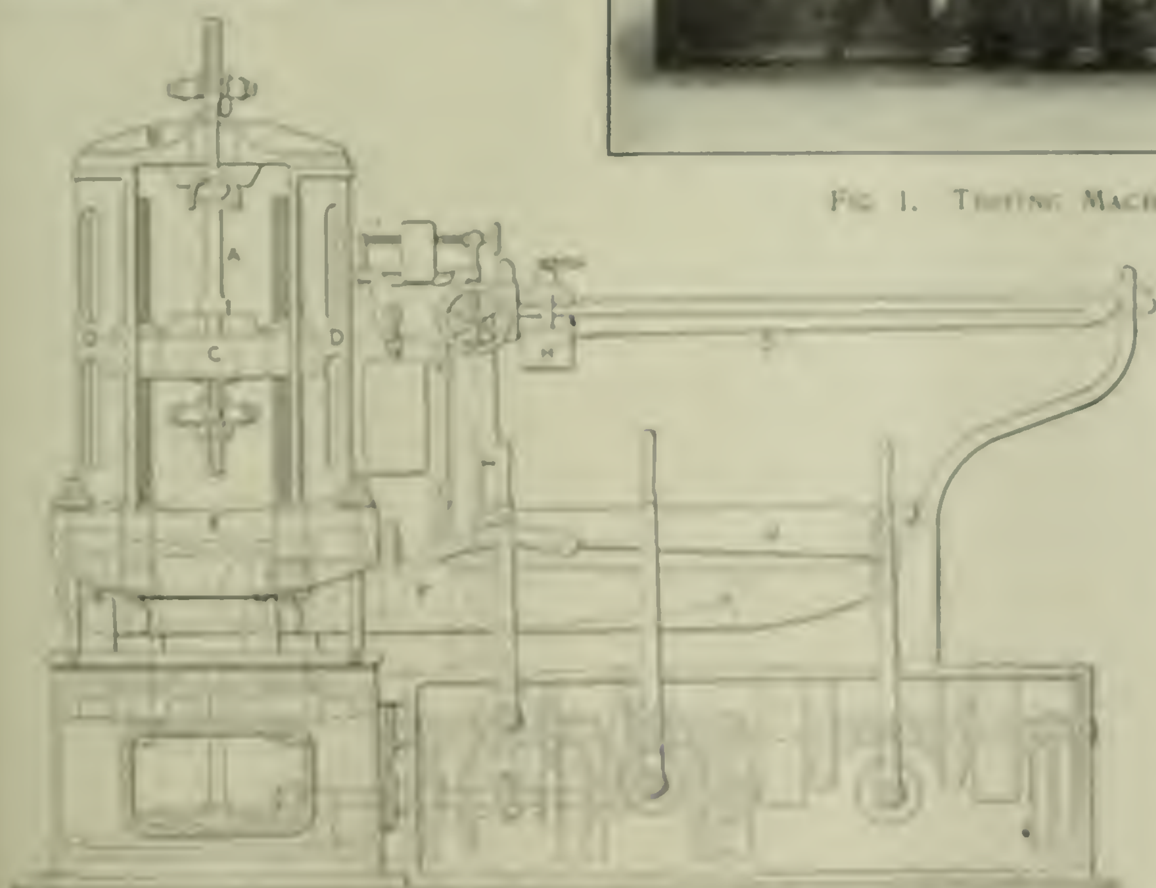


Fig. 2. Sketch of Testing Machine with Test Piece in Place

shown in Fig. 3. Taking one of the specimens thus prepared, two punch marks are placed on it 8 inches apart, the width and thickness are carefully measured and the readings recorded, after which it is placed in the grips of the testing machine. The machine is started and the observer then operates the poise so that the weighing beam is kept floating; it is necessary to maintain this condition in order that the load on the specimen at any instant may be known. For a short time the load rises rapidly until a point is reached at which the beam drops suddenly. Noting the load on the beam at this point and recording it as the elastic limit, the test is continued, generally at a higher speed, and the beam maintained in the floating position as before.

After passing the elastic limit the load increases steadily but slowly, even with an increase of speed, until the maximum load that the specimen can sustain is reached, when the beam drops and remains down. The load indicated on the beam at this point is recorded as the ultimate tensile strength. Also, the test piece is seen to be growing thinner at the place where rupture later occurs. From now on until the specimen breaks it is necessary to run the poise of the weighing beam backward if it is desired to keep the beam floating; this is practically never done as load readings beyond the maximum are not desired.

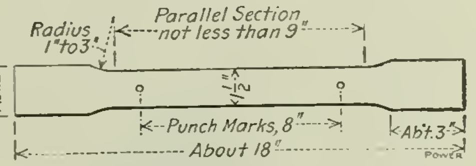


FIG. 3. STANDARD SIZE OF TEST PIECE

Immediately after rupture has taken place the machine is stopped and the specimen is removed. The shape of the fracture and the character of the steel are carefully examined and noted. The pieces are fitted together in their original position and the distance between the punch marks is measured. This dimension shows how much the specimen has been stretched.

Assume, for instance, the data taken during the test to be as follows: Final size, 1.48x0.52 inches; final area, 0.77 square inch; elastic limit, 25,680 pounds; ultimate strength, 46,820 pounds; elongation in 8 inches, 2.32 inches.

In order to be able to compare the results derived from the tensile tests of

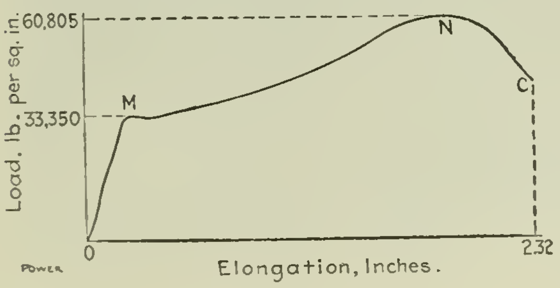


FIG. 4. CHARACTERISTIC CURVE

specimens of different thicknesses and widths, the data must be reduced in each case to the same basis. The necessary calculations are made so as to show the elastic limit in pounds per square inch of original area, the ultimate strength in pounds per square inch of original area and the percentage of elongation in 8 inches. Therefore, the final results of the test are recorded as: Elastic limit, 33,350 pounds per square inch; ultimate strength, 60,805 pounds per square inch; elongation, 29 per cent.

During the test, as described, no attention is paid to the elongation of the specimen other than to measure the distance between the punch marks after rupture. If, however, a number of readings of the elongation are taken and these results are plotted in connection with the loads which produced them, a characteristic curve similar to that shown in Fig. 4 will result. This diagram shows plainly the rapid increase in load for the small elongation which takes place up to the time the elastic limit at *M* is reached; here the load is seen to remain stationary for a time and then increase slowly while the specimen is stretching rapidly. This condition continues until the point *N*, representing the ultimate tensile strength, is reached, after which the load decreases, the specimen now stretching rapidly until rupture occurs at *O*.

The ultimate tensile strength of boiler steel varies from 55,000 to 65,000 pounds per square inch so that in the calculation for the safe working pressure of a boiler the average value of 60,000 pounds per square inch is generally used.

Writing for the Technical Paper

By E. Dixon

Havin' ben afflict'd with "writer's itch," almost since berth, sum pain, plesure an' profit hav' kum mi way from usin' a pencil. Mi furst experience, wuz with mi mother, after I'd dek'erat'd a newly paper'd wall with a few chaste records of mi thoughts. She chas'd me an caught me an I need'd a cushin real bad for the next few days. Gee, but she stung me proper. When I went to the skool, the teacher an' I got in wrong with each other an I us'd the blackboard to express my opinion. The illustrations were rather raw but I had a fair opinion of the writin' until the teacher convinced me that it was impolite.

When I got into the shop, I commenced to fin' out where a lot of the "dope" I'd side stepped wuz useful. Well, there were induc'ments. I saw the foreman knew more nor I did an' wuz not a hull lot delited to supply informashun. It didn't seem squar' to me an' I kep' mi eyes wide opun a lookin' fur things. One day I caught on to the fac' that the way Jim figgered out the change gears fur a screw I wuz to cut had a sorter familiar look, an' that nite to hum I dug up mi rithmetic. I found a part of it call'd "proportion" an' I set down to study it out. I'd made a list of the change gears fur the lathe an' the number of threads in the lead screw an' the number of teeth on the spindle gear. I dugged 'till I got the thing strait in mi noddle an' the nex' time I had a thread to cut I made bluff an' figgered out the gears. Jim nearly scart me stiff after figgering them for he changed the two intermediates, but I didn't hold mi breth none. I jus' counted their teeth an foun' out I'd been right an' Jim 'd chang'd them to keep me frum gettin' wise. I'd foun' out I wasn't the only one an that week I foun' a copy of the *American Machinist* at the library. It looked good to me, an' I saw a notiz that they pade fur things sent in wich they used. I knew sum of the other boys didn't know how to figger out the gears an' to get it fast in mi nut I made a try tu put it down on paper so I could understan' it. When I got it in shape I'd near swet blood, an', thinkin' of the others who didn't know, I puts 'er in an envelop an' mails 'er. Well, I got a notiz sayin' my contribushun had been receipted an' I waited, an' I waited. Then one day I saw mi piece, at least they had mi name to it. I wuz sore. After all the time I tuk to get that thing done good the editur hadn't left much to it but mi name. I wuz mad, but aftur I'd cooled down a bit I read 'er again, an tuk mi time to it. The editur'd done sum things which made me take notiz. Sum of the things had ben a bit muddy when I wrote them out but now they'd ben made clear. I got tu thinkin' to miself that they'd never think mi stuff woth payin' for, they way they'd treat'd it, an' when I got the check frum the papur it seem'd like sumthin' fur nothin'. I need'd the mun' an tuk the check tu the cashier.

Say, I must 'a spent that "V" 'steen times, ther' wer' so many things I want'd, but Old John, the engineer, waz a teachin' me tu run the engine an' I sent fur a "Tulley." I'd had longin's fur that book but I'd never had the coin tu get it. The rest uv the "fortune" tuk me an' mi steady tu the "Lake" an' we had a boat ride an' sum ice-creme soda. Mebbe I didn't feel that "brain money" burn mi pockit. When Old John quit they gave me the engine an' after I'd run 'er awhile I'd got a better job to the power house. By this time I'd seen mi name in print several times an' I kep' right on a writin' an' a sendin' it in. The more I writ, the easier it becum an' the goods seem'd to stick to me. I studied to write an' I writ'd what I studied. Then I got a raise, not the toe kind.

Onc't I learn'd sumthin' not in the books or the plant. I'd been a visitin' an I told about a place I saw. The man that run it was heftier nor me by 50 pounds an' sum kin' fren' show'd him what I'd said. He came over tu see me an' after he'd gone I bo't sum beef steak. Then I'd foun' sum of mi frens'd argue 'bout what I'd said an' get real personal. An' I fin'lly conclud'd that I'd use a nomme due plum like sum of the big ones. The editur didn't object an' gradu'ly cut out writin' in my own name, an' it 'sav'd a heap of argument. Sum of the boys as't me 'bout it an' I 'splained the writin' took too much time an' they want'd to know who the guy wuz who seemed to kno' so much about the lokul doin's. I didn't tell but I kep' right on a writin' an w'ile I'll never get rich quick at the game, there's a big lot more in it than the checks I get. I'm helpin' the other feller an' am a charter member of the league of self-risers, no dues, no admission fees, the only qualifications bein' a bit of grit an' stic'-to-it-iv'ness.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Some Features of Induction Motor Operation

By W. A. Hill

When the Willys-Overland Company took over the plant of the Pope Motor Car Company, of Toledo, O., to manufacture automobiles, the factory machinery was group-driven by direct-current motors ranging from 1 to 50 horsepower, the total connected load being about 650 horsepower. In most cases the motors were mounted on the floor in the corners of the rooms; in some instances, however, one motor was used to drive three floors. Upon extending and rearranging the plant it was found expedient to change over to alternating current, the increased load being large enough to justify the central station in putting a transformer substation right on the factory premises.

Three-phase currents at 4000 volts and 25 cycles are transmitted from the central station, about three miles distant, through one-half mile of underground and 2½ miles of overhead feeders consisting of three No. 0000 solid copper wire and a neutral of No. 4 copper wire which is grounded at the power house. The high-tension feeders are brought over the property on poles to a transformer station located at the center of distribution, and there stepped down to 440 volts for power purposes and 115 volts for lighting service. Separate transformers are provided, of course, for the lighting and power services.

Notwithstanding the separation of the secondary circuits, however, the fact that the lighting transformers are supplied with current from the same primary circuit which supplies the motor transformers has caused some difficulty in maintaining constant voltage at the lamps. This is occasioned by the fall and rise of the primary voltage when motors are thrown on and off the circuits, the trouble is worse, of course, when a large number of motors is stopped at one time, as at noon and evening each day. In fact, it is so objectionable that special provision has been made for correcting the voltage variation.

The 115-volt incandescent lamp circuits are supplied from transformers connected star or Y-fashion at the primary terminals. The primary winding of each of these transformers is provided with a 5 per cent. tap and these taps are connected to one pole of a single-pole double-throw knife-blade switch. The primary terminal nearest the 5 per cent. tap is carried to the other pole of the corresponding switch. The blades of the three switches are connected together, forming the neutral for the star connection. This arrangement is illustrated diagrammatically in Fig. 1.

Normally, when the motors are in operation the primary voltage is pulled down to approximately 3800 volts, which would reduce the secondary voltage of the lighting transformers to about 110 volts if the full primary windings of the lighting transformers were in circuit, and this, of course, would dim the lamps to a very objectionable degree. When the motors are started, the switches are set to supply the lighting transformers through the 5 per cent. taps, thereby reducing the transformer ratio and consequently raising the secondary voltage. Under these conditions the 5 per cent. drop in primary voltage is offset by a 5 per cent. reduction in the turns of each primary winding, giving practically the same voltage to the secondary circuits that the full primary windings would give with the full primary voltage.

After the motors have been stopped the voltage comes back to normal and with the lighting transformers connected as described an excessive voltage would be impressed on secondaries; to prevent this the automatic arrangement shown in the diagram is provided. The operation of the apparatus is as follows:

When the motors are thrown on, pulling down the primary voltage, the switch blades *A*, *B* and *C* are pulled to the right by means of the rope with a handle at *H*, connecting the neutral point to the 5 per cent. taps instead of the main terminals. The weight *E* is lifted until caught by the latch *F* and the switch *D* is closed, completing a circuit through the voltmeter relay *R*. This voltmeter is so adjusted that when the secondary voltage rises to 125 it closes the circuit through the solenoid *M* which trips the latch *F* and allows the weight *E* to fall. The weight pulls the switches *A*, *B* and *C* to the left, cutting in the whole of the primary winding, as shown here, and preventing the secondary voltage from remaining too high. At the same time the switch *D* breaks the solenoid circuit; consequently the windings of the meter and the solenoid are not kept in circuit unnecessarily.

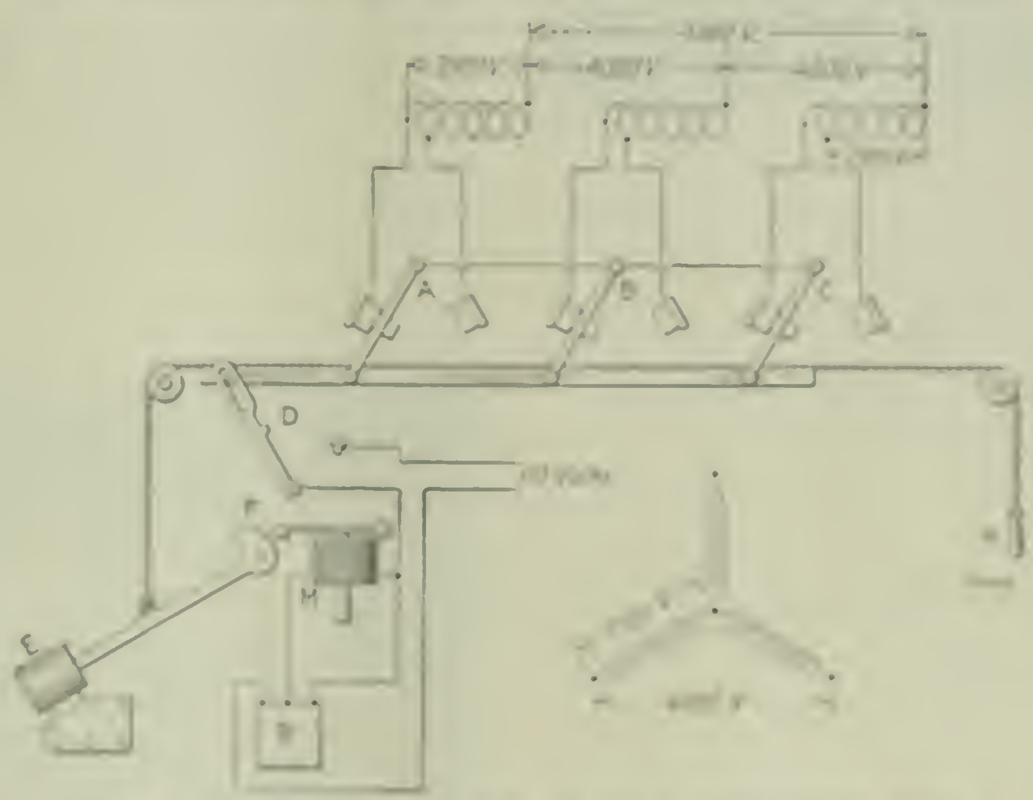


Fig. 1. Diagram of Device for Changing Transformer Ratio

A single stick connects the switch blades and is pulled back and forth by ordinary sash cord running over pulleys. The weight *E* drops on a rubber buffer and, therefore, the switch contacts are not subjected to any extra shock when the weight falls.

Owing to the character of manufacture and plant arrangement, group drive was retained except in a very few cases. The direct-current motors which have been displaced were set on the floor and belted to the line shafts at about 45 degrees. Owing to the amount of space required for the motor and belt, which necessarily

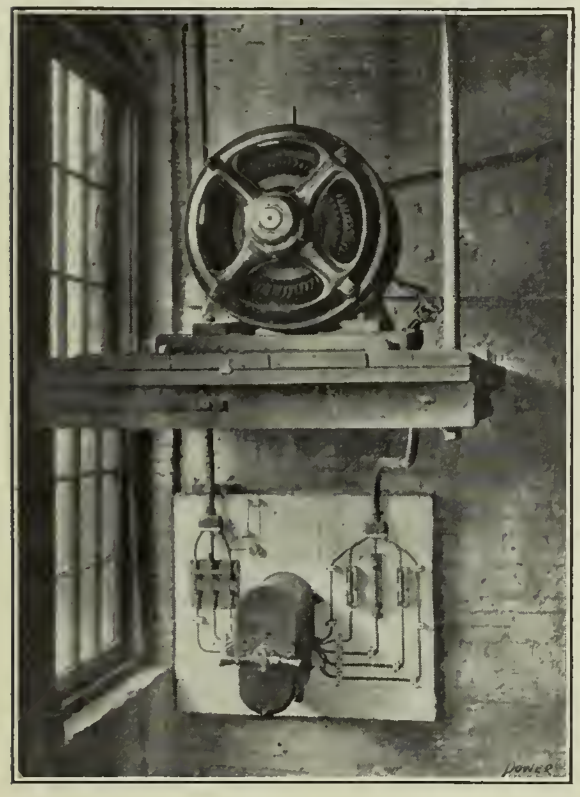


FIG. 2. A PLATFORM EQUIPMENT

had to be boxed in so as to eliminate the possibility of employees coming in contact with it, it was found advisable to either suspend the new motors from the ceiling or mount them on platforms. Most of the motors are of 20 to 50 horsepower, and motors of such sizes are not so accessible when suspended from the ceiling; moreover, the ordinary ceiling will not stand such an arrangement without reinforcement; consequently, the platform installation was adopted. Fig. 2 illustrates one of these. The ceilings average about 16 feet from the floor, and the motor platform clears the floor 8 feet.

In some instances the platform is placed in the corners of rooms, as in Fig. 3, and in others it is located in a convenient space and suspended by 1-inch round-steel rods in 2-inch pipe spacers. The platform frame is of 6x6-inch pine timbers and floored with a double layer of 2-inch planking. The platform is large enough to allow the removal of the rotor without lowering any parts to the floor below. Where the platform is located in a corner the walls carry a portion of the weight of the frame through a projection of the frame timbers mortised into the brickwork. The frame is further tied to the wall by means of lagged straps which pass through the brickwork. Those platforms located away from side walls are suspended by four bolts and steadied by ⅝-inch tie rods and turnbuckles which extend from each corner to the ceiling at an angle of 45 degrees to the edges and surface of the platform. Beneath every platform is a cluster of four incandescent lamps, the function of which is not merely to give light at this particular location but also to indicate whether the power is off or on.

In starting an induction motor one of the running fuses may blow and leave the motor running single-phase; if left in this condition very long, the active winding may be burned out. To detect burnedout fuses, an arrangement is used which consists of a fuse-block with a 2-ampere fuse connected to about six feet of lamp cord equipped with terminals similar to those on a portable voltmeter. Upon connecting this to the terminals of a fuse to be tested, if the fuse has blown the fact will be indicated by the blowing of the 2-ampere test fuse. This is a cheap device and can be used while the motor is running.

Some difficulty was experienced due to the static electricity generated by the slipping of the belt on the iron line-shaft pulley. Various brush devices were tried to take the static charge from the belt, but these soon become deranged and rendered useless from various causes. All motor frames are now grounded through resistors of about 200,000 ohms resistance, made up of two ¼x12-inch round graphite rods; this effectively removes the static charge.

The motors are blown out with compressed air once a week. Compressed air is piped to most departments to op-

FIG. 3. A SIDE-WALL PLATFORM

erate portable tools or to keep machine tables free from chips. Taps are taken from this general distribution system and a ⅜-inch pipe is carried close to each motor, terminating in a valve and the male portion of a hose coupling to receive a hose for blowing out the motor (note the air tap at the left of the motor in Fig. 2).

The oil is changed in the bearings and the bearings washed out with gasolene at least every six months; those located in dirty places are cleaned more frequently. Current readings are taken from the motors at frequent intervals, or whenever a motor appears to be overloaded, a portable ammeter being provided especially for that purpose. As nearly as possible the motors are given full load; by changing motors to suit the load, the power factor and load factor are maintained reasonably high. At present the load factor is 75 per cent. and the power factor 82 per cent.

Telephones in the Power Plant

By W. H. RADCLIFFE

Amongst the minor devices that have contributed largely toward facilitating the supervision and executive control of power plants is the telephone. In the average power plant, telephones can be advantageously used for communication between the boiler room, the engine or dynamo room, the switchboard gallery, the storage-battery room, the repair shop, the stock room and the offices of the various officials of the company.

Ordinarily, the telephone requirements of a power plant come well within the range of capacity for which intercommunicating telephones are manufactured; the maximum capacity is about thirty stations or telephones. On the front of each telephone set is a button or key for each of the stations in the system. If there are ten stations in the plant there are ten buttons on each telephone; if, in addition, there is one trunk line to a central exchange, there are eleven buttons on each telephone. The buttons are labeled "Boiler Room," "Dynamo Room," "Switchboard Gallery," "Battery Room," etc., and pressing a button automatically connects the caller with the telephone corresponding to the button pressed, and signals the called station by ringing the bell there.

One of the principal advantages of the intercommunicating telephone system for a power plant is its low operating cost as compared with other telephone systems. It is entirely automatic in action; that is, no telephone operator is required to complete the connections, this being done by pressing the proper button, as just explained. There is therefore no operating expense except the renewal of a few dry cells once or twice a year.

Another advantage of the intercommunicating telephone system for power plants is the fact that the service is available at all hours of every day and night. Furthermore, no separate switchboard is needed, the buttons and keys on the telephone sets serving in place of this expensive and rather complicated piece of apparatus.

If more than thirty telephones or thereabouts are required, and if connections with outside parties through a central exchange are of frequent occurrence, the private exchange system is necessary. A separate switchboard is required in the private exchange system, as well as an operator to attend it, connections between stations within the plant being made by the switchboard operator instead of by the party who uses the telephone.

Whichever system is used, the benefits derived from the prompt giving and receiving of orders and the transmission of information without leaving one's work, the quick adjustment of matters in emergencies and the coöperation among the employees result in a saving of time and an efficiency of operation that are out of all proportion to the expense of the telephone system.

Connecting a New Compound Wound Dynamo

By G. J. Reynolds

While employed as construction foreman for a large factory, I was sent out

Fig. 1. First Connections

to wire up and start a 100-kilowatt railway generator. This machine was to operate in parallel with two others that were already in service. Before beginning to wire up the new generator the switchboard was looked over but the connections to the old generators were not

Fig. 2. Second Connections

checked. The positive and negative busbars were easily identified by the connections to the outgoing feeder circuits.

Assuming that the old machines equalized on the positive side, the new generator *C* was wired as shown in Fig. 1 and started, but it refused to generate. In order to restore its residual magnetism, all of the brushes on the machine were raised from the commutator and its main switch thrown in; instantly, the circuit-breakers on the old machines went out. The condition that really existed is easily seen by observing the arrows showing the direction of the current. A short-circuit was thrown on the machines *A* and *B* through the series field winding of the new machine. If all the connections had been normal, the shunt field winding of the generator *C* would have been energized by current from the bus-

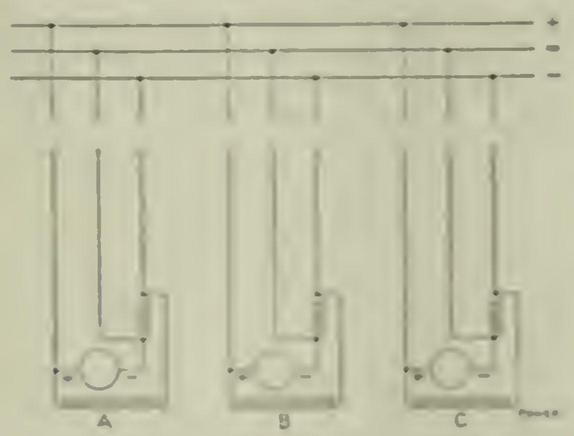


Fig. 3. Final and Correct Connections

bars without interfering with the operation of *A* and *B*.

In endeavoring to locate the trouble we found that *A* and *B* were connected to equalize on the negative side. When making changes in the wiring, the equalizers were connected to the busbar side of the series field windings, as shown in Fig. 2; the machines would not run in parallel satisfactorily when connected in this manner, for the reason that the series field windings were not equalized, as the diagram disclosed. For fear that a mistake had been made in testing for polarity, a portable voltmeter was used to check the one on the switchboard. As an additional but very simple proof, we connected wires to the machine terminals and stuck them into a bucket of water. Bubbles arose from the negative terminal.

After many unsuccessful attempts to parallel the generators, we finally connected them as in Fig. 3 and no further trouble was experienced.

LETTERS

Sparking Brushes Cured by Paraffin

Some time since, the brushes on two motors in our plant began sparking very badly. One was a 15-horsepower machine running at about two-thirds its full load, and the other was rated at 5 horsepower; both ran continuously from sixteen to eighteen hours per day. The brushes sparked so badly that it was necessary to sandpaper the commutators and brushes two or three times a day. The ammeter showed that the motors were not overloaded, and shifting the brushes did no good.

As an experiment we took the brushes from the 15-horsepower motor and boiled them in paraffin. They worked "like a charm," and we lost little time in "experimenting" with the other motor, which is now doing as well as the smaller one.

E. D. Nitchals.

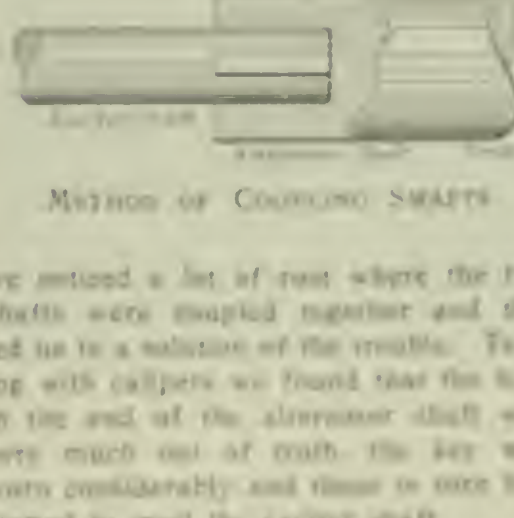
Kansas City, Mo.

[This remedy frequently, but not always, produces the result described. The explanation seems to be that the paraffin increases the electrical resistance of the brush face, which merely increases the difference between the "commutating ability" of a carbon brush and that of a copper brush. The paraffin also lubricates the surfaces and thereby reduces chattering and abrasion.—Editor.]

An Unusual Cause of Commutator Trouble

Some time ago we began to have brush trouble with the exciter of a belt-driven alternator. The commutator became so rapidly and badly injured by sparking that it had to be turned off every two weeks. Our efforts to remedy the trouble were somewhat instructive as we began to make various adjustments which resulted in a better knowledge of the machine and smoother running.

However, we ordered an extra armature and installed it and as everything started off all right we thought our troubles were over. But after two months we had to turn down the commutator of the new armature. On taking out the armature



Method of Coupling Shafts

we noticed a lot of rust where the two shafts were coupled together and this led us to a solution of the trouble. Testing with calipers we found that the hole in the end of the alternator shaft was very much out of truth, the key was worn considerably and these in turn had started to spoil the exciter shaft.

At week-end I had a slide rest taken from a 24-inch lathe and having taken the exciter off the base I blocked up with wood until the tool lined up true with the hole. I then plugged up the keyway with hard wood and started to bore by running the engine as slowly as possible and feeding the tool very gradually. In two hours we succeeded in getting a perfectly round hole [illegible] inch larger than the original one. Then we chipped the keyway deeper and [illegible] it up. The end of the exciter shaft was turned true and a phosphor-bronze bushing was fitted to the new diameter, and a keyway cut along its length.

The exciter was again put in operation and up to the present time we have had no trouble, although we have run it ten months, during four of which the machine has run 24 hours a day.

GEO. H. HANDLEY.

Newburgh, N. Y.

Effect of Impaired Rotor Insulation and Contacts

In a recent number of POWER I noticed a letter relative to an induction motor that refused to carry its rated load. This calls to mind an experience I had some time ago with a 50-horsepower two-phase motor that I rewound after a primary burn-out. The insulating material around the bars of the rotor was carbonized and the bars had been hot enough to oxidize them. As the bolts which held the bars to the end rings were battered over the nuts it was almost impossible to remove the nuts with the tools at hand, so I let the rotor go as it was.

After rewinding the stator and putting the motor in place it ran up to speed when tested with no load. It is direct-connected to a centrifugal pump and as water was not needed at the time I heard nothing of it for some time after. When they began to pump, however, I was notified that the pump was not lifting its usual amount of water. Investigation showed that the motor ran 100 revolutions per minute slower with the load than when it was free. I could attribute this to nothing but extra resistance in the rotor circuit. We made suitable socket wrenches and took out the rotor bars, cleaned the contact surfaces to bright metal with emery cloth, cleaned out the slots and put in new cells of paraffined paper and reassembled the rotor. This remedied the trouble. I think Mr. Blue will find his trouble to be like mine.

F. W. CERNY.

Mesa, Ariz.

The Simplest Current and Polarity Indicator

During the past few weeks this department has contained letters from various correspondents describing different methods of testing electric circuits in order to determine whether the current was alternating or direct; and also in some cases of detecting the polarity of direct-current circuits. All of the methods described were very interesting, and of various degrees of utility and convenience.

I have used for many years a method which might prove interesting to those of your readers who have need for it, and one which I believe has not been mentioned by any other correspondent. Simply tear a small piece off a blueprint, wet it and place the two ends of a pair of wires connected to the circuit to be tested in contact with the blue side of the print. The wire ends should be placed from a half inch to two inches apart, depending on the voltage. If the current is alternating, practically no effect will be produced, but if the current is direct, a white spot will appear under the *negative* wire. Any piece of blueprint paper will do provided it has been exposed.

I. SAWFORD.

Sydney, Nova Scotia.

Can These Alternators Be Operated in Parallel?

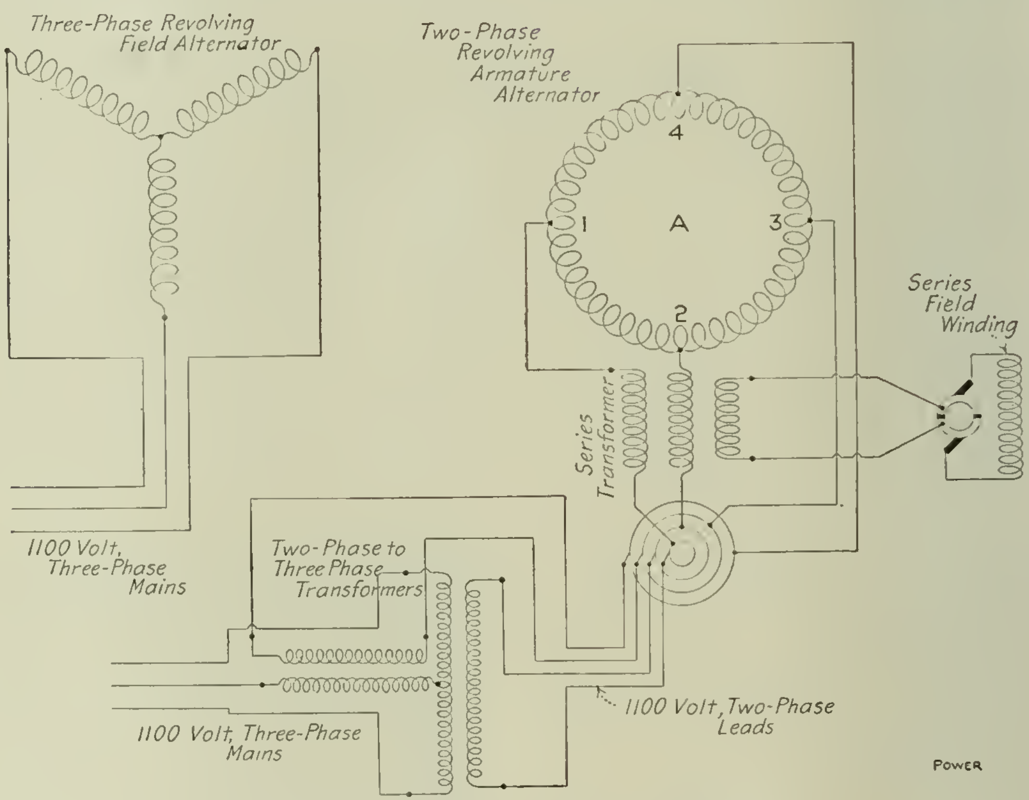
In our plant are two alternators which we wish to operate in parallel through transformers if possible. One is a three-phase 150-kilowatt revolving-field generator and the other is a 120-kilowatt two-phase revolving-armature machine equipped with a rectifier and a compensating winding. Both generate 1100 volts and 60 cycles.

Will some of the other readers express their opinions as to whether the two-phase machine, delivering through a two-phase three-phase transformer, as indicated in the sketch, can be worked in parallel with the three-phase machine? Furthermore, if the two machines can be operated in parallel, would the compensating winding of the two-phase machine have to be discarded altogether and new field-magnet coils installed in order that the field magnet may be energized entirely by the exciter, or could the winding be left as it is and the machine connected as shown in the sketch?

As the load supplied by these alternators is made up principally of incandescent lamps, the power factor may be considered relatively high. There are a few motors, all of them small, and only ten arc lamps; the rest of the load is in incandescent lamps.

D. M. GROVE.

Covington, Va.



CAN THESE ALTERNATORS BE PARALLELED?

Side Stepping Crane Troubles

It is not always the highly educated man but rather the practical man threatened with intelligence and natural resourceful ideas who gets results without looking up his card system—which, however, is of great value.

A short time ago the hoist armature of a 50-ton electric crane became badly grounded, with a load of 60 tons hanging about ten feet in the air and in the middle of a large machine shop. The electrical expert was called up on the jump and decided the armature must be changed; as the load hung in the middle of the shop too low to be bridged to one end and the two other cranes tied up one side, the delay meant dollars and cents to the firm. The idea occurred to the repairman to place heavy paper on the rails of the bridge, rack the trolley onto the paper, thereby insulating the trolley from ground, and lower the load to the wood floor. This was done, the block hoisted up and the crane run to one end of the shop for repairs, with about fifteen minutes' delay all told.

In another instance a hoist controller was burned out with an important job hanging on. The wires to the hoist motor were tapped onto the bridge controller, the job handled, the wires transferred back again and the crane run to one end of the shop for repairs without serious delay to the work.

In another instance one field-magnet coil of a hoist motor burned out with the load on; the coil was cut out and the motor run without it until the job was finished. The repair was made at a more convenient time. A little ingenuity will often save a whole lot of time and trouble in cases of this kind.

WILLIAM PRICE.

Philadelphia, Penn.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Engine and Piping Changes

A tandem compound high-speed engine gave trouble from the time it was installed about ten years ago. In spite of all that could be done by the engineer in charge, local machinists, or even the man sent by the makers, the engine still pounded and made so much noise that it could be heard for blocks at times. Finally, the crosshead shoe came off, the crosshead dropped down, bending the piston rod, and that broke off the stuffing box which was screwed into the cylinder head.

For six or seven years this engine ran for about 15 hours a day, six days a week for nine months in the year, but for the last three or four years it had only run about 12 or 15 days during the entire year, and every time it became necessary to run it there was a general kick from the fireman.

The engine was connected to exhaust into the heating system, the back pressure in which varied from zero to 20 pounds. At the higher back pressure the engine would not carry its full load and was a steam eater. The fireman claimed that it made little difference whether the exhaust went to the heating system or not.

The engine was turned over to me with instructions to have the necessary repairs made to put it in a condition to run. I removed the high-pressure cylinder, which also formed the head for the low-pressure cylinder, and separated the high-pressure cylinder from the low-pressure cylinder head by drilling a series of holes around at the point where the front ports entered the cylinder and faced it off. As the high-pressure valve was of the piston type this left a hole through which the steam formerly passed from the high-pressure cylinder to the low-pressure steam chest. A flange was secured over this hole by cap screws, and to this, by means of nipples and an ell, the throttle valve was attached, as shown in Fig. 1.

FIG. 1. HOW THE THROTTLE VALVE WAS ATTACHED TO THE STEAM CHEST

Another condition prevailed which was unsatisfactory. The steam piping entered the engine room through an 8-inch header. From this header steam was taken out of the top through a 5-inch short nipple and ell, and then through about 4 feet of pipe running at a right angle to the header with a turned-up ell at the end; then through a short nipple and another ell with about 3 feet of pipe running parallel with the header, on the end of which was an ell turned downward and from which the pipe led down to the separator and throttle valve. This formed a large pocket where water could collect, both when the engine was shut down and when running light. When the engine was started or a sudden load came on, more water would come over than the separator could handle. I had this piping taken down and the order reversed, taking steam from the bottom of the header and leaving no point in which water could collect. What condensation there was came gradually to the separator, where it was taken care of. The changed piping is shown in Fig. 2.

FIG. 2. NEW ARRANGEMENT OF THE STEAM PIPING

The engine was then put together and started up. To the surprise of all, it ran so smoothly that standing 10 feet away one could not hear it run, not only with no load but with full load, when handling a 10 to 20 per cent. fluctuation without the attendant ever knowing that there had been a change in the load.

The engine exhausted from the bottom and immediately under the cylinder there was a valve to prevent the water from backing up into the engine from the heating system when the engine was shut down. The pipe dropped about 20 inches into a trench and extended horizontally about 8 feet, and then turned up and went to the heating system through an oil separator and past the relief valve.

At the ell where the pipe turned up out of the trench there was placed a ¾-inch bleeder valve. With the engine shut down and the valve under the cylinder closed, all of the pipe, including the drop from the engine, the horizontal pipe in the trench and the riser, about 30 feet in all, would fill with water and before starting up it was necessary to drain this pipe by opening the bleeder. All would go well until the water got down to the level with the top of the horizontal pipe, when a water hammer would start. In order to remedy this I removed the valve from under the cylinder and placed it in the vertical pipe at a convenient hight with a bleeder tapped in just above the valve

Fig. 3. Valve and Bleeder in Vertical Exhaust Pipe

to drain what water might collect above this point. This is shown in Fig. 3. Since then I have had absolutely no water hammer. Before this change it was necessary to go over the engine every day, and a straight run of 34 hours was the longest the engine had ever been known to run without a stop for adjustment. Since then I have made runs of 60 hours and there was no reason why it could not have continued in service as there was nothing to be done before starting again.

S. E. Shaff.

Iowa City, Ia.

Steam Plant Installation Costs

Published articles that would be of permanent value to engineers would be those dealing with the details of methods and materials used in installing engines, boilers and other power-plant apparatus. Also data regarding the prices paid per hour to erectors and other workmen, the time required and the material used for each separate piece of work.

One engineer could give reliable data about an installation of water-tube or fire-tube boilers and another about installing an engine, when they might not be in a position to give reliable cost data on an entire plant.

Descriptions of power plants can be found in almost every issue of technical journals, but very little itemized installing-cost data can be found in any of them.

The small amount of reliable information along this line makes it very difficult for an engineer inexperienced in this class of work to give his employer satisfactory information as to the cost of installing apparatus of various kinds. The novices will generally underestimate the cost and the difficulties of doing good work.

Of course, cost of material and labor vary in different sections of the country, but this matter could be adjusted to suit the conditions existing by the interested investigators.

Supply costs should be complete to the smallest detail to be of real value.

J. E. Noble.

Toronto, Can.

Throttling Governor Failure

A rather queer failure of a throttling governor came to my notice lately, which may be of interest.

The 4-inch governor was of the common type without a safety attachment of any kind. One night it was necessary to screw the stem up several turns more than was usual to make the engine carry the load and as shutting-down time arrived steam was cut off completely.

When the governor was taken apart, the pin through the nut was found sheared off, the nut had unthreaded and the plug had dropped down. A new pin was put in place and everything went all right for two or three nights more when it was again necessary to screw the valve stem clear up. Of course, it was expected that the nut had again worked loose, but to the surprise of all hands everything was all right, and when the governor was put together the load was carried with the stem in the usual position for a while, but it soon had to be put up again. When in this position the engine suddenly began to race and only the sprinting ability of the engineer on watch kept the flywheel in one piece. Next day the pipe line was examined for anything that might obstruct the passage of steam, but nothing could be found.

The engine and governor had always been cold when looked into. One more try was made but something still held the steam back. As the engine stopped, I took hold of the governor flyballs and tried to spread them, but with a very slight movement the plug at the end of the stem struck hard against the pin which limits the downward travel.

Here was the trouble sure enough, but as nothing could have made the stem longer the parts in the valve body must have shifted. Another look when everything was hot showed that the brass lining was up about ½ inch above its proper place. The valve body was of cast iron and the brass bushing had been pressed into it but no provision had been made to hold it in place. The difference in expansion between iron and brass allowed the bushing to drop down into its proper place as soon as it cooled off and as no one had never looked at it immediately after stopping, the bushing had never been noticed out of place. A good strong pin now holds it where it belongs.

My theory is that when first warming up the engine a slug of water or perhaps the steam would force it up before the expansion had tightened it.

Verne L. Ballou.

Shirley, Mass.

The Human Element in the Power Plant

Perhaps one could find a greater variety of opinions upon the subject of the human element in the power plant than any other; it may also be quite true that no two men can be handled in the same way, in consequence of which no set of rules can be applied in the handling and treatment of subordinates, whereby the most efficient results may be secured.

It is quite true that experience is the best teacher; however, one may have a variety of experiences, covering a great number of years, and yet be utterly incapable of securing results from his assistants, just because the subject never received logical nor analytical consideration.

Recently, a very successful chief engineer of a large paper mill laughed when I mentioned this subject of handling men to him and said that it was something one could learn only by everyday experience. Furthermore, he wanted to know if anybody expected to find out anything through a discussion in Power upon such a subject. I replied that the space would not be given up to a worthless subject.

His argument was that what might be a good line of procedure for one man would be ruinous for some other fellow to carry out. Furthermore, he was of the opinion that good judgment coupled with hard work and a good physique, together with plenty of push on the part of the subordinate, would go farther toward securing the best results than all the "dope" that could be devised or dug up in a century.

Continuing, he said, "I would rather have one good man than three of the general run of men found in this 'neck-of-the-woods'; really good men are hard to find, that is, men who will take a real, live interest in the plant and work to the end that the very best service may be secured at the least possible cost. In return one should make it worth their while in a material way to do good work and not make it just a 'thank you' proposition. If a man can achieve results where the other man did not, and perhaps could not, then he should receive a percentage of the saving made."

We both were of the opinion that if a man is energetic, possesses some initiative, is loyal to the chief and not afraid he may insubordinate himself too much, he is pretty sure to be a valuable man to his employer. On the other hand, if he is continually finding fault with the equipment and the management, and works along from day to day in a half-hearted manner, the concern and the chief would be much better off without him. Moreover, any man who requires careful handling and becomes incensed upon the slightest pretext, will not help to form a strong organization, but may be the means of disrupting it.

If a strong organization is desired, and success depends greatly upon the organization, there should be a sort of family feeling among the men, and every man should be a coworker with the chief, so that the plant may be run at the very highest degree of efficiency and economy. If there is a backbiter among the men, the sooner he is eliminated the better for all concerned.

One point which I have invariably noticed is that the wage is not always the sole attraction in securing and retaining valuable men. The candidate for a position asks such questions as, "How many hours will I be expected to put in per day, and will I be able to get a Sunday or two off out of each month? Would I be at all certain of my job, or might I expect to get the 'can' on the slightest provocation? What kind of a man is the chief; is he a grouch or is he one of those fellows that has no feeling for anybody but himself? If I show him what is in me, will he appreciate it and in time advance me when conditions permit?"

I have noticed that the "boys" appreciate little things in a really greater degree than they do the big things; for instance, after a hard day's work and it is two or three hours until quitting time, and nothing very urgent remains to be done, telling them to wash up and go home is only one of the many ways whereby the services of loyal and valuable men are not only retained but enhanced as well.

One more point. If the highest economy in firing and the use of supplies is sought, the men should be informed of the cost of the particular articles which they handle. The fireman should know how much the coal costs per ton; how much it costs per day for coal; tests should be made and the results explained in a simple way, so that they may understand what inefficient management and recklessness cost the company. This is why the chief should receive a bonus, as he will continually be after the men in respect to economy, continually impressing upon them that their success as well as his depends upon following out his methods and instructions.

WALDO WEAVER.

Middletown, O.

Prevented Water Hammer

Following is an account of how I beat a case of water hammer at a very small expense:

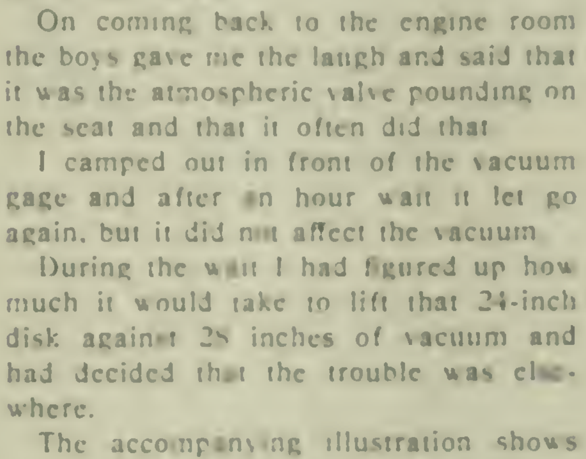
I had only been in the plant a few days when I was startled to hear a loud bang in the cellar and, although I looked over everything carefully, I could not place the noise.

On coming back to the engine room the boys gave me the laugh and said that it was the atmospheric valve pounding on the seat and that it often did that.

I camped out in front of the vacuum gage and after an hour wait it let go again, but it did not affect the vacuum.

During the wait I had figured up how much it would take to lift that 24-inch disk against 28 inches of vacuum and had decided that the trouble was elsewhere.

The accompanying illustration shows



ARRANGEMENT OF DRIP SYSTEM

the exhaust piping from the turbine and that the under part of the casting going to the atmospheric exhaust projects farther than the top side, causing a small percentage of the condensation to drain back into the offset in the line to the atmospheric valve, making a water seal on the wrong side.

The valve leaked and the vacuum drew the hot steam from the auxiliaries on the exhaust line into the cold water; a water hammer was the result.

I got an old galvanized hot-water boiler and piped it up, as shown, so that by leaving the top valve open and the other two closed the water came to the trap by gravity, and by closing the top valve and opening the others I could dump the trap into the hotwell.

At the first opportunity I opened up the atmospheric valve and found both guide stems broken. It was repaired and the disk faced off and there has been no trouble since. I dump the trap every hour and get 10 or 12 barrels of good water every day and that helps here, where the water is bad.

A. STEVENS.

Renfrew, Penn.

Corroding Economizer Tubes

I would like to ask if any reader has had trouble with corroding economizer tubes?

My economizer is placed between the boilers and chimney. The water is pumped through closed primary and auxiliary heaters and through the economizer to the boilers. The water enters the economizer at from 170 to 200 degrees Fahrenheit and leaves at a temperature of from 220 to 242 degrees Fahrenheit.

It is opened up once a year and a tube scraper run through the tubes and the headers are cleaned out; a soft scale more than [illegible] inch thick is found and looks like oxide of iron. It is not like the scale in the boiler tube, but forms in bunches and ridges, much resembling barnacles. Under this deposit the tubes are wasting away and some of them are not more than half of their original thickness and many are giving out.

The feed water is taken from the river and is considered good. It does not contain more than a trace of free carbonic acid and in the boilers it forms a slight scale that is quite hard. Soda ash and some kerosene are used. The economizer has been in service eight years.

If any engineers have had the same difficulty and found a remedy, I would like to know what it was.

C. B. SMITH.

South Framingham, Mass.

Trouble with Refrigerating System

There is one source of trouble in a refrigerating system upon which I have never seen any comments. In a system where brine is used as a refrigerating medium and where air is passed over (or through) the cold brine, the hot vapors are carried from the rooms that are being cooled to the brine tanks in which they are condensed. Thus the quantity of the brine is increased and its strength consequently reduced. The required density can be maintained only by removing the excess water by evaporation or by adding brine-making material.

It is this evaporation that I would like to see discussed. In my plant there is an overflow pipe from the brine tanks to a concentrating tank in which there is a set of steam coils to evaporate the excess water. When the brine is boiled down it is pumped back to the brine tank. I have had considerable trouble with this concentrating tank and with the steam coils in it. Due to its nature the brine is severe on iron when the brine is at or near the boiling temperature. I have to renew the coils about every four months and the tank itself does not last over two years. I have experimented with different kinds of coils without great success.

Stratford, Conn. W. O. WATSON.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Connecting High Pressure Drips to Heating Mains

I think that Victor Borm, in the February 21 issue, in trying to criticize W. T. Meinzer on the subject of connecting high-pressure drips to the heating mains, does not realize that condensed steam under a high pressure contains more heat units than under a lower pressure. Mr. Borm says that if the high-pressure traps were made to perform their function there would not have been very much heating done in the sewer. With Mr. Meinzer's arrangement the drips from the high-pressure traps are discharged to a lower pressure, part of the drips reevaporates and goes to the heating main and does work; the remainder goes to the return pipe. I think that this one point of economy is enough to justify the change made.

If there is not economy in saving the drips, why do engine builders do so? For instance, take the arrangement of steam jacketing and receiver reheating pipes on a triple-expansion pumping engine. Various arrangements are used but the following is simple and typical: Steam from the main steam pipe near the engine passes to the high-pressure jacket at boiler pressure, then to coils in first receiver, then through a reducing valve to the intermediate jacket and out to coils in the second receiver, then to a trap and from the discharge of this trap to the low-pressure jacket. The condensation from the exhaust side of the high-pressure cylinder, first receiver and inlet side of the intermediate cylinder goes to the low-pressure jacket, a valve being placed in the pipe so as to maintain the required jacket pressure. The outlet from the low-pressure jacket goes to a water seal in the basement of the building. The condensation from the working steam of the exhaust side of the intermediate cylinder, second receiver and inlet side of the low-pressure cylinder also goes to a water seal in the basement.

An illustration of the saving made possible by suitably employing high-pressure drips is that of a cross-compound condensing engine which once came to my notice. When the engine was installed, a testing engineer was sent by the builders to prepare and conduct the acceptance test. After getting ready he made several preliminary tests. He experienced some difficulty in getting the engine to perform the duty required. Among the several changes which he made one affected a high-pressure steam trap that removed the condensation from the coils in the receiver to the hotwell. Its discharge was connected into a pipe that drained the condensation of the working steam in the receiver to a trap. Part of the drips from the high-pressure trap reëvaporated and did work in the low-pressure cylinder. The tester claimed that this change caused a good gain in the duty of the engine.

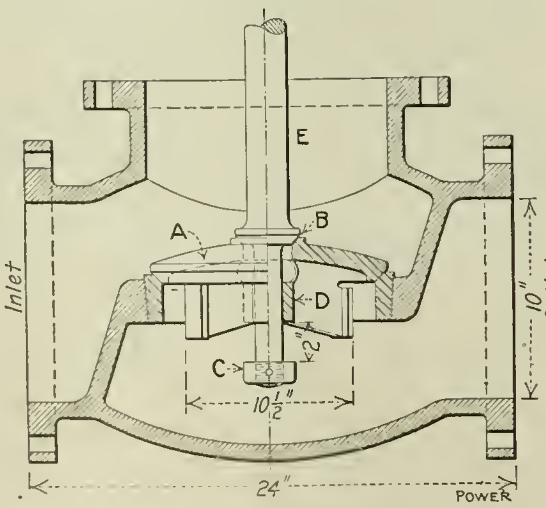
Mr. Borm states that he wonders why Mr. Meinzer did not think of putting in a back-pressure valve. This would undoubtedly have been more effective in preventing the back pressure from blowing the seal into the drip return; also, it would have been more simple.

R. E. Enigne.

Kansas City, Mo.

Special High Pressure Valve

I read with great interest the articles in recent issues of Power dealing with the danger to boilers and piping when opening a stop valve suddenly. As to the side from which steam should enter



Valve with Internal Bypass

a valve, I fully agree that the steam should act on the bottom side of the valve; that is, the valve should close against the pressure. But with large valves and high pressures the opposite may sometimes be adopted with advantage.

A bypass arrangement should be fitted to all high-pressure valves over 4 inches in diameter to help when opening or closing the valve. Most engineers know that it is next to impossible to open a large parallel slide-type valve without using the bypass arrangement.

A few years ago I worked with Richard Pohle, Limited, of Riga, in Russia, when they were constructing the new electric-power station at Windau. All large valves, according to specification, were to have an arrangement for slow opening and be fitted with bypasses.

We made a valve after the design shown in the accompanying figure. In this valve the pressure comes on the top of the disk. This arrangement was preferable as we had experienced considerable difficulty in keeping large valves, closing against the pressure, from leaking when shut.

What the total pressure against a valve disk really is, only few engineers know. In the case of a 10-inch valve under 150 pounds pressure per square inch the total pressure would be upward of five tons. To keep the valve from leaking, the spindle must force the disk downward with at least six tons' pressure. For the Windau power station we therefore preferred to let the steam help to keep the valve tight.

Referring to the figure, the spindle *E* has a collar *B* which acts as a bypass valve in the topmost part of the disk *A*. The lower part of the spindle passes through a guide *D*, cast as a part of disk *A*, and is fitted with a nut *C* which allows the spindle to be lifted 2 inches before acting on disk *A*. The slightest turn of the spindle will admit steam through the bypass *B*.

A. Wind.

Penn, England.

Action in Emergency

The description of the engine wreck at the Boott mill, Lowell, Mass., reminds me of two experiences along the same line which I have had.

The first took place in a five-story mill with a 2000-horsepower engine. Owing to the distance of sections of the mill from the engine room, the manager decided to have the mill wired and to have push buttons located in every room. Then, in the event of an accident, an overseer could ring the emergency bell in the engine room as a signal to shut down.

As first arranged, the push buttons were fastened to the walls without cover or notice relative to their use. One forenoon, about a month after the system was installed, the bell rang and before I had the throttle valve half closed the bell rang again. When the machinery began to slow down, the superintendent, the master mechanic and some of the overseers came to inquire where the trouble was. Not having an indicator on the line wire I could not say from which room the alarm came.

After the officials had investigated and found no cause for the alarm being rung in, the order was given to go ahead. In about half an hour the superintendent came back and said, "Who authorized you to stop the engine when that bell rings?" I replied that no one, in just so many words, but that I had been consulted in regard to its location, had helped to install the system and I took it as generally understood that I was to shut down when signaled. "Well," he growled, "hereafter when that bell rings don't stop the engine until you get word from me or the master mechanic."

I had thought him a lightweight and that superficial remark confirmed my opinion—the absurdity of such an order! There were three large mills and both superintendent and master mechanic were liable to be anywhere about the works, therefore, often difficult to find. But, fortunately for me at least, the manager had an automatic engine stop and speed limit installed to be operated through the system of wires already in use.

In another plant I worked under a very different type of superintendent. The engine was a compound, size 24 and 44 by 72-inch Corliss and ran at 62 revolutions per minute. This engine was not fitted with safety cams to prevent the engagement of the steam-valve latches when the governor is at the lowest point. On account of its hight the starting valve had to be operated while standing on a step ladder, always kept there for the purpose.

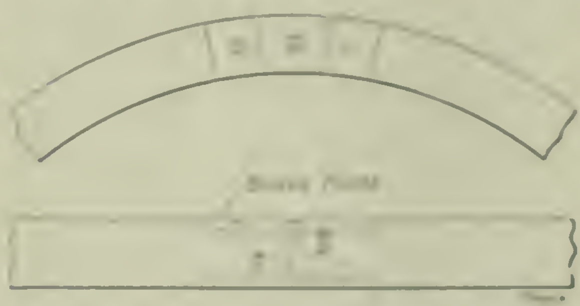
One day, while working at the bench, I heard the engine speed up, and looking around I saw the governor had stopped, which startled me so that I thought of a number of things in a very short time. My first impulse was to mount the step ladder and shut the starting valve, but the accelerating speed of the connecting rods convinced me that the process would be altogether too slow, so I jumped down to unhook the wristplate. At that instant, however, I realized that the consequences of instantly arresting the valve motion at an unknown point in the stroke might be disastrous. So I grabbed a lever connected with the governor and raised the balls to their highest point; this prevented the valve latches from hooking on. I held them in that position until the engine had nearly stopped, then I released the lever, ran up the step ladder and shut the starting valve.

In a moment the superintendent came in and with the help of a machinist and an electrician we straightened out the tangle and had the engine going after a few minutes. This superintendent, instead of trying to browbeat me for the slight shutdown throughout the mill, complimented me on my quick action in preventing what might have been a very serious accident.

Clinton, Mass. J. W. Parker.

Piston Rings

In the March 7 issue is a contribution on piston rings by Lloyd V. Beets in which lap-joint and diagonally cut piston rings are criticized. The criticism is well taken. An improvement which I have found to be satisfactory is shown in the



Arrangement for Preventing Leakage

accompanying figure. Care must be taken with thin rings to use tap screws of proper proportion.

George H. Handley.

Newburgh, N. Y.

Neglecting Opportunities

The editorial in the March 14 issue entitled, "Neglecting Opportunities," certainly is worthy of considerable notice and serves as food for thought on the part of a majority of the men who are operating isolated plants.

The assertion that certain men are contented to let a piece of apparatus run in any condition is only too true and, as a rule, they will not put it in proper condition unless compelled to.

In regard to getting after a repair job as soon as possible, such men often do put it off until Sunday, and frequently it happens that the apparatus gives out before that day comes, resulting in a shutdown which at times proves very expensive.

As far as thinking that you may make a thing worse instead of better is concerned, a man who thinks this way, as a rule, generally does make them worse when he gets at them; the only way to do a good job, so far as I know, is to determine to do it and then go ahead.

A great many men do poor work simply because a job is distasteful to them and in their eagerness to get it off their hands do it in any old way as long as it will stand up until they leave the job.

Any man who will allow a number of tubes or nipples to leak in a boiler is indeed a poor business man for, as the editorial states, he could make them tight in a very short time if he would only get at it.

With reference to leaky and improperly set engine and pump valves, I venture to say that if engineers generally would formulate a plan to examine and test the smaller apparatus intrusted to their care, a good deal of power-plant loss would be done away with and the central station would have less to do.

H. H. Hurley.

Brooklyn, N. Y.

On Assisting the Inspector

It is a remarkable fact that those men who by training, experience and general knowledge are best qualified to judge every condition affecting the plants under their charge are the very ones who afford every possible aid to a boiler inspector, while those whose conceptions are of the very crudest concerning the proper maintenance and operation of the machinery in their keeping view the service of inspection and supervision with everything from good natured indifference to open hostility.

The same conditions seem to obtain among owners. Let any movement be started toward a provision for more rigid supervision of boilers and a great hue and cry goes forth. Many a costly object lesson is required and perhaps many lives sacrificed before opposition is sufficiently removed to allow a betterment of conditions.

I am a boiler inspector and, operating as I do in a field where absolutely no form of regulation is provided by statute, I am often brought face to face with conditions of ignorance and indifference that are absolutely appalling. Time and again have I known of the inspection service being refused because of the safety limitations imposed, even when concessions beyond what good engineering practice would dictate had been granted. In one instance, perhaps the most cold blooded that has come to my notice, I was severely upbraided by an owner whose partner had made application for inspection, when I told the engineer of the dangerous condition of a boiler he was operating. The boiler was twelve years old, designed for 125 pounds pressure and was at that time carrying 190 pounds. I do not doubt that my judgment was a matter of considerable derision, for I was informed that other boilers of the same type had carried over 200 pounds and still held together. I did not dare attempt to explain safety factors for fear that anything below the ultimate strength would be considered all bluff.

However, the inspectors' pet aversion, so-called engineers, it is a constant source of friction to find safety valves screwed down to points where release of all the steam generated is impossible, to find the gage hands set back and other simfices intended to deceive. I will say that this practice is most common on the boilers used for logging purposes and where few engineers as we understand the term are found. It is a matter of real pleasure to find one of the three gage cocks on these rigs in working order, while for all of them to be in order should make the engineer almost deserving of honorable mention.

There is one thing, however, to be brought to the attention of a great many engineers, men who are really skilled good men, men who are making real successes at their vocation, and that is the conditions under which an inspector is required to work. In many of the plants the boilers are not or for some reason cannot be sufficiently cooled and the heat is terrific. More than a passing glance at the various portions is beyond human endurance. Even at that, there is little that the inspector misses but a little less onerous conditions would add to his efficiency.

Then, there is that matter of cleaning the parts sufficiently. How much less effective must an inspection be and how much it adds to the disagreeable part of the work, to dig out the buried blowoff pipes, to crawl around in a foot or two of soot and ashes to look over with minute care several thousand feet of tubes and a number of drums and headers. It is little wonder that cases of incipient failure and the progress of corrosion and attendant evils escape the notice of one working under such handicaps.

The more frequent use of the hydrostatic test has been suggested as one means of reducing the number of disastrous failures. Yet, there is a question as to whether the strain so set up at the time of such a test, commonly 50 per cent. in excess of the working pressure, might not cause incipient failure not discernible at the time, especially in the case of buried and covered drums and the seams of horizontal tubular boilers. Little uneasiness need be felt regarding those boilers which are free of access and whose parts can be well examined, even if subjected to the visual test only.

Perhaps the best and safest plan to pursue is to adopt some such rule as that in force in the State of Massachusetts, fixing a factor applicable to the age of the boiler, for the fact that the material undergoes a change is very apparent from the manner in which the metal of an old boiler works when attempts to use it for other purposes are made, and one is often led to wonder that it lasted as long as it did when the crumbly, brittle and nonfibrous nature is noted.

Unfortunately, instead of thus reducing the burden upon a boiler whose age should be respected, even if not respectable, the common practice is to add more pressure as the business grows, then to place in the battery boilers of newer, later type and let the old well tried servant continue to carry the limit. How many plants are found with such units in them, where the pressure is limited only by the original design of the oldest boiler in the plant. No comment is necessary on this practice, yet owners and, in many cases, operators, would have to be shown signs of actual distress before discarding them.

At most, upon finding undesirable conditions, the inspector can only recommend the cancelation of the insurance. At that, his influence often ends. This fact is frequently taken advantage of by both owners and operators. To overcome the handicap imposed by these conditions, the inspector is required to be more or less of a diplomat. He must accomplish by other means than the absolute authority of Federal and State officials, the safeguarding of the lives and property of those most concerned and at the same time maintain pleasant business relations between his employers and their clients. Considerable judgment and decision are necessary to require immediate action in place of promises and to refuse to accept faulty arrangement even if imminent danger cannot be pointed out.

Certainly a little thought along the foregoing lines will make it easily apparent to any engineer in what manner he may for his own part help to make the work of an inspector a still greater medium of safety. With the proper coöperation and influence of the engineer, the present appalling list of disasters can be reduced to the minimum.

HORACE HANKS.

Portland, Ore.

Burning Lignite

Referring to Mr. Bergman's letter under the above in the March 7 issue, I wish to say that I have been burning North Dakota lignite for about eight years and have obtained higher efficiency from boilers and grates with lignite than with any other soft coal. This is due no doubt to its cleanness; it forms no soot on the tubes during an 8- or 10-hour test and such a test can be run without making a general fire cleaning. This may not be true, however, of all the Dakota lignites. The Wilton coal is considered to be of the best grade. It has a heat value of about 7000 B.t.u. per pound, contains from 5 to 6 per cent. ash and from 35 to 40 per cent. moisture.

Mr. Bergman states that he evaporated four pounds of water per pound of coal, which contained 6029 B.t.u., and secured an efficiency of 68 per cent., which I consider to be a very good showing.

Lignite burns much like wood and does not require much air. As a general thing too much air is admitted and the heat is carried through the boiler and lost up the stack. It has been truly said that in order to generate steam there are only two steps required: First, produce the heat, and, second, transfer the heat to the water in the boiler. I have made many tests with lignite and under favorable conditions have evaporated 4.86 pounds of water per pound of fuel, containing 35 per cent. of moisture, 5.92 per cent. of ash and 6591 B.t.u. This is equal to evaporating 8.80 pounds of water into steam from and at 212 degrees Fahrenheit per pound of combustible, and shows an efficiency of 76.98 per cent.

Engineers employed by the Government have made tests with North Dakota lignite and from the reports of such tests that I have seen no such efficiency was obtained. No doubt the poor results were due to the fact that those who were in charge had not learned how to burn North Dakota lignite. Many have turned down lignite for the same reason, but some day the large fields of lignite will be of great value to the people of the United States. I regret to see the Government use coal from Pennsylvania and Ohio for its buildings in this State.

C. P. LARSEN.

Bismarck, N. D.

Smoke Abatement

In the March 21 issue, I notice that Waldo Weaver makes some criticism of my letter in the January 3 number on the smoke problem.

It may be true, as he says, that it requires a good man to use the coking method of firing; but so far as my experience goes, it requires a man with no more physical capacity than the other methods and gives far better results as regards economy and smoke. As far as keeping steam is concerned, none of the plants where this method is used, to my knowledge, has had any difficulty in producing all the steam it required. In fact, these plants have been keeping up the pressure with one less boiler than was formerly used, mainly due to the increased economy resulting from this method of firing, since through this method all of the volatile matter which formerly went up the stack in smoke is now consumed, resulting in a considerable increase in evaporation per pound of coal or, for the same steaming capacity, a considerable reduction in the amount of coal fired. When it comes to forcing a boiler beyond its normal capacity, no method of firing can be used which will result in smokeless combustion. If one fires frequently with a thin layer of fresh coal all over the fire, a very considerable amount of volatile matter is driven off in smoke and is unconsumed. This is never economical, nor is it preventing smoke.

The question of which method to indorse is a question of which is the most satisfactory from the smoke-prevention standpoint and economy. The fact that the spreading method is used far more frequently than the coking method is due to its being easier, not necessarily more economical.

I quite agree with Mr. Weaver that the bonus system of payment is well worth considering.

HENRY D. JACKSON.

Boston, Mass.

The Benefit of Organization

Mr. Levy hits the nail on the head in the February 28 issue when he says in his letter under, "Engineer or Laborer": "There is no mistaking the fact that the engineers of this country must organize. Not only engineers but every man engaged in the generation and transmission of power should be a member of one organization." The engineers and firemen of this city have just formed an organization such as he mentions, called the Brotherhood of Power Workers, composed of engineers, firemen, oilers and other power-plant workers. The consolidation of all power workers into one organization has proved a good move and the engineers, firemen and others can readily see that it is to their advantage to pull together.

According to a circular being distributed, there is nothing in the rules or by-laws of this organization that the most timid and conservative need object to. I quote a few lines from the circular:

"This organization does not demand a uniform wage for its members as conditions differ in every plant. It does not demand recognition of the brotherhood or the signing of agreements; neither does it ask that none but members of the brotherhood be employed in any particular plant. It has eliminated everything that would cause needless friction between its members and their employers. The brotherhood has a labor bureau for the benefit of unemployed members, also a system of education on trade lines that will raise the efficiency of the membership. License legislation and enforcement of the present law will be followed up. It will pay a sick and accident benefit of $5 per week and at the death of a member his beneficiary will receive $1 for each member in good standing. To raise the efficiency of power workers, to secure the results due a higher efficiency and to establish an insurance department that will bury the dead and care for the sick and disabled members, is the work cut out for this organization."

It will be seen from the foregoing that possible causes for friction are removed, such as the demand for "closed shop," etc. The organization is not affiliated with any labor union (though it is not opposed to unions) and has provided for fine or expulsion of any member who takes the position of any organized worker trying to better his condition. The brotherhood has received inquiries from many of the surrounding cities and towns asking for information. It is said that steps will soon be taken to organize this section of the State.

C. C. HARRIS.

Springfield, Mass.

Pumpless Condenser

I read with interest Mr. Fryant's article in the March 7 number concerning a pumpless condenser. Here in the copper country there are several such condensers. In the plant where I am engineer there are two; only one of these is ever in use at one time. The exhaust of three engines is received by the condenser a part of the time.

The condenser is about 75 feet above the engine-room floor and there is about 50 feet of horizontal exhaust pipe before the rise to the condenser begins. Water comes to the condenser under a pressure of about 40 pounds. The reason why the condensers are so high above the engines is because the discharge water is used for cooling the jackets of a blast furnace which is considerably taller than the power house.

F. W. BAIR.

Hancock, Mich.

Grouting Bedplates

I take exception to that part of Mr. Knowlton's article in the March 14 issue which deals with the wedging and grouting of engine bedplates. First, he states that when using concrete foundations the bottom of the bedplate cannot be planed. But, what is the use? Seeing that the bedplate and cylinder have to be leveled and alined, and there is to be at least 1½ inches of grout put under the bedplate, it is a useless expenditure of time and money to plane the bedplate. Further, the grout will not take as strong a hold on a machined surface as it will on a rough one.

If the grout is properly placed it does not make any difference whether a rib is 4 or 6 inches wide as far as the prevention of end motion is concerned. Nor is it necessary to have machined wedges with which to level up an engine bedplate as he states. The practice of two of the largest engine builders in America bears me out in this. The usual supply of packing plates and wedges furnished to their road men is made from ordinary bar steel and consists of plates of assorted thicknesses, such as 1/4, 3/8 and 1/2 inch and 2 or 2½ inches wide by about 5 inches long. The wedges are made of the same material, but drawn to an edge of about 1/16 inch. As these wedges and plates are usually pulled from under the castings by the erecting men before leaving the job and either left on the premises or thrown away, it will be seen that it is not good economy to furnish very expensive material.

Assuming that the foundations are built of concrete (in modern practice this material is used almost exclusively), if the upper surface of the foundations is smooth, it should be roughed up, with either a diamond-point chisel and sledge or a pick, and then thoroughly cleaned of all fragments and dust. After placing the bedplates and cylinders and raising them to and leveling them at the proper hight the surface of the foundations should be thoroughly wetted with clean water.

Should pockets or spaces between ribs in the interior of the casting not be provided with vent holes, short pieces of 1/2- or 3/4-inch pipe can be bent into a U-shape and inserted in each pocket or between the ribs that have no core holes cast in them. The pipes should be stood in a vertical position, so that the upper ends will be at least 6 inches above the surface of the foundation. A dam built of boards or other material can then be built around the engine at a distance of 3 inches from the edge of the casting. The dam can be made practically water tight by placing ordinary sand against the outside. Grout can now be mixed in a box made for the purpose. The proportions should be one part of sand and one of cement. Water should be added until the mixture is of the consistency of good thick paint. It may then be bailed out of the box and poured under the casting until it reaches a hight of at least 4 or 5 inches above the bottom of the castings.

After a lapse of 48 to 60 hours the grout will be found to be hard enough to require a hammer and chisel in cutting away all of the surplus material extending outside the bedplate.

The purpose of the U-tubes is to allow the escape of any air that might otherwise be trapped when the grout was poured. The trapped air might prevent the grout from flowing under the casting evenly if there were no means provided for the escape of the air.

After the grout beyond the edge of the casting has been trimmed off, the job is completed and the engine about ready to start. The wedges can be withdrawn and the U-tubes cut off with a hammer and chisel at the face of the bedplate. It is a safe plan to remove the wedges as this will eliminate any tendency of the engine to move. It is a well known fact that two metal bodies move more easily on each other than metal resting on some other material such as concrete. If the surface of the foundation has been properly prepared so that the grout can form a good bond to the foundation, there need be no fear of the engine becoming loose if anchor bolts should become loose.

[illegible]

[illegible]

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Loss of Steam Through Nozzle

What would be the loss in horsepower per hour through a nozzle if the circular opening at the end is 11/64 inch in diameter, blowing into the atmosphere with 110 pounds boiler pressure?

R. A. H.

The opening at the end of a short, smooth converging nozzle may in this case be regarded as an orifice from which the steam will issue at a velocity closely approximating 900 feet per second. The area of a circular orifice 11/64 inch in diameter is 0.0232 square inch, and at a velocity of 900 feet per second there will be discharged

$$\frac{0.0232 \times 900}{144} = 0.145 \text{ cubic feet}$$

One cubic foot of steam at 110 pounds gage pressure weighs 0.2791 pound and the discharge per hour will be

$$0.145 \times 0.2791 \times 3600 = 145.65 \text{ pounds per hour}$$

Calling a boiler horsepower the evaporation of 30 pounds of water per hour, the horsepower required to supply the steam blowing through an 11/64-inch nozzle at 110 pounds pressure will be

$$\frac{145.65}{30} = 4.855 \text{ horsepower}$$

Using Napier's formula

$$W = \frac{A\,P}{70}$$

for the flow of steam from an orifice, in which

W = Pounds of steam discharged per second,
A = Area of orifice, square inches,
P = Absolute pressure, pounds per square inch,

the flow would amount to

$$\frac{0.0232 \times 125}{70} = 0.041 \text{ pound}$$

and

$$0.041 \times 3600 = 147.6 \text{ pounds per hour}$$

$$\frac{147.6}{30} = 4.92 \text{ horsepower}$$

Waterproof Belt Dressing and Cement

Please give me formulas for waterproof belt dressing and waterproof belt cement.

W. N. K.

Gutta percha dissolved in enough bisulphide of carbon to make a liquid of the consistency of molasses makes a reliable waterproof belt cement.

Neatsfoot oil containing 10 per cent. of dissolved beeswax makes a dressing which preserves the leather and makes it somewhat repellent of moisture. A repellent quality can be imparted to the leather during the tanning process by the use of bichromate of potash.

Single Valve Engine

What is meant by the term single-valve engine?

S. E.

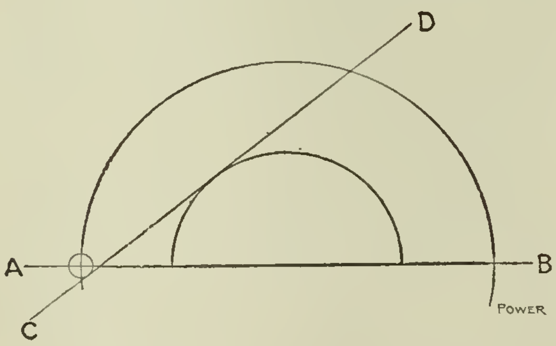
A single-valve engine is one in which one valve controls the admission, distribution and exhaust of steam for both ends of the cylinder.

Point of Cutoff

If the travel and lap of a plain slide valve are given, how can the point of cutoff be found?

V. C. P.

On the line $A\,B$ draw a semicircle with a radius equal to one-half the valve travel. From the same center draw another with a radius equal to lap of the valve and at the intersection of the valve-travel semicircle and the line $A\,B$ a circle with a radius equal to the lead of the valve. Then where the tangent line $C\,D$ cuts the outer semicircle will be the point in the path of the crank pin where the cutoff will take place.



FINDING POINT OF CUTOFF

Protection for Cotton Hose

What preparation can I use on the outside of cotton fire hose to prevent decay?

H. C. P.

None at all. Keep it perfectly dry and free from dust that may collect and hold moisture.

Motor Operation on Circuit of Higher Voltage

Can a 110-volt motor be operated on a 220-volt circuit without injuring it? If so, how?

L. S.

Yes; by connecting it in series with a resistance the number of ohms of which is equal to 110 ÷ *motor current.* It must be operated at constant load; if the load is reduced the motor speed will increase, and *vice versa.*

Alternating-current Phase Relations

Is the working or power component of an alternating current in phase with the wattless current or with the impressed e.m.f.?

F. W. G.

It is in phase with the impressed e.m.f. Two different components of anything cannot coincide; if they did there would not be two of them.

Steam Consumption and Power Factor

If the power factor of the load on an alternator is 80 per cent., will the engine driving the alternator take more steam or less than it would with 100 per cent. power factor, the true power being the same in both cases?

C. W. N.

Slightly more steam, due to the fact that the armature losses are greater with the lower power factor. For the same true power and terminal e.m.f., the armature current will be 25 per cent. greater at 80 per cent. power factor than at 100 per cent. The difference in total driving power required, however, is very small, because the increase is 25 per cent. of a small percentage of the net output.

Gas Engine Power and Cylinder Temperature

Does the power of a gas engine increase with an increase in the cylinder temperature?

F. E. W.

Not necessarily. When it does, the increase is not great enough to justify running the engine over-hot.

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POWER

Merit and Bonus System Combined

In a special message to Congress, President Taft transmitted the twenty-seventh annual report of the Civil Service Commission. The report shows that the commission is in favor of the merit system, because it is indispensable to economy and efficiency in governmental affairs.

The commission urges legislation looking to increased efficiency in the service, especially a reclassification of salaries in accordance with the work performed, with enough grades to insure frequent promotion.

Although the merit system will work to the advantage of large corporations and those employed by them, and also to the benefit of power-plant owners, it is not so attractive to engineers and firemen employed by them.

It would seem that a combination of merit and bonus systems would work well in the power plant. If this kind of a system were adopted, it would not mean that the man who did good work would occupy the best position, but that the man who did good work and operated his shift more efficiently than the other man would be the favored one.

For instance, a power plant is operated with three shifts of men. On each shift there is an engineer, an assistant engineer, two oilers and four firemen. The men on each shift draw the same pay and use the same amount of supplies and fuel. In fact, one costs the company as much money as the other.

The engineer of one shift, however, begins to take an interest in cheaper operation. He has a talk with the chief engineer who agrees to give the men a certain percentage of the money they can save the company by being more careful in the use of supplies and in the consumption of fuel. The men on the shift are notified and every avenue of needless waste is closed. There can be no doubt but that this shift will make a better showing than the other two shifts in the cost of delivering electrical energy to the switchboard.

And it is not far to look for the reason. The men of one shift have been working for additional pay, the men of the other two shifts have simply been working to earn their weekly wage. Let them know that the men of one shift have been drawing a bonus of a dollar or more per week, because they used a little extra precaution in doing their work, and a protest will be made because they also have not been given an opportunity to make extra money. In one case the men were merely holding their jobs and firing coal; in the second case they shoveled coal with intelligence and were paid according to their ability to save.

Not glory, nor a burning desire to save the company money prompts a fireman to save coal, or an engineer to prevent needless loss of steam because of leaky valves; the incentive is the dollar. Hang one up and men will struggle to reach it. Tell them it is theirs if they earn it, and they will fight for it. Tell them that a percentage for every dollar saved over existing operating conditions in the power plant will be theirs, and a saving will be made in the operating expenses of the plant.

A bonus to the men rather than a check to the coal dealer for an amount several times in excess of their increase looks like a profitable investment. Try it out and see.

Low Pressure Turbines with Gas Engines

In a gas engine having an efficiency of thirty per cent., seventy per cent. of the heat furnished to the engine, minus the small amount lost by radiation, is voided in the jacket water and the exhaust. The jacket water may be delivered at a temperature approaching that at which water will boil at atmospheric pressure. The exhaust gases leave at temperatures upward of a thousand degrees. The jacket water, if placed in a vacuum, would, without further heating, give off considerable steam which might be used in a low-pressure turbine, and the gases could be used in a boiler which would furnish steam at a higher pressure. The two could be used in a mixed-flow turbine, or the jacket water could be used as the boiler feed and all the steam sent to the turbine at the higher pressure.

The hot gas as it comes from the producer has, by reason of its high temperature, considerable potentiality for steam making, but this is largely absorbed in the boiler or vaporizer which makes steam for the producer itself, and any attempt to take low-pressure steam off from the hot water coming from the wet scrubber would similarly involve trouble from carrying impurities into the turbine.

The possibilities of the subject are discussed in an article by Edwin D. Dreyfus in this issue, and it is suggested that by a system of thermal storage the heat voided by gas engines when running upon light and normal loads may be accumulated and used in a turbine to help over the peak.

The Scrap Habit

A noted English engineer on being asked what single feature of American shops most impressed him, replied: "The scrap heap." It is undoubtedly one characteristic of American practice to discard machinery as soon as it becomes out of date or inefficient, without much regard to its physical condition. The Englishman is economical of material and less so of labor. Here it is the labor that counts and, until recently, material has received scant courtesy.

It is not, however, of this phase that we wish to speak, but of individual economies, of private scrap heaps.

The corporation may scrap valuable machinery and the superintendent in his official capacity may approve of it, but the individual in his private life still retains traits of frugality and economy which have come down to him from his Puritan ancestry. When a man is living in a log cabin in the wilderness, he naturally saves every scrap of leather, every bit of iron, for he does not know when or where he may get others; and in the old-fashioned country villages with every man his own tinker, similar customs prevailed.

A recent issue of one of the standard magazines contains an article in which a well-to-do business man is represented as jumping from his carriage to pick up a new brick by the wayside and as saying that he gets enough bricks in this way to save a large part of the expense of repairs about his premises. He furthermore intimates that even if he has no use for the brick, he hates to see good material wasted. None but a rich man, whose time has ceased to have a market value, can afford to get his brick in this way. No, this is not economy, it is just the old Puritan habit of collecting and saving everything in one's path, whether useful or useless, a miser's instinct. The man just mentioned might, with as good reasons, have extended his drive to the railroad yards and picked up fragments of coal, thereby reducing the heating bill at his residence.

One who is constantly picking up scraps of leather, brass and iron, old hinges, bolts, nuts or pieces of pipe, usually has his labor for his pains. The stuff is never used and gradually accumulates in the attic or cellar, on the bench or under it until the would-be owner gets desperate and throws it all away. The argument used to be: "Save it, for you never know when you may want to use it." The argument should be: "If you never know when you may want to use it, don't save it."

There is a reasonable excuse at the house for saving twine and wrapping paper, for experience has taught that there is always use for them. In the engine room, nuts and bolts, pipe fittings and pieces of brass or leather may have future value. If saved, each should have its pigeon-hole or compartment, where it can be found when wanted.

A miscellaneous collection of junk, such as is found in some engine rooms, is wasteful rather than economical and should be disposed of to Tony or Isaac for what he will give.

Experience is a good teacher in this matter; in each particular vocation—the man-at-home, the superintendent or the engineer, has learned by experience that certain things are in demand and always find use; such things can well be saved.

Shall I keep this stove bolt and nut? Yes, I do use one occasionally and it may save a trip to the store.

Shall I keep this cast-iron bracket? I never did have a use for one and I do not know that I ever shall. No, better throw it away than to litter up your bench or floor "on suspicion."

The writer speaks feelingly on this subject for he has had the habit in its worst form. Repeated cleanings of attics and sheds and boxes and barrels have finally convinced him that much scrap means weariness and vexation of spirit and he has reformed. He does not pick up pins or bent nails or bricks; he passes by on the other side and leaves them to the Good Samaritan who has a carriage with which to haul them home.

The rusty hinge and the old bolt have no further attractions. He does not even save a piece of string unless he sees in the immediate future a use for that particular kind of string. He has more time available, he enjoys walks abroad and has no longer the terrifying prospect of an attic or a cellar crowded and disfigured with miscellaneous junk.

Apparent Efficiency

Just now we are hearing a lot about efficiency; the salesmen have taken it up as their slogan and even the daily newspapers have begun preaching it, since the recent claim of a certain Bostonian to the effect that he could save the railroads of this country a million dollars a day by introducing more efficient methods. Ostensibly, efficiency is the goal to be aimed at in all fields of activity, whether railroading, power generation or purely commercial enterprises, but in every case the meaning of the term "efficiency" in its broadest sense—the relation of useful result to effort—should be kept in mind. Too often only one phase of the problem is considered and "apparent" efficiency is attained at a sacrifice in economy. This is illustrated more particularly in the generation of power where the installation of a certain piece of apparatus may effect a saving of three or four per cent. in energy between the grates and the switchboard; yet its first cost and the cost of maintenance may more than offset the saving in energy.

It has been estimated that, excluding special cases, the cost of power in a manufacturing establishment amounts to from two to four per cent. of the cost of producing the manufactured article. Hence a piece of apparatus effecting a saving of three per cent. in the production of power would save only twelve-hundredths of one per cent. on the cost of manufacture, which slight gain might not warrant the extra investment. It is always well in such cases to carefully consider economy as well as efficiency before passing snap judgment.

It is a good thing to know that a steam line is thoroughly drained. Water has a habit of smashing things if, while traveling at high velocity, it is brought to a sudden stop.

Some engineers can tell you all about the horses and sporting events generally but when it comes to intelligently explaining the why of the simplest things in the engine room, they are all at sea.

A nonreturn valve in a steam main may never pay for the cost of the paint on the outside, but if a pipe or fitting should burst, there are great possibilities that it will pay for itself a hundred times over in preventing loss of life and damage to property.

Have you ever noticed how reckless the man in charge sometimes is when it is necessary for him to personally work with his hands? He should be the man to set an example to others of being careful.

According to their talk, some men can do anything, but when put to the test they cannot do even a third-class job without help.

Have you noticed how some engineers, repairmen and others leave everything to the last minute and have to stay on and finish after shutdown when the repairs could have been made just as well during the day?

You know that there are always some men who can run your plant far better than you are doing it.

A small trouble neglected will often cause a big shutdown.

Not much use throwing coal into a furnace while the safety valve is blowing.

An engineer cannot get experience for nothing; it must be paid for.

Reduction Gear for D.C. Generator

A multistage turbine running at three thousand six hundred revolutions per minute, driving a direct current generator through a seven to one single reduction gear.

Heretofore, the steam turbine in large sizes has found application only in driving alternators and in the propulsion of ships, very little progress having been made in adapting it for driving direct-current or other machinery of moderate speed. High speeds applied to direct-current generators involve serious commutator troubles and structural difficulties, and it is conceded by most designers that the speed of 1000-kilowatt machines should not exceed 600 revolutions per minute and this speed has, in fact, been found most suitable for smaller machines even down to 500 kilowatts.

This speed, however, is entirely too low for the ordinary turbine. The speed of a turbine may be reduced in two ways: First, by increasing the diameter of the rotor, and, second, by increasing the number of stages. To accommodate it to the speed of a direct-current generator would necessitate a rotor of such a diameter as to seriously affect its strength; on the other hand, this speed would require such a large number of stages as to make the machine unusually long and thus introduce other difficulties and losses. The alternative then is to introduce reduction gearing between the turbine and the generator.

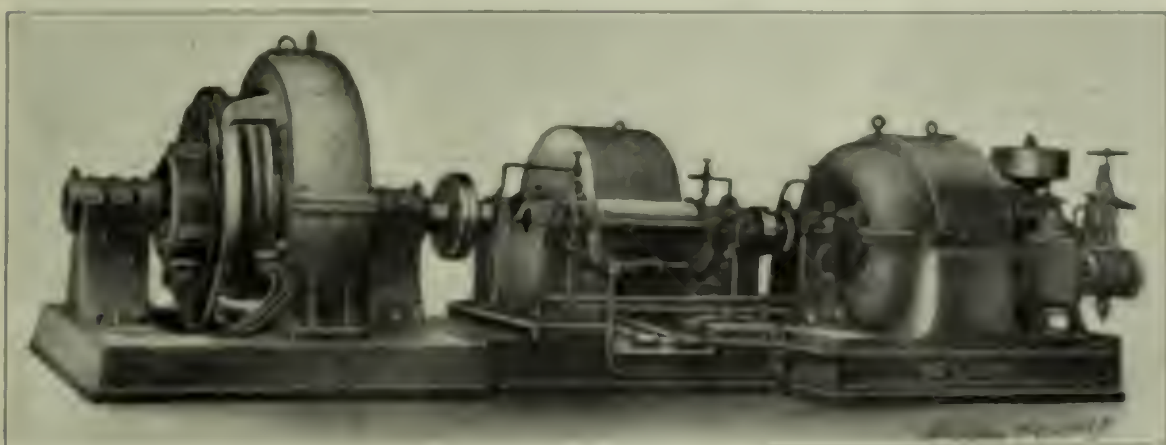


Fig. 1. Turbo-generator Complete

The De Laval Steam Turbine Company for a number of years has employed single- and double-helical reduction gears on its small- and large-sized single-stage machines, respectively; the latter, however, driving only alternators or high-speed pumps. But only recently have they applied the single-helical gear to the multi-stage turbine for driving a direct-current generator of large size.

This unit, which is shown in Fig. 1, consists of a four-stage turbine driving a 500-kilowatt direct-current Crocker-Wheeler generator through a pinion and single gear, the speed of the turbine shaft being 3600 revolutions per minute and that of the generator 500 revolutions per minute, making the reduction ratio over 7 to 1.

The main casing, which is of cast iron, is nearly cylindrical in shape, being split horizontally so that the top half may be lifted off to give access to the revolving and stationary members of the turbine. The casing is supported on a level with the center of the shaft by two pedestals rising from the bedplate, one on each side, and is bolted down only at one end, thus permitting expansion and contraction in an axial direction between steel guides. As the endwise position of the shaft is also determined by a thrust bearing at the same end, the results of axial expansion are largely compensated for.

Steam is admitted to the turbine first through a strainer case and then through a combined trip and throttle valve, shown in Fig. 2; next through the adjacent governor valve and, after passing through steam nozzles, impinges upon the blades of the first-stage wheel. Partial admission is used in the first stage, and full admission in the succeeding stages. The wheels are of the standard De Laval type, and as a protection against flying pieces of metal in case a wheel should break, it is completely surrounded by a heavy steel band.

The governing mechanism, which is also shown in Fig. 2, is in duplicate, that is, there is a speed-regulating governor and a speed-limiting or emergency governor. The former is mounted at the top of a vertical shaft and is driven by a worm gear from the turbine shaft. It controls the movement of a vertical double-seated poppet valve similar to that used on standard De Laval turbines. The lower end of the governor shaft is connected to an oil pump which supplies the bearings of the machine and the pinion and gear. The emergency governor is located at the end of the turbine shaft and is ordinarily not in contact with the trip. Upon touching the latter, however, steam pressure is at once released from under a piston, by means of which a toggle gear is released, allowing the combined trip and throttle valve to close under the pressure of the steam in the supply pipe.

Fig. 2. Governor and Trip Valve

The pinion and gear are shown in Fig. 3. The gear is of the double-helical or herring-bone type, differing from the standard gears supplied with De Laval turbines only in size and the fact that a single gear is used for large capacities. The pinion is cut from a solid bar of steel and is carried in plain babbitted bearings supported in a rigid cast-iron frame, which also supports the gear bearings. The pinion bearings are lubricated by sight-feed oilers from the pump system, the excess oil overflowing to the wells of the gear bearings, which are ring oiled. The gear consists of a solid cast-iron center upon which are shrunk two thick steel rings, and the hub is mounted on a stiff shaft, which carries at one end half of the flexible coupling for connection to the driven machine. The lubrication of the gear and pinion teeth is accomplished by jets of oil directed at the line of contact on the entering side. This oil after use is passed through an oil strainer located in the base of the turbine, then through a cooling and settling chamber and finally to the oil well, from which it is again pumped through the circuit. Temperature measurements taken after the machine had been running for several hours showed a difference of four degrees between the oil entering the gear case and that leaving the case.

The operation of the turbo-generator is remarkably free from vibration and noise and as it stands in the test room, supported upon small screw jacks without other means of support, it is hard to tell at a distance of a few yards whether or not the turbine is running without noting the moving parts.

It might be mentioned in passing that the determination of the efficiency of such gears within reasonable limits of accuracy is a comparatively simple matter and does not require the use of cumbersome and expensive hydraulic brakes or similar mechanisms. That is, since all energy lost in friction in the gear must be converted into heat, the measurement of the heat emanating from the gear case will give an accurate measure of the loss of energy in the gears. Such measurement of the heat is not difficult. The radiation from the casing can be determined accurately for any given temperature by observing either the rate of cooling under fixed conditions or by keeping the casing warm by means of hot water or steam. The amount of heat removed from the gears by the lubricating oil is even more easily determined by measuring the inlet and outlet temperatures and the weight of oil used per minute or per hour.

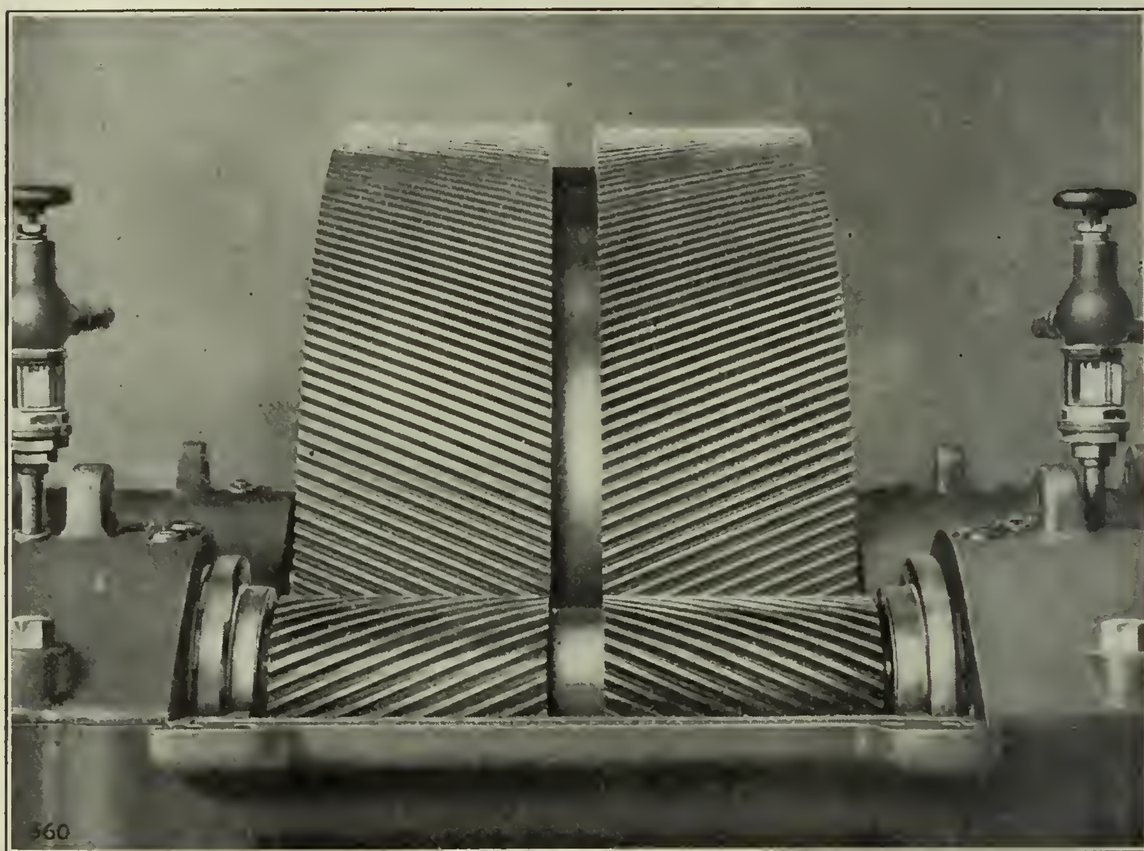


Fig. 3. Pinion and Gear

Blank Flange Bursts with Fatal Results

The fracture by water hammer of a blank cast-iron flange on the side outlet of a 20-inch tee in a live-steam line in the Amoskeag Mills, causes the death of three men. The pipe had a pitch of 20 inches in 500 feet and was drained by a trap. The damage to the plant was confined to the blank flange.

As a result of water hammer, a cast-iron blank flange on a tee in a 20-inch live-steam pipe at the new power plant of the Amoskeag Manufacturing Company, Manchester, N. H., fractured early Monday morning, March 27, causing the death of three men.

This 20-inch pipe runs the entire length of the 500-foot boiler room to the pump room, where it drops down to the basement under the turbine room. There are two 20-inch pipes, one supplying steam to two turbines, the other delivering steam to what is known as the Langdon mill.

Just inside of the basement wall under the turbine room the pipe running to the Langdon mill has a steel-riveted tee connection, put in so that the side outlet faces lengthwise of the basement, as shown in the illustration. This tee is constructed of $\frac{3}{8}$-inch steel and has a $\frac{1}{2}$-inch thick flange. The blank flange was made of 1-inch cast iron, ribbed on the outside. It was this flange that fractured, a V-shaped piece being blown from the solid section, as shown.

This particular tee was put in place when the pipe line was constructed to provide an outlet connection for another pipe line when desired.

The accident occurred just at the time the engineer of the Langdon mill was getting his reciprocating engine up to speed for the day's run. Two shocks of water hammer were felt by men employed at the far end of the boiler rooms; these were followed by a third and more severe shock, which was immediately followed by a roar, as the steam in the 20-inch main, fed by 16 boilers, rushed through the opening in the fractured flange.

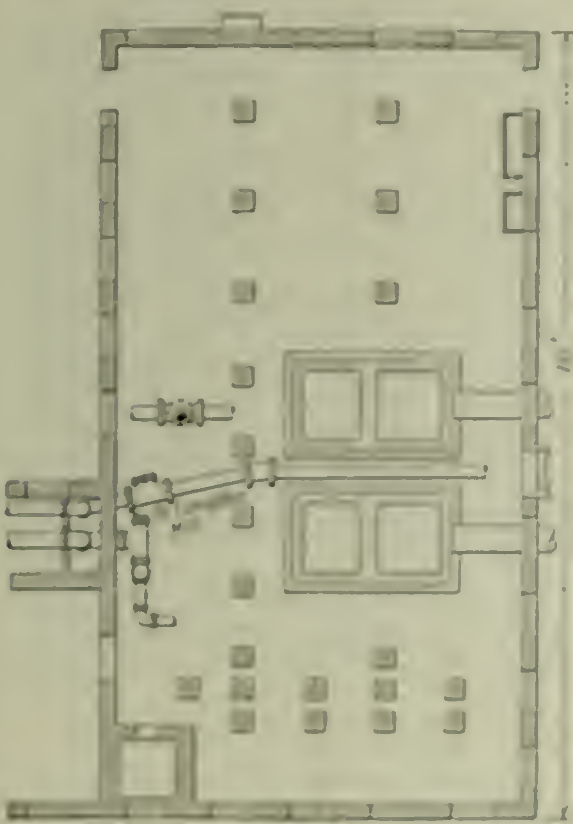
Engineer Pettigrew and Electrician Webster escaped without serious injury. As soon as Pettigrew heard the roar and saw the steam coming up through the cracks in the temporary plank flooring, he made his way through the steam to the door leading into the pump room and on into the boiler room where the steam was shut off. Webster, on his way past the one turbine that was in operation at the time, pulled the automatic which shut the unit down and probably prevented serious damage to the electrical end from running with a load while moist vapor filled the room.

A steam pressure of 170 pounds per square inch was carried on the pipe, and before the flow had been gotten under control, one man was dead, two so severely burned that they have since died and several others were burned, but not dangerously so.

Horace Crawford, an electrician, was so badly scalded that he died in a few hours. He had been at work all night and at the time of the accident had some wire in his hand. Later a window was found broken and the wire was on the outside, but evidently Crawford became confused and attempted to find another means of exit. When found he was on the floor near the double door at the end of the turbine room.

James Cassidy, a piper's helper, was found dead on the floor near where he had been last seen crossing the room. He was enveloped in steam which came up through the loose flooring. It is supposed that he inhaled steam, and immediately succumbed.

Frank Dyer, 18 years old, the last to die, was the son of Engineer Dyer, also



SHOWING LOCATION OF TEE AND NATURE OF THE FRACTURE IN THE BLANK FLANGE

seriously burned. He was just about to begin work during his Easter school vacation in order to gain experience in engineering. He had gone down into the basement to enter the wash room that was located on the opposite side of the basement from the tee connection and near the far end. He was just about to open the wash-room door (the key was later found in the lock), when the accident occurred. With rare presence of mind, Dyer ran around the end of the wash room and, opening a window that faced a dry raceway, dropped a distance of 20 feet, ran across the raceway, climbed up a ladder and jumped into a canal, doubtless to relieve his suffering. The burns and the shock of the ice-cold canal water was more than his system could withstand.

The only damage to the plant was the rupture of the blank flange. The fractured flange showed no indication of a flaw or other weakness. A new 3/4-inch steel blank flange, bumped to a radius equal to that of the diameter of the pipe, has been riveted to the dead end of the tee in place of the cast-iron blank flange.

Just why water hammer should have occurred is not known. The pipe was drained by a trap and Engineer Dyer had gone down to ascertain if a new trap that had been put in place the Sunday before was working properly. As it was, he left the basement just before the flange fractured. The steam pipe has a 20-inch pitch toward the discharge end.

Contrary to the accounts published by the daily papers, concerning the secrecy maintained by the officials of the company regarding the accident, it is but just to state that such reports were false. A POWER representative received most courteous treatment while investigating the accident and every question was freely answered.

Water Rights in California

An important decision regarding water rights for power and irrigation purposes in California has been handed down by Judge Hutton, of the superior court, Los Angeles. It distinguishes between the rights of private appropriators and the rights of riparian owners, the case at issue involving the right of the use of a 10-inch stream known as Garden Gulch creek, both parties relying on claims to prior appropriation.

On this subject, Judge Hutton rules: "It is a great mistake to assume that the waters of a stream under these conditions are the subject of appropriation. The only waters that may be appropriated are the waters of streams on Government land and this before the rights of settlers upon the stream, who, by reason of their settlement became riparian proprietors, have accrued.

"The system of riparian rights is in full effect in California; that is to say, that the riparian owner, as against all other classes of appropriators, has a right to the full flood of the stream, undiminished in quantity and unaffected in quality, except that each riparian proprietor may divert so much of the stream upon his riparian or bank land for irrigation purposes as he can put to economical, beneficial use. From the date that the rights of the settler attach to the land no appropriation can be made that will interfere with his riparian rights. His riparian rights are just as much a part of the land as the trees upon it, and unless taken away before the settler's rights accrue, he must be left in the enjoyment thereof unmolested. The evidence discloses that the plaintiff (the upper riparian owner) is threatening to take water, not from the stream proper, but from a nearby spring which obviously must either feed or be fed from the stream, and belongs to the watershed. Plaintiff has no right to carry his threats into execution and to remove all or any part of this water from the watershed. He cannot, even temporarily, do this without the consent of defendant (lower riparian owner)."

This decision shows conclusively upon what waters appropriations may be filed, and the extent of the appropriator's power of diversion.

Pressure Tank for Sprinkler System Explodes

By Edward T. Binns

On March 14, the pressure tank for the sprinkler system at the old Press building, Pittsburg, exploded. Considerable damage was done to the property and three persons were seriously injured. The tank was 72 inches in diameter and 21 feet long. It was made up of three 86-inch sheets 1/2 of an inch thick. The seams were triple-riveted lap joints, 3/4-

RUPTURED HEAD OF AIR TANK

inch rivets being used on a 3-inch pitch. The heads were made of 11/16-inch plate and were not braced.

There was no safety valve or pressure regulator on the tank, the pressure being regulated by the engineer in the engine room. The tank was located on top of the house. The boiler pressure carried was 80 pounds, and a duplex pump with a ratio of two to one was used to pump up the pressure in the tank. Some idea of the force of the explosion may be gained from the fact that one of the heads was blown out and driven broadside-on through the wall of the building. It lodged under the floor of the adjoining apartment, bending five 8x10-inch steel I-beams. Several fragments of metal and piping were blown clear through the main building and out onto Fifth avenue, a distance of 300 feet. The body of the tank was wrenched loose from its moorings, moved about 20 feet along the roof, stopping with several feet of its length protruding over the street, where hundreds of people pass constantly.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Vater System of Water Purification

This can be briefly described as a hot-process water-purifying system which takes advantage of the well known fact that chemical reactions are much more rapid and complete when they take place at high than at low temperatures. The system depends essentially on three fundamental propositions. First, the use of solutions of uniform strength; second, feeding in proportion to the load, and, third, plenty of time for the reactions to take place.

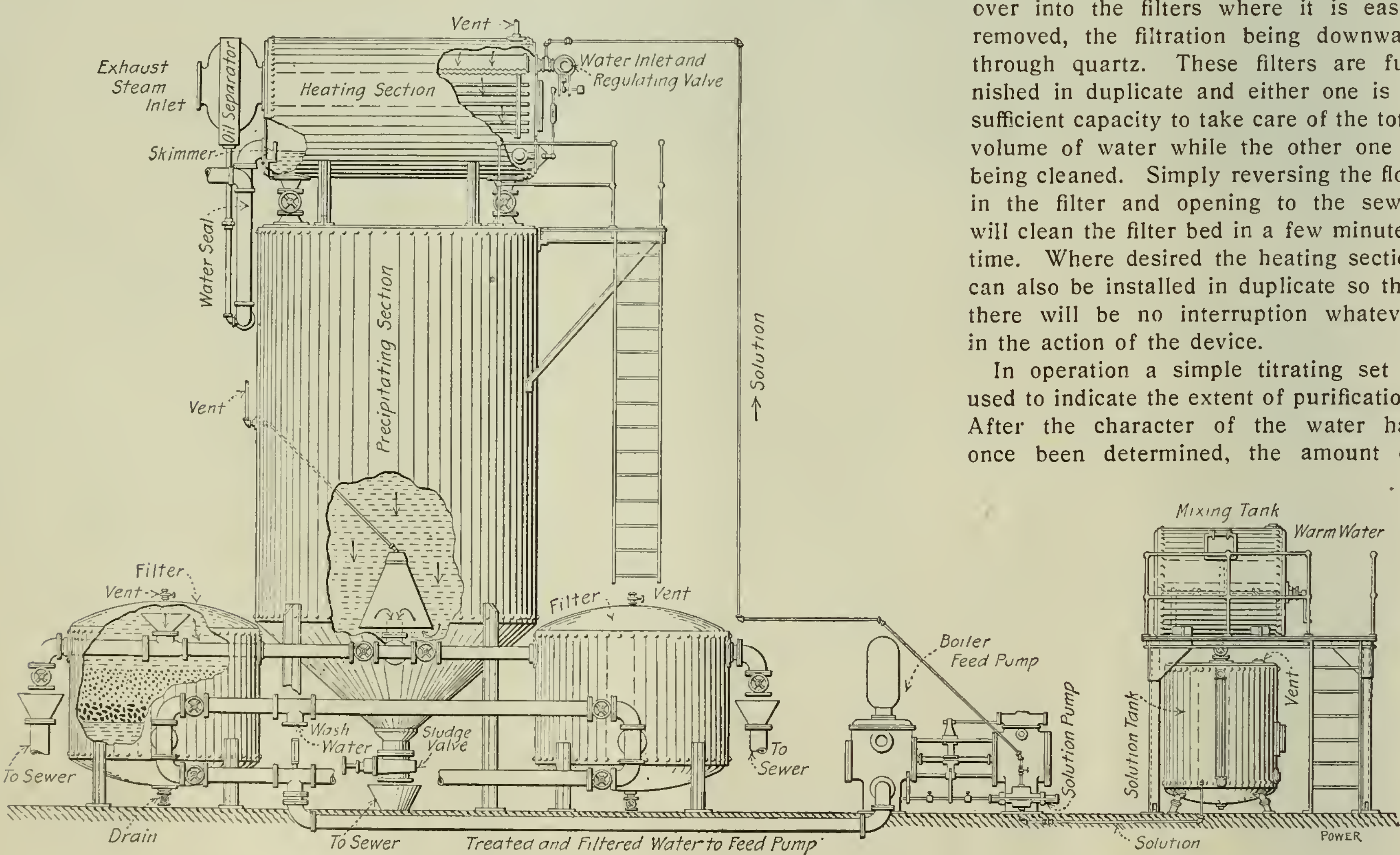
A mixing tank with paddles and crank for hand operation is provided, as shown in the part-sectional illustration. Here the reagents are mixed in the proportion indicated by the character of the water. After the mixing has been done and the solution has settled and clarified it is siphoned into the holding tank below, from which point it is taken by a special solution pump attached to the crosshead of the boiler-feed pump and delivered to the purifier proper. The solution pump is specially designed for this purpose, with a variable stroke which can be adjusted while the pump is in operation and provision is made to withstand the action of the reagents on its working parts. By providing a mixing tank and solution tank as shown, continuous runs can be made, the effect of the two tanks being the same as if this piece of apparatus were provided in duplicate.

The purifier proper consists, first, of a heating section, which is an induction open heater, in which is arranged a system of pans designed to break up the water into small particles and facilitate the transmission of heat, and, second, a precipitating tank. An oil separator is connected to the heater, which removes any oil that may be in the steam and allows the condensed steam to form part of the treated water.

A float valve control is arranged in the heater, maintaining the water level at the desired point, and two valved connections are arranged for the water to descend into the precipitating section. As the solution pump is connected to the feed pump, just the amount necessary for softening the water being used is introduced into the heater, where it is raised to exhaust-steam temperature and intimately mixed with the water before entering the precipitating tank.

The latter has been designed to give ample time for the reactions to take place. It is found that 90 per cent. of the impurities are precipitated at this point in the form of a sludge which can be blown out from the cone-shaped bottom of the tank. The light, flocculent material passes through the inverted cone-shaped intake, over into the filters where it is easily removed, the filtration being downward through quartz. These filters are furnished in duplicate and either one is of sufficient capacity to take care of the total volume of water while the other one is being cleaned. Simply reversing the flow in the filter and opening to the sewer will clean the filter bed in a few minutes' time. Where desired the heating section can also be installed in duplicate so that there will be no interruption whatever in the action of the device.

In operation a simple titrating set is used to indicate the extent of purification. After the character of the water has once been determined, the amount of color given to a test sample when titrated is a correct indication of the condition of the purified water. The operator is given a small bottle of water properly colored and he uses this as a guide when making up his solution. If he finds on titrating a sample that he has mixed a solution



Showing Arrangement of the Vater System of Water Purification which is too strong, or, in other words, if the result of his test shows too much color in the sample, he simply reduces the stroke of the solution pump so as to feed the solution in less quantities. Similarly, if he finds the solution weak he can increase the stroke of the pump to compensate for this weakness.

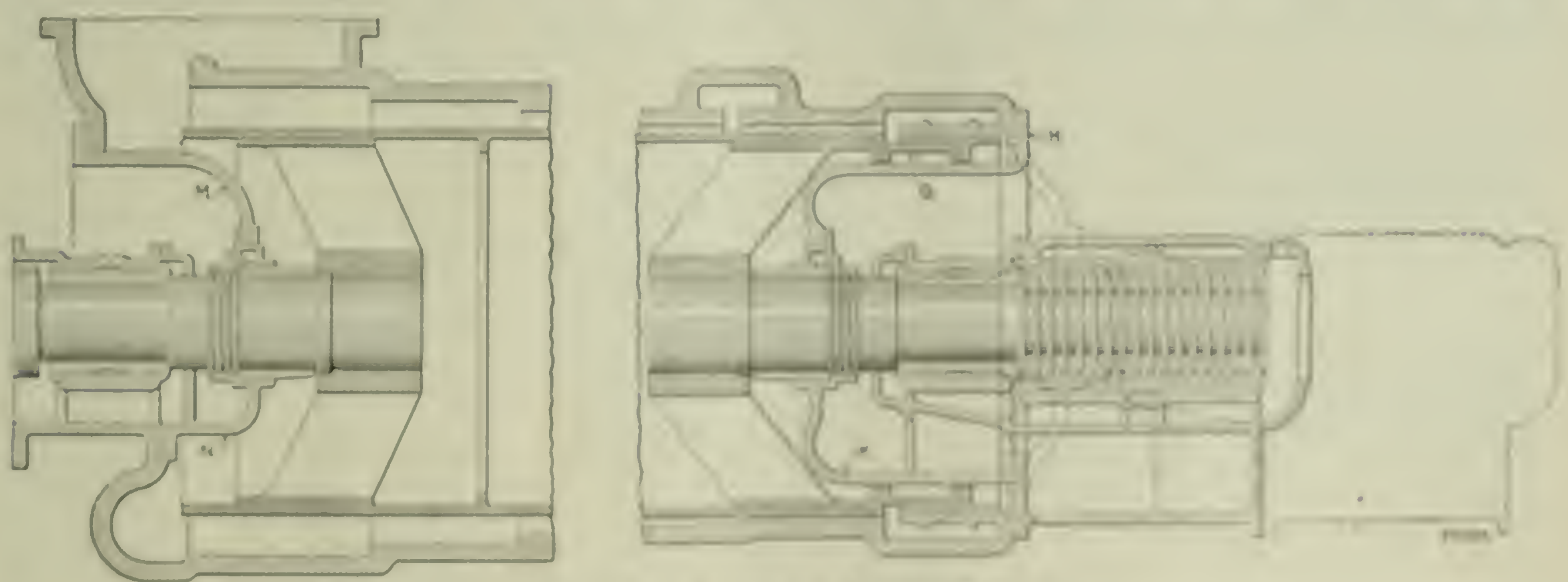
It is claimed that the apparatus will reduce the incrusting solids to as low as 1½ grains per gallon, with an excess of solution not exceeding ½ grain per gallon. Any combination of reagents can be used without making alterations in the equipment and the water is delivered to the boilers at a high temperature, thus doing away with the necessity for a feed-water heater where a softener is installed.

The Vater water-softening system is built by the Power Plant Specialty Company, Monadnock block, Chicago, Ill.

New Parsons Turbine Casing

When the turbine casing is made in halves, with the ends cast on, the end or head cannot project inside of the rotor drum, as it would not allow the latter to be lifted out; nor indeed to be inserted. A British patent has just been issued to the Hon. Charles A. Parsons for a casing of which the form illustrated herewith in an example.

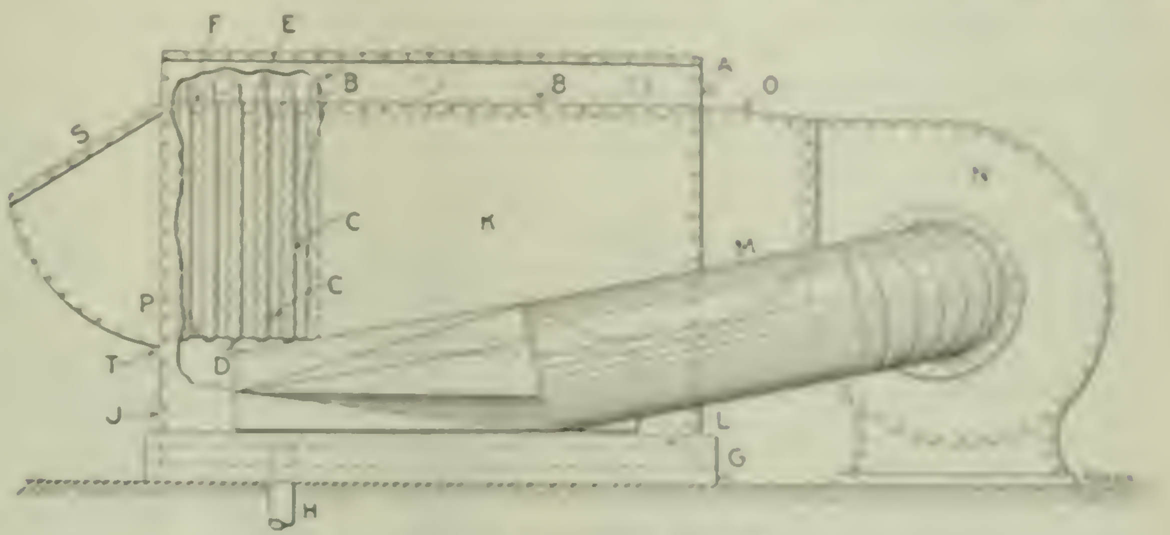
The cut shows the casing, parted longitudinally at the center as usual, but with the heads cast in the four separate pieces H K and M N. The rotor G, including the driving pistons, extends well over the head, but the latter can be unbolted and removed in sections, the under halves being turned around the shaft and lifted out like the lower boxes of a bearing. Were the heads cast integral with the rest of the casing the bearing and thrust block would extend at least to the dotted position, greatly increasing the length and weight of the turbine, and the difficulties which go with a long rotating member.



New Type of Casing for Parsons Turbine

A Liquid Cooler

The accompanying illustration represents a liquid cooler that has been designed for the purpose of cooling liquids, such as condenser water from ammonia coils.



Details of Liquid Cooler

The cooler consists of a blower and a bank of double cooling tubes inclosed in a sheet-iron casing. The liquid to be cooled flows through a header (not shown) and is distributed over the pan A by the short pipe connections B B; it then takes a downward course through the bank of tubes, between the tubes C C and D D. E, it will be noticed, is only an extension of the tubes D, bringing the top of the tubes far enough above the tube sheet F to prevent the liquid from flowing over the top into the center of the tubes D D, thus producing a hollow column of liquid.

The lower ends of the tubes D are expanded just large enough to pass snugly through the larger tubes C, thus making a regulating valve of each set of tubes so the flow of liquid can be controlled, as the time taken by the passage of the liquid through the tubes plays an important part in the final temperature. The liquid is then received into the tank G, the level of which is maintained by the height of the top of the return pipe H through which the liquid is returned to the point it came from as hot liquid to again do its mission as a cooling agent.

The extension J at the bottom of the casing K drops below the liquid line L maintained by the top of the pipe H, thus forming a seal for the purpose of keeping the air drawn downward through the tubes D and to prevent the outer air entering the suction pipe M of the blower N and destroying the vacuum thus created.

The air is then discharged back through the connection O into the chamber around the outer tubes C and between the upper and lower tube sheets P and F and finally is discharged out of the cooler through the connection S.

The water which is carried over with the blast of air through the cooler is allowed to drain back through the opening at T; thus none of the liquid is wasted but is all finally carried back to the tank G. The temperature of the liquid can be lowered from 100 degrees to about [illegible] degrees in summer weather, it is stated. The cleaning of any sediment or deposit that is common in an equipment of this kind can be easily removed at any time without stopping the cooler at all, on account of the arrangement of the tubing.

The adjustment of the flow of the liquid is accomplished by a lever (not shown) which, by a movement either up or down, increases or diminishes the flow of the liquid through the inner tubes *D*.

The only additional water used is the water with which the air is sprayed—this makes it possible to reach a low temperature during the hot and sultry days of summer. This spray is at the top, over the pan *A*, and is not lost as it unites with the water being circulated through the cooler.

This device is made by F. P. Hopkins, 1361 Bonnie View avenue, Lakewood, O.

New Era Self Lubricating Metallic Packing

The packing shown herewith is an improved product, which, consisting of a nonelastic, compound mass of metallic lubricants, requires no lubrication whatever except that contained within its own substance. It is claimed by the manufacturer that it never becomes charred or otherwise unfit for service and that it will not lock or score the rods, plungers, or shafts on which it is used. Fig. 1 is a sectional view of the packing in place, as manufactured by the New Era Manufacturing Company, Kalamazoo, Mich. *A* represents the piston rod; *B* the body or stuffing box; *C* the stuffing-box gland; *D* the main body of packing container; *E* the supplementary gland; *F F* the bearing rings; *I I* the self-lubricating metallic packing, and *J* the metallic rings which surround the rod in three sections, as illustrated in Fig. 2.

The bearing rings *F F* admit lateral motion to the main body of the packing container *D*, and supplementary gland *E*, to compensate for any movement of the piston rod when out of alinement.

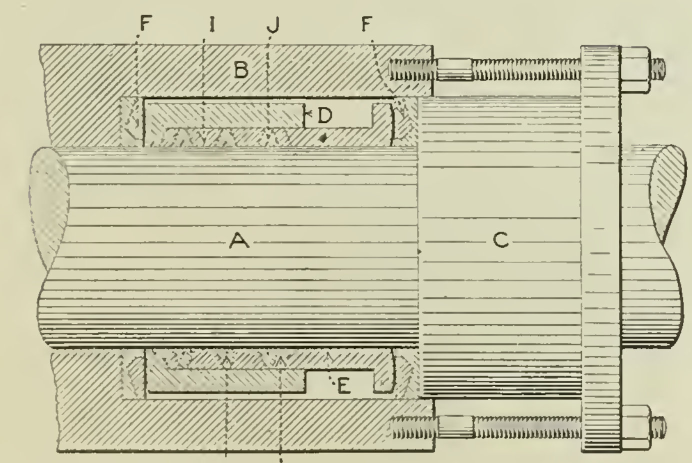


Fig. 1. Sectional View of Packing Container

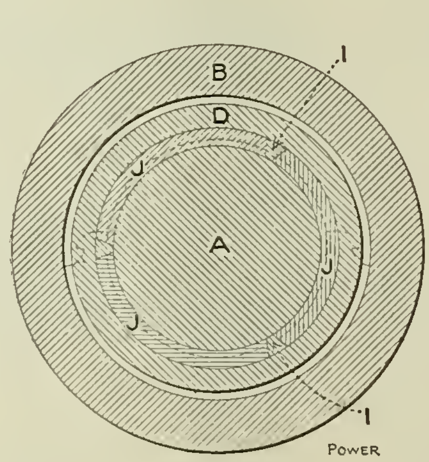
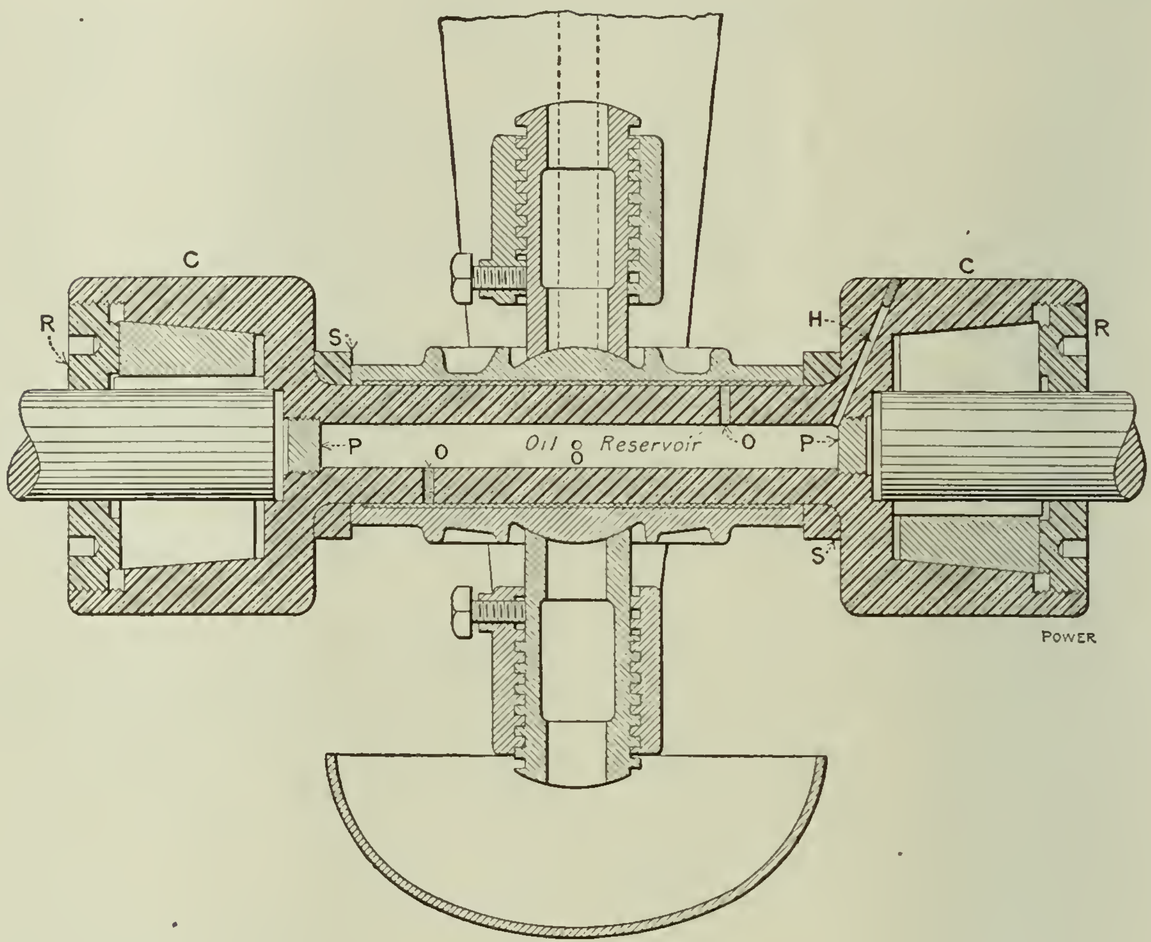


Fig. 2. Transverse Section

As shown in Fig. 2, there are three metallic packing rings surrounding the rod, the space between their ends being occupied by the plastic packing *I*. This latter may be renewed whenever necessary and serves to take up wear on the packing as it occurs. It can be placed on an engine without dismantling and when occasion requires.

A Self Oiling Hanger Coupling

In the accompanying drawing is shown a self-oiling hanger coupling, the object of which is to connect two sections of a line shaft at a hanger, thus providing more space on the shaft for pulleys. It is made with a reservoir for holding lubricating oil that is fed to the bearing through the oil holes *O*, which are fitted with felt to prevent the oil from flowing too rapidly.



Combination Hanger and Coupling

This style of coupling supports the shaft at its weakest point. The coupling can be used on any standard hanger and can be made with or without the oiling device.

It consists of a steel forging *C*, which is turned in the center to form the journal, and has the cone cups on each end to receive the ends of the two sections of shafting to be coupled together. The cones are forced in by the threaded rings *R* with a spanner.

The split rings *S* are used to take up the lateral play of the shaft.

In making the oiler for the coupling, a hole is drilled through its entire length and the ends are closed by the cast-iron plugs *P*. To fill the reservoir the passage *H* is drilled from the outside, and the outer end plugged by a tight-fitting screw.

This hanger is the invention of H. C. Williamson, 309 London street, Portsmouth, Va.

Coal Land Frauds

It was reported on March 28 that Charles F. Munday, a lawyer of Seattle, Wash., was placed on trial in the Federal court on a charge of having conspired to defraud the Government of $100,000,000 coal lands near Katalla, Alaska. He and Earl E. Stacey, private secretary to the late M. J. Heney, builder of the White Pass & Copper River and Northwestern railroads, the latter the property of the Morgan-Guggenheim syndicate, and Archie W. Shields were indicted by a Federal grand jury sitting at Tacoma last October.

Generally, the indictments charge Munday and his associates with having several years ago induced dummy locators to file on the claims best known as the English group for the Alaska Development Company and the Pacific Coal Company. These claims comprise 6087 acres of what is declared by experts to be among the richest coal lands in Alaska.

Notice!

Paul Kirk, who formerly represented POWER as a subscription solicitor in New York City, is no longer in the employ of this paper.

Large Plant Taken Over by Central Station

It is reported in the daily press that the Walworth Manufacturing Company has signed a five-year contract with the Edison Electric Illuminating Company, of Boston, for all the light and power service in its big manufacturing plant in South Boston. The contract calls for service to replace five steam plants aggregating a total of 1100 horsepower capacity. The business of the Walworth company has increased to the point where the management was confronted with the necessity for a practically complete renewal of its steam-power system, the installation of an electric light and power plant of its own or the adoption of the service of the Edison company, and the central station won out.

Central Station Welfare Work

The public-policy committee of the National Electric Light Association, which, during the past winter, has been devoting considerable attention to the various aspects of welfare work as related to the central-station industry, held a final meeting at the New York headquarters in the United Engineering building on March 28, when the report which has been prepared through a series of long conferences was unanimously adopted, and the recommendations and suggestions were put in definite shape for presentation to the member companies, in number nearly a thousand, at the annual convention in New York next May.

Several of the companies already have in force some of the schemes proposed, but it is not assumed that every company will wish to adopt every form of relationship outlined in the report. The plan includes accident insurance, sickness insurance and death benefits, service annuities, profit-sharing, employees' savings and investment funds, and life insurance, although with regard to the last item it is suggested that the companies limit themselves to providing their employees with all possible information in connection with safe low-cost life insurance, and do not put in force any plan of their own.

The coming report will give in detail the methods by which provision can be made under each of the other heads. By unanimous vote the term "pension" has been dropped and the service annuity adopted as the recognition of an automatic recompense for continuous service, and the committee is of the opinion that member companies should provide such annuities for every male employee reaching the age of sixty-five, and every female employee of sixty years after continuous and satisfactory record of ten years of service. The details of profit sharing are based upon the idea that it is better to have those engaged in the industry as partners rather than employees and that preferably profits of the employee based upon his wage scale should reach him in the securities of his company and that dividends upon such securities should be paid in cash, in the manner customary with other security holders. Details are also given with regard to savings funds and investment funds, with the object of promoting thrift amongst employees and, where feasible, combining the plan with profit sharing, it having been found that the two work out very satisfactorily together.

The report will be awaited with interest by all connected with public utilities and by economists in general.

PERSONAL

John B. Youngblood, formerly State examiner for the Cleveland district, has been appointed assistant chief examiner with headquarters at Columbus, O. Thomas Eaton has been appointed to fill the vacancy left in the Cleveland district.

On April 1, James A. Donnelly, of New York City, addressed the Robert Fulton Association, Illinois No. 28, National Association of Stationary Engineers, in the rooms of the association in the Masonic Temple, Chicago. His subject was "Steam Circulation."

Robert Bosch, of Stuttgart, Germany, designer and inventor of the Bosch products, has arrived in the United States. Doctor Bosch is much interested in our great manufacturing industries, and with Otto Heins, president of the Bosch Magneto Company, of New York, is making an extended tour of the United States with the object of visiting some of the larger American industries as well as natural points of interest.

OBITUARY

George Bowers Caldwell, of Yonkers, N. Y., died, March 31, 1911. Mr. Caldwell was born at Lawrence, Mass., in 1863 and was for many years connected with the engineering department of Westinghouse, Church, Kerr & Co., as one of the chief mechanical engineers. Prior to his connection with this company he was employed for thirteen years in the machine shops of the Lawrence Manufacturing Company, of Lowell, Mass., and the Washington Mills Company of Lawrence, Mass., also in charge of their new construction and repair work.

During his connection with Westinghouse, Church, Kerr & Co., which began in 1893, he was connected with the design and construction of the following important pieces of work:

The mechanical and electrical features of the South Terminal Station, Boston, Mass., the terminal station of the Pittsburg & Lake Erie Railroad, the railroad shops of the P. & L. E. R. R. at McKees Rocks; the construction of the Kingsbridge power station, New York City, for the Third Avenue Railroad. He also supervised the design and installation of the Long Island Railroad Company's electrification, including the large power house at Long Island City. His last work was in charge of design and construction of the mechanical and electrical features of the Pennsylvania terminal station in New York City, which he was obliged to relinquish just before it was completed.

Mr. Caldwell was a member of the American Society of Mechanical Engineers and the American Society of Civil Engineers. He was also a member of Grecian Lodge A. F. & A. M. and Mt. Sinai Chapter R. A. M., of Lawrence, Mass. He leaves a wife, four children and his father, Lewis H. Caldwell, the latter being a resident of Los Angeles, Cal.

SOCIETY NOTES

The board of governors of the American Society of Heating and Ventilating Engineers held a meeting at the headquarters of the society in the Engineering Societies building, 29 West Thirty-ninth street, on Friday afternoon, March 24. Twenty-five applications for membership were approved and ordered prepared for the usual membership ballot. It was voted to issue during the present year the proceedings for 1909 and 1910. The proposal to hold the summer meeting on a three days' steamship trip on June 27, 28 and 29 on Lake Michigan and Green bay was favorably received and it was decided to canvass the membership to learn if a sufficient number may be counted on. Tentative arrangements have been made to charter one of Lake Michigan's leading steamships. Special entertainment is planned for the three evenings taken up in the journey; proper periods of morning and afternoon are reserved for the technical sessions and a considerable number of stops at interesting cities and interesting places with perhaps an hour's sojourn in each case are possible.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

[illegible]

[illegible]

ELASTIC-FLUID TURBINE. Carl Richard Waller, Trenton, N. J., assignor to De Laval Steam Turbine Company, New York, N. Y., a Corporation of New Jersey. 987,842.

INTERNAL COMBUSTION ENGINE. Jamie Hunter Batchelor and Herbert H. Smith, Dothan, Ala. 987,848.

GAS ENGINE. John T. Cowie, New Westminster, British Columbia, Canada, assignor of one-half to Henry Schaake, New Westminster, Canada. 987,860.

ROTARY GAS ENGINE. Franklin D. Thomas, Saginaw, Mich. 987,929.

AUTOMATIC WAVE APPARATUS. Robert Max Mobius, San Diego, Cal. 988,012.

INTERNAL COMBUSTION ENGINE. Perry Okey, Columbus, Ohio, assignor of one-half to Sarah Louise Okey, Columbus, Ohio. 988,021.

TURBO DISPLACEMENT ENGINE. Lewis Hallock Nash, South Norwalk, Conn., assignor to Nash Engineering Company, a Corporation of New York. 988,133.

BALANCED WATER MOTOR. Philander T. Dodson, Creston, Iowa. 988,256.

INTERNAL COMBUSTION ENGINE. Geo. W. Brown, Salamonie township, Huntington county, Ind. 987,860.

BOILERS, FURNACES AND GAS PRODUCERS

MECHANICAL STOKER. Arthur R. Selden, Rochester, N. Y. 987,834.

FURNACE. Herman A. Poppenhusen, Evanston, and Joseph Harrington, Riverside, Ill. 987,911.

FURNACE. Herman A. Poppenhusen, Evanston, Ill. 988,027.

OIL BURNER. Ernest L. Kendall, Riggold, Tex. 988,111.

FURNACE. William McClave, Scranton, Penn., assignor to McClave-Brooks Company, Scranton, Penn., a Corporation of Pennsylvania. 988,123.

INJECTOR BURNER. Nicholas S. Sibert, Neodesha, Kan. 988,216.

FEED-WATER HEATER. Jared S. Sweeny and William W. Grindle, Decatur, Ill.

POWDERED-COAL BURNER. Alva D. Lee, Boston, Mass., assignor to Lee Furnace and Burner Company, a Corporation of New York. 988,271.

POWER PLANT AUXILIARIES AND APPLIANCES

BOILER SKIMMER. Byron Epson Foss, Chicago, Ill., assignor of forty-nine one-hundredths to Richard H. Malcomson, Chicago, Ill. 987,710.

ROTARY PUMP. Adelbert Fournier, Sprague, Wash., assignor to James F. O'Brien, Seattle, Wash. 987,711.

LUBRICATOR. George H. Menzies, Pittsburg, Penn. 987,735.

VALVE. John W. Smith and Elmer H. Smith, Minneapolis, Minn. 987,757.

INJECTOR. William Henry Stirling, St. John, N. B., Canada, assignor of one-half to James E. Hogan, St. John, N. B., Canada. 987,769.

ENGINE CROSSHEAD. Robert W. Bryan, Aberdeen, Wash., assignor of one-half to George B. Reid, Aberdeen, Wash. 987,853.

PUMP. Charles Williams, Brooklyn, N. Y. 987,934.

TURBINE PUMP. Walter L. Forward, West Berkeley, Cal., assignor to Byron Jackson Iron Works, Berkeley, Cal., a Corporation of California. 987,976.

BEADING TOOL FOR BOILER TUBES. Eugene Wiet, San Francisco, Cal. 988,054.

OILING DEVICE. George W. Cook, Jr., Bainbridge, N. Y., assignor to American Separator Company, Bainbridge, N. Y., a Corporation of New York. 988,080.

SEPARATOR FOR BOILERS. Joseph E. Harrison, Harvey, N. D. 988,264.

APPARATUS FOR PREPARING GROMETS OR PACKINGS FOR STUFFING BOXES. William Heron, Birkenhead, England. 988,267.

MECHANICAL MOVEMENT FOR AUTOMATIC STOKERS. William McClave, Scranton, Penn., assignor to McClave-Brooks Company, Scranton, Penn., a Corporation of Pennsylvania. 988,275.

ELECTRICAL INVENTIONS AND APPLICATIONS

ELECTRIC HIGH-WATER ALARM. Edwin E. Brackett, Central Falls, R. I. 987,694.

ALTERNATING-CURRENT MOTOR AND CONTROLLING DEVICE THEREFOR. Vance I. Gray, Toledo, Ohio, assignor to the F. Bissell Company, Toledo, Ohio, a Corporation of Ohio. 987,979.

Engineering Societies

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City. Spring meeting in Pittsburg, May 30 to June 2.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York. Next meeting in New York City, May 29 to June 2.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Commander U. T. Holmes, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., O. P. Chamberlain; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill. Meeting first Wednesday of each month.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., Walter Riddle; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Pres., R. P. Bolton; sec., W. W. Macon, 29 West Thirty-ninth street, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio, September 12-15, 1911.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June 5-10, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting at Detroit, Mich., January 15-19, 1912.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May 23-26, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

BUSINESS ITEMS

"Boiler Room Tactics" is the title of a booklet, which has been issued to give some general rules for the care and management of the Heine boilers. The booklet contains a good deal of very useful information for those having this type of boiler in charge and will be sent on application to the Heine Safety Boiler Company, 2449 East Marcus avenue, St. Louis, Mo.

A 36-inch Swartwout horizontal oil separator was sold last month to the Holly Sugar Company, Huntington Beach, Cal., by the Ohio Blower Company, of Cleveland, Ohio. Other oil separators were sold to the Michigan Paper Company, Plainwell, Mich.; D. C. Armbrust, Los Angeles, Cal.; Ellwanger Barry Realty Company, Rochester, N. Y; M. D. Olds, Cheboygan, Mich., and Bachelor Timber Company, West Branch, Mich.

F. L. W. Saunderson has been appointed the Canadian manager of the Magnolia Metal Company, with factory and offices located in Montreal. Mr. Saunderson graduated at McGill University in class of 1891, taking a course in electrical engineering and afterward took a special practical electrical course with the Thomson-Houston Electric Company, and for the past fifteen years has been identified with the mill-supply business in Canada.

Persons having a liking for mechanical devices will be interested in an ingenious model, now being distributed by the Harrison Safety Boiler Works, Seventeenth and Clearfield streets, Philadelphia, Penn., to illustrate the valve-timing gear in the new Cochrane steam stack and cut-out valve feed-water heater and receiver. The model, which is constructed of stiff celluloid, illustrates neatly the fact that when the heater is cut off from the exhaust steam supply, the separator attached to and forming a part of the heater continues to furnish exhaust steam purified of oil to the heating or drying system, while the trap is cut off from communication with the heater, but still continues to drain the separator. Upon the reverse of the model it is stated that full particulars regarding the application of these heaters in connection with all kinds of exhaust steam-heating systems are fully explained in the "Exhaust Steam Heating Encyclopedia," published by the manufacturer, which, with the model, is sent gratis to persons who are interested in the design, installation or operation of exhaust-steam heating systems.

NEW EQUIPMENT

Brockton, Mass., is contemplating the installation of a municipal electric-lighting plant.

Ernest Marshall, Oakes, N. D., has been granted franchise to install an electric-light plant.

The Standard Ice Company, Seattle, Wash., is planning to erect a new boiler-house addition.

Troy Laundry, Hagerstown, Md., is in the market for a 125-horsepower return-tubular boiler.

The Ottawa (Ont.) Electric Railway Company will build an addition to its power house.

The Lowes Laundry, South Norwalk, Conn., is contemplating installing a 60-horsepower boiler.

The Preston Fertilizer Company, Laurel Hill, R. I., will install boiler, engine and pumps.

Power plant of the Milwaukee Electric Railway Company, at Racine, Wis., was burned.

The cities of Marshfield and North Bend, Ore., are planning a joint municipal water system.

POWER

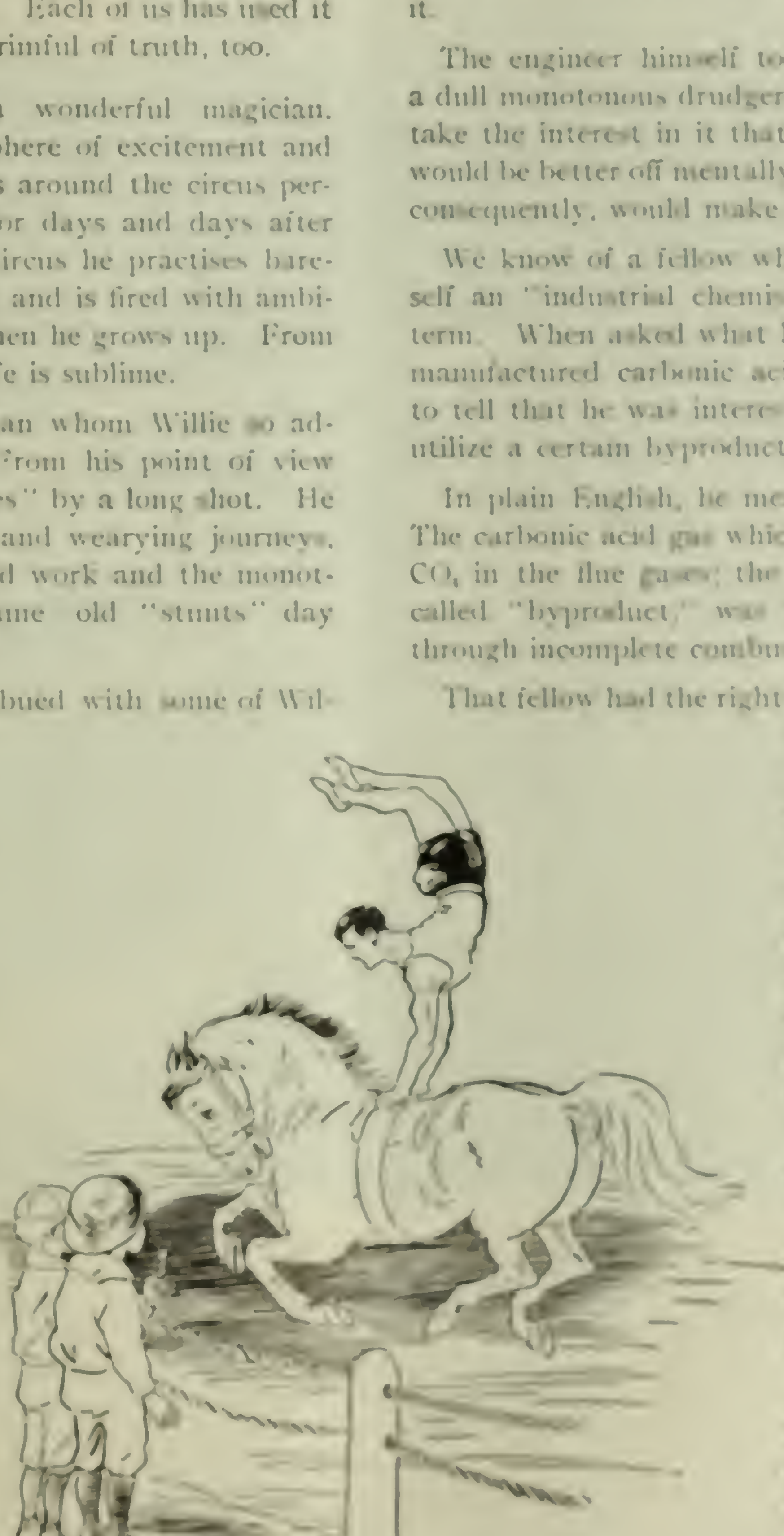
NEW YORK, APRIL 18, 1911

"IT ALL depends on how you look at it"—a familiar quotation that. Each of us has used it time and again. It is brimful of truth, too.

Old "Point-of-view" is a wonderful magician. For instance, what an atmosphere of excitement and fascinating romance he throws around the circus performer for the small boy. For days and days after little Willie has been to the circus he practises bareback riding on a kitchen chair and is fired with ambition to become a performer when he grows up. From Willie's point of view circus life is sublime.

But, how differently the man whom Willie so admires looks at the matter! From his point of view life is not all "beer and skittles" by a long shot. He sees the long, uncomfortable and wearying journeys, the one-night stands, the hard work and the monotony of going through the same old "stunts" day after day.

If he could but become imbued with some of Willie's romantic views of his profession, how much more contented he would be, and what a much better performance he would be likely to make. There would be a dash and style to his act that would stamp him as an ARTIST.



In many ways the engineer and his work are similar to the circus performer and his.

To "hoi polloi" the engineer is a wonderful institution and his occupation is full of fascination. He can make all sorts of machines work just when and as he wishes; he understands their intricate construction and when trouble occurs, he knows how to seek it out and eliminate it.

The engineer himself too often considers his work a dull monotonous drudgery. If he would but see and take the interest in it that the layman often does, he would be better off mentally, would do better work and, consequently, would make better, faster progress.

We know of a fellow who once, in fun, called himself an "industrial chemist"—quite a high sounding term. When asked what his line was he said that he manufactured carbonic acid gas. Then he went on to tell that he was interested in the study of how to utilize a certain byproduct, carbon monoxide.

In plain English, he meant that he was a fireman. The carbonic acid gas which he manufactured was the CO_2 in the flue gases; the carbon monoxide, what he called "byproduct," was the CO which was formed through incomplete combustion.

That fellow had the right point of view. He saw the interesting side of his work. He dug into the reasons why certain causes produce certain results, not sometimes but always. He studied. The more he learned the more interested he became. He applied the interesting knowledge that he had acquired "for the fun of it" and he made a wonderful showing.

Today he is superintendent of motive power for a big industrial concern at a salary of $[illegible] a year.

He still has the right point of view. He gets enjoyment out of his work. No wonder he is making good.

The Steam Turbine in Germany

By F. E. Junge
and E. Heinrich

This instalment of the series on A. E. G. turbines deals with features of design, taking up the frame, casing, bearings, lubrication, stuffing boxes, disks and blades, nozzles and regulation.

All types of A. E. G. turbines have the following features in common:

1. One rigid frame for the whole unit, as shown in Fig. 29.
2. Three bearings, there being only one bearing between steam turbine and electric generator, while a rigid flange coupling is provided on the side of the turbine.
3. A rigid shaft, the critical speed of which is above the normal speed.

Frame: Those firms who build both the turbine and the electrical equipment have the advantage that they can cast the two frames in one piece, allowing both parts to be erected and tested together. If turbine and generator are built by different firms, of course, separate frames and separate bearings must be provided and a flexible coupling between the two units arranged. In the latter case the aggregate unit cannot be tested until after erection in the power house, the reliability of operation depending very largely on the ability and thoroughness of the erecting engineers. Here is an element of technical importance which speaks for concentration of production in the shops of one and the same firm. The frame plates of the A. E. G. turbine possess considerable hight and their walls have considerable thickness so that great rigidity of construction is assured. This is important, because light frame plates are apt to bend during erection, changing the relative position of the surfaces which are to fit. The mass or weight of frame is increased by filling its cavities with brickwork or cement, so that no special holding-down bolts are required to fasten the frame to the foundation. If the condensing plant is located below the turbine, as obtains in most cases, the turbine resting on I-beams, a rigid connection by bolts in the manner shown in Fig. 30 commends itself for the sake of stability. From this figure it is seen also that in order to facilitate attendance and avoid stairs, galleries, etc., the frame is set below the engine floor.

Casing: The casing of multiple-stage turbines consists of three parts, the front cover and the upper and lower halves of the casing, the latter divided horizontally and containing the low-pressure portion. The front cover and the first wall of the inner partition form a chamber or receptacle in which the Curtis wheel, equipped with two or three rows of blades, revolves. While to this wheel steam is fed to only a portion of the circumference through nozzles, the following wheels, having each only one row of blades, are impinged by means of guide blades with parallel walls, admitting steam over the whole circumference. The guide blades are of polished nickel steel, very accurately cast between an external

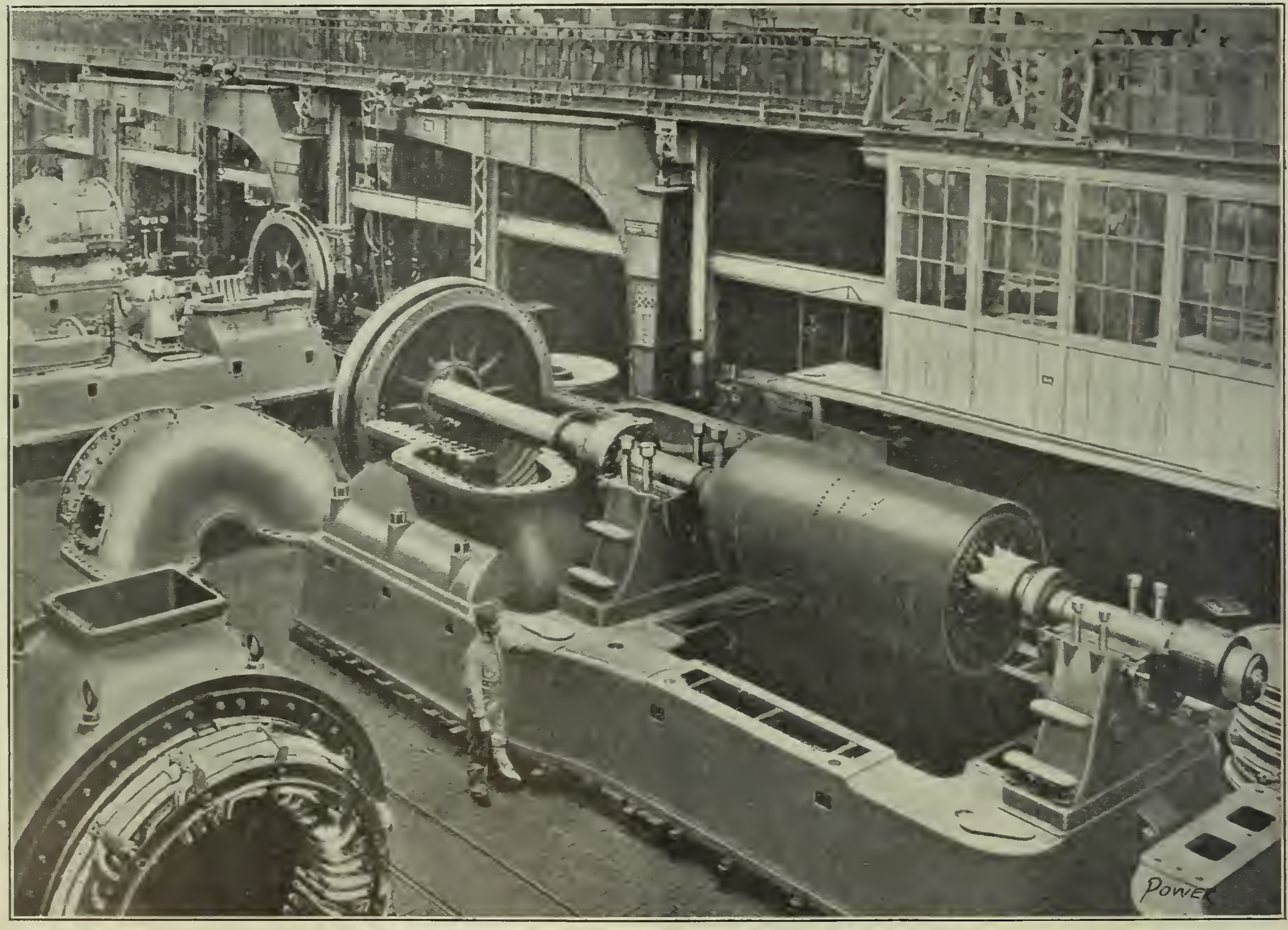


Fig. 29. A. E. G. Turbine Direct Connected to 6000-kilowatt Three-phase Generator in Course of Erection

and an internal cast-iron ring. These guiding rings are fastened in the two halves of the casing and remain there if the shaft, the wheels, and the separating walls are dismounted. The separating walls rest on the hubs of two consecutive low-pressure wheels. When the turbine is being mounted the key projecting from the inner circumference of the guiding rings engages the slots cut in the circumference of the separating walls. This construction is lately being replaced by another, which employs disks consisting of two parts, similar to those used in other makes. Disks made of one piece possess several disadvantages. If, for instance, the packing on the hub gets overheated, in order to obtain access to the source of trouble it is necessary to dismount the whole turbine and to withdraw the wheels from the shaft, which is a very difficult or, at least, complicated piece of work. This may occur when the turbine is connected with the exhaust, so that higher temperatures occur suddenly in the casing.

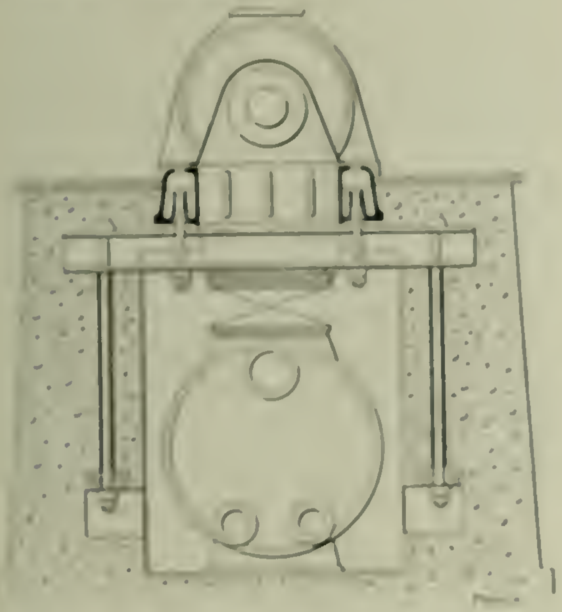


FIG. 30. FOUNDATION AND FRAME

The front cover is, as a rule, a steel casting, while the other sections of the casing are made of cast iron. Fig. 29 shows a turbine of high capacity (6000 kilowatts), of which the lower half of the casing with the guiding rings and the front cover with the nozzle segment are already mounted. The upper half of the casing lies on the floor. The two other turbines in the picture also show the composition of parts very clearly.

The construction of the high-speed type, in which two wheels are used, is somewhat different, no horizontal division throughout the casing being provided. The vertical section, Fig. 27, and the horizontal section, Fig. 28, show the details of construction very clearly, while Fig. 31 shows how this type of turbine is dismounted. First, the front cover is removed, then follows the first running wheel, afterward the intermediary guiding wheel, and finally the second running wheel. In order occasionally to inspect the inner working parts of the turbine, especially the nozzles and blades, it is not necessary to dismount the machine. As for the first stage, inspection can be made by removing one of the nozzle chests, while on the low-pressure part openings with covers are provided, permitting a complete inspection of the second stage.

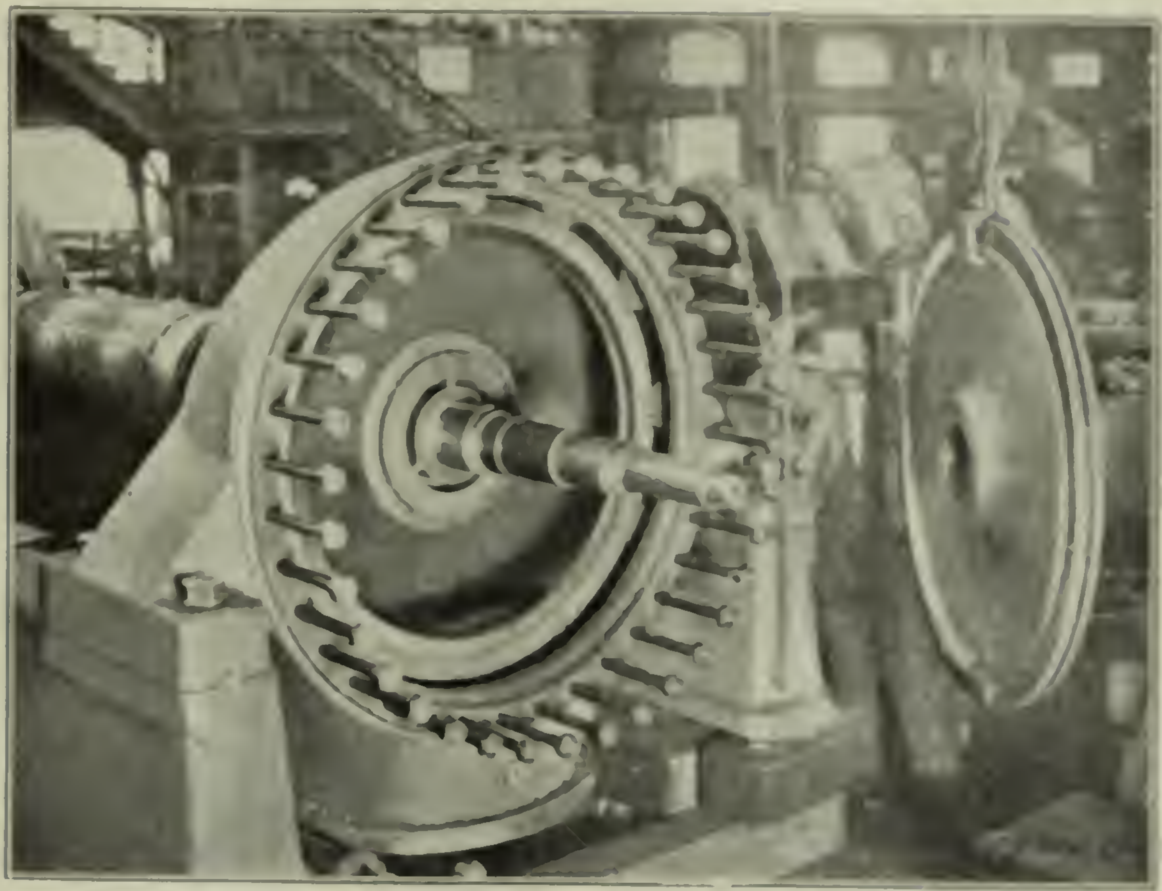


FIG. 31. A VIEW SHOWING INTERIOR CONSTRUCTION OF TURBINE

Though during operation the casing is subjected to low pressures only, all parts before leaving the shop are tested under several atmospheres of water pressure in order to locate porous or weak spots in the castings. In the A. E. G. construction the front bearing with the governor and oil-pump drive is connected by means of bolts to the front cover. Owing to the wide range of expansion in the first stage the temperatures in the casing are comparatively low; hence, this mode of construction is fairly free from objection. Some designers, however, prefer to separate the front bearing entirely from the casing by extending the base plate beyond the front side of the turbine.

Bearings: In the design of steam-turbine bearings the following general considerations arise: If p is the pressure per unit of area, u the circumferential velocity of the journal in units per second, l its length, d its diameter and μ the coefficient of friction, then we have $R = l\,d\,u\,p\,\mu$, the friction work of the journal per second and $r = \mu\,p\,u$, the friction work per unit area of the horizontal projection of the journal, or what is called the specific friction work. The results of all experimenters go to prove that the product $u\,p$ is constant for all pressures within the available limits; hence, we can use as a measure for the friction work per second the readily determinable product of the pressure and the circumferential velocity of the journal. Until lately this value was kept quite

FIG. 32. SECTIONAL VIEWS OF MAIN BEARING

low, especially when employing flexible shafts, the dimensions of bearings being laid out amply large. The value pv seldom surpassed 40 meter-kilograms, or, in English units, 1830 foot-pounds. Today all firms follow the example set by the Allgemeine Elektricitäts Gesellschaft. They shorten their turbine bearings, permitting a value $pv = 130$ to 150 in metric, or 6000 to 7000 in English units.

The construction of bearings embraces two parts: floor stands, or pedestals, and boxes. The former rest upon and are rigidly fastened to the base plate. The bushings are lined with white metal and are fitted by hand into the boxes, thus guaranteeing an oil-tight fit all along the surface; see Fig. 32. Lubrication is effected by means of oil pumps driven from the turbine. The oil piping is con-

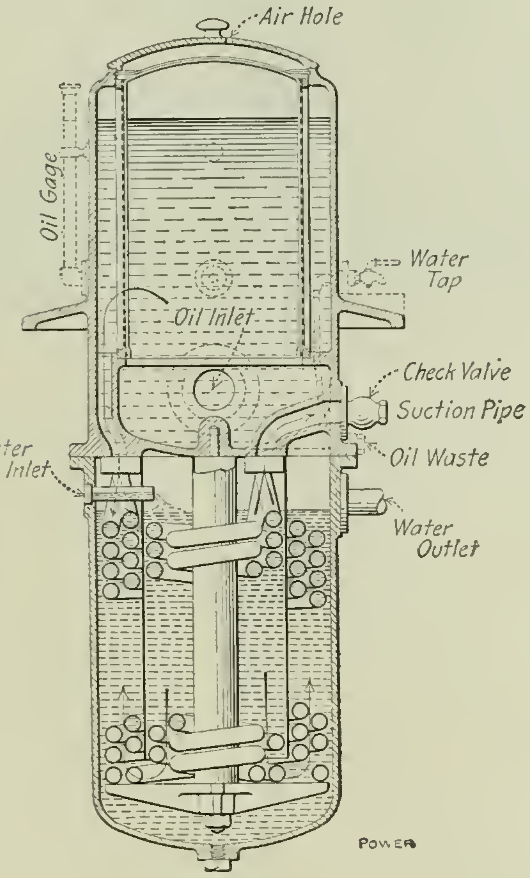


Fig. 33. Oil Cooler

nected to the pedestal and extends in its interior up to the bottom end of the bushing. The oil enters through a vertical channel into a broad groove, being driven by the revolving shaft toward the center line of the bearing, where the highest pressure occurs, and emerging on both sides into the cavities of the pedestal. The front bearing is constructed similarly to the rear one, with the difference that it contains the thrust journal. The main purpose of the latter is not to receive and absorb heavy shocks or stresses, but to maintain the relative axial position of rotating and stationary parts and to preserve and control the interstices and play which are provided during erection. As the pivot journal is subjected to wear the collars are not made in one piece with the shaft, but are attached to the latter, together with the worm gear for driving the governor, so that they may be easily exchanged.

Lubrication: The convection of the friction heat is effected partly in the bearing itself and partly by means of special oil coolers, similar to those used in other turbine systems. In one construction

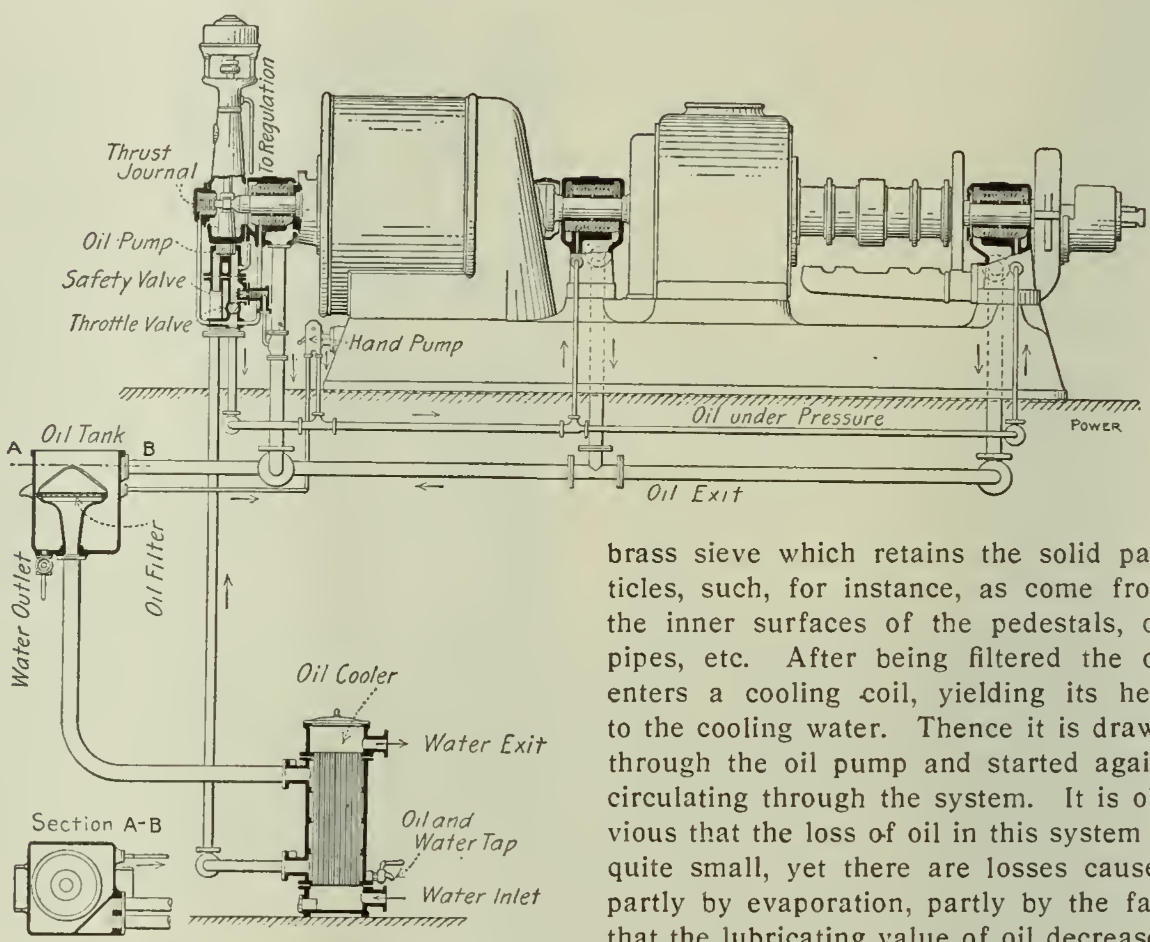


Fig. 34. Outline of Turbine Oiling System

the brasses are made hollow so that the cooling water may pass through them, before it enters the oil cooler. In other constructions the lubricating oil, coming from the oil cooler under pressure, is it-

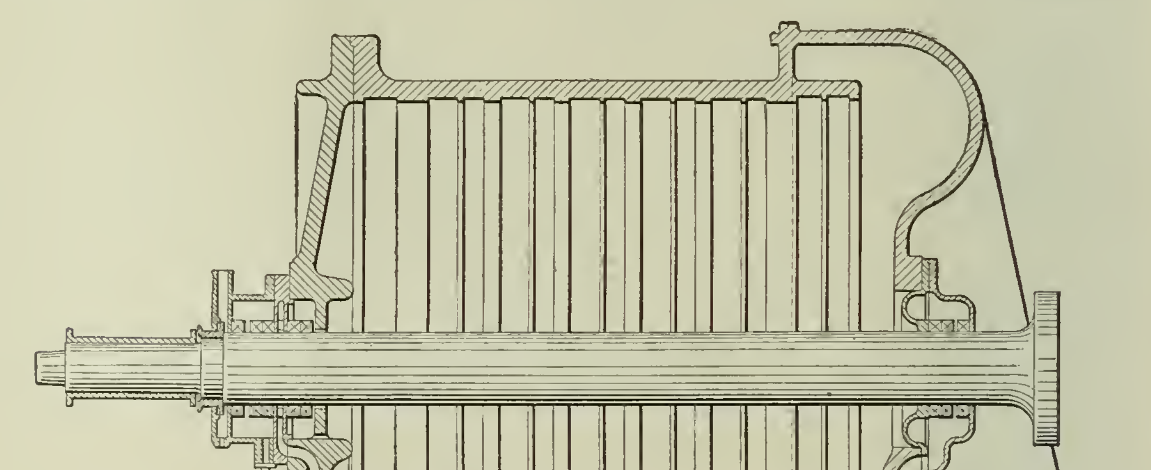


Fig. 35. Sectional View of Turbine, Showing Labyrinth Packing

self used to cool the bushing from without before entering the wearing surface within. The cooling of the oil is effected in a special apparatus, shown in Fig. 33. In the upper part the hot oil, returning from the turbine, is collected, and the impurities contained therein are allowed to settle to the bottom and can be removed from time to time. On its way downward the oil passes through a fine brass sieve which retains the solid particles, such, for instance, as come from the inner surfaces of the pedestals, oil pipes, etc. After being filtered the oil enters a cooling coil, yielding its heat to the cooling water. Thence it is drawn through the oil pump and started again, circulating through the system. It is obvious that the loss of oil in this system is quite small, yet there are losses caused partly by evaporation, partly by the fact that the lubricating value of oil decreases after some time, so that the oil must occasionally be renewed. The oil in the tank serves also as a reserve supply, guaranteeing the circulation in case, owing to some defect, the lubricant should leak out during operation. The oil pump which is driven from the governor consists of two spur pinions meshing in the ordinary manner. The absence of valves, pistons, springs, etc., favors reliability of operation. When starting, the speed of the governor and oil pump is too low to secure the delivery of sufficient oil under pressure. For this purpose a small emergency hand pump is provided, and for larger units a special steam-driven auxiliary oil pump is provided, which supplies the lubricant until the main turbine is up to speed. Oil circulation and pressure can be controlled through several gages, being switched in at different places by means of valves. The temperature of the oil is registered and observed both in the tank and on the bearings, for which purpose thermometers are inserted in the upper bushings. The whole scheme of oil circulation is illustrated in Fig. 34.

Stuffing Boxes: The packing of the turbine shaft on the high-pressure side is a comparatively simple matter, because in the first chamber the pressure is comparatively low. In the multiple-stage A. E. G. turbines the pressure difference is about three atmospheres. In the two-stage types the pressure is zero at full load and can even become negative at the lower loads. In this case the pressure of the atmosphere without is higher than the internal steam pressure, the effect being the same as on the low-pressure side. With the high circumferential speeds occurring in steam turbines it is, of course, impossible, to employ the same packings which are used in steam-engine practice. Neither soft materials pressing around the shaft nor metal packing rings can be used. As to the latter they could hardly be kept tight without being cooled, and would require lubrication which is apt to spoil the condensate for boiler-feeding purposes. A labyrinth packing is, therefore, employed in which the steam itself acts as a packing medium, being forced to flow through a series of ring grooves and being gradually throttled down, its acquired velocity being absorbed in enlarged spaces located between the grooves. The steam travels through the labyrinth packing from without to within, the low-pressure box being arranged behind the high-pressure stuffing box; see Fig. 35. The latter is surrounded by two annular channels which connect through radial passages with the labyrinth proper, dividing the latter into three parts. The outer channel receives the steam after it has been throttled in a reducing valve to a certain pressure, while the inner channel connects through a pipe with the annular chamber of the low-pressure stuffing box. Through this connection the vacuum in the low-pressure stage of the turbine draws steam through the middle labyrinth of the high-pressure stuffing box, but at the same time it draws steam from the first turbine chamber in and through the low-pressure stuffing box, so that the steam used for packing is included in the condensed water of the turbine. The low-pressure stuffing box also contains a special admission for throttled live steam which is used in case not enough packing steam is supplied through the above-mentioned connection. The short outer labyrinth chamber prevents the leakage of steam so perfectly that only a slight trace of vapor is visible, by which indication the proper adjustment of the admission of packing steam is controlled. On the high-pressure side the steam is emitted through a short vertical pipe in order to prevent the settling of sediment within the box. The collars of the shaft are made of steel, the meshing collars of the surrounding boxes of nickel bronze. Though the play allowed in the labyrinth is quite small it is ample to permit both expansion and contraction as result from the heating and cooling of the shaft.

Fig. 36. Disk Wheels with Factors of Safety of 5 and 10

Another form of packing which commends itself in certain cases employs rings made of carbon, which are pressed together by means of springs, the rest of the arrangement being identical with that above described; but for shafts which rotate at high speeds the labyrinth packing is preferable. Though not giving absolute tightness it has the great advantage that it works without friction and requires no lubrication, the steam friction in the labyrinth being a negligible amount. Thus the labyrinth packing makes possible one great advantage of the steam turbine over the steam engine; namely, the output of a condensate which is free from grease. The inner packings between two consecutive chambers are also of the labyrinth variety but simpler, the shaft having no collars but running through. The amount of play permitted depends entirely on conditions of operating reliability, the leakage of steam being accepted as an unavoidable loss.

Disks and Blades: Disks are made of high-class steel, a high factor of safety being assumed for their computation. Fig. 36 gives a comparison of a normal A. E. G. wheel built for tenfold safety with a wheel computed for half this amount. Wheels carrying two rows of blades have enlarged rims in which the blades are inserted. The heavily built disk hubs are fastened upon the shaft by means of conical caps in order to

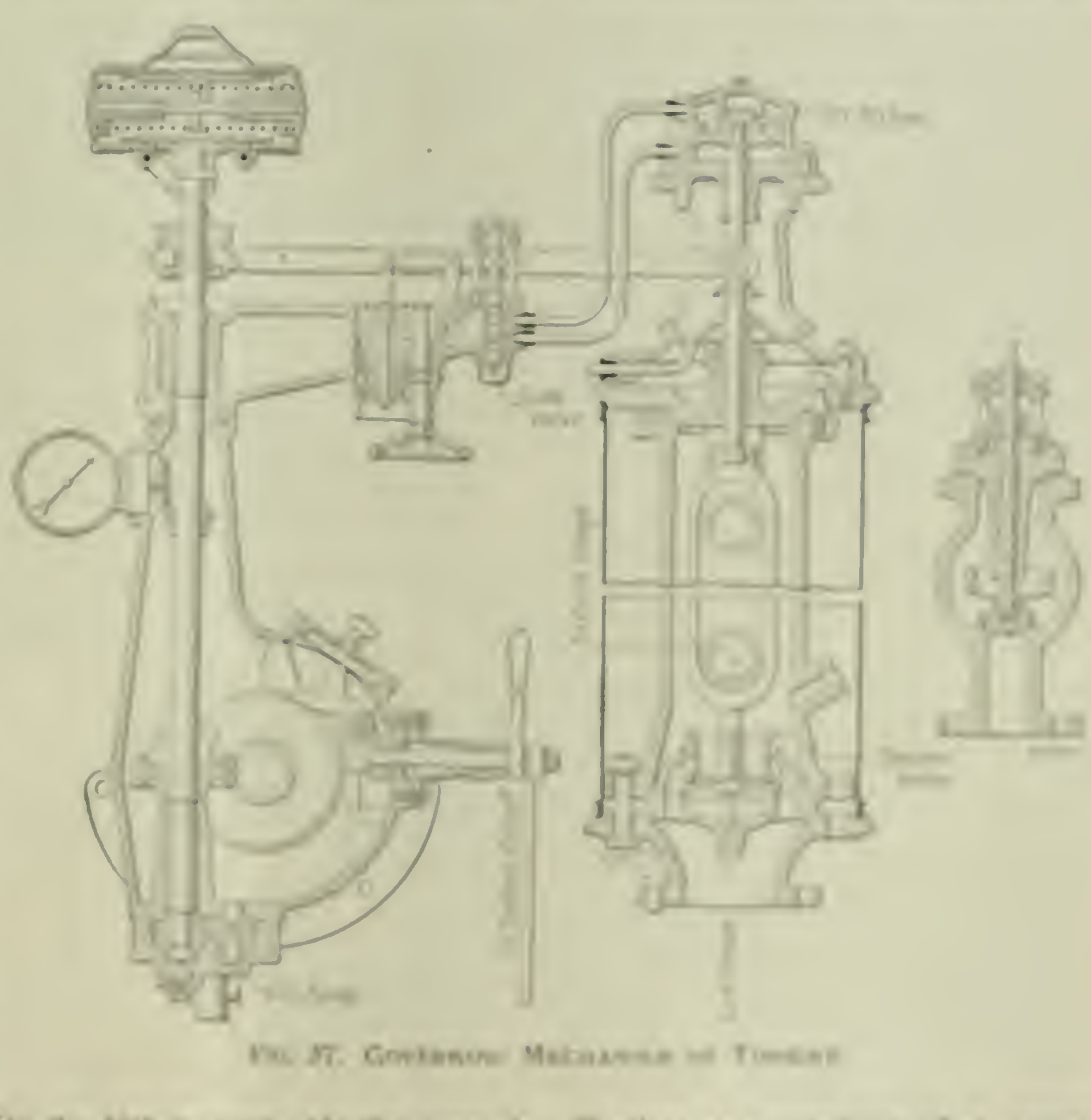


Fig. 37. Governing Mechanism of Turbine

secure accurate fit and ease of dismounting. The blades are made either of a special bronze alloy or of nickel steel. They are cut from solid profile bars, being set into the rim at an enlarged portion of the groove. The space between two consecutive blades is filled in with a special piece which projects as high as the foot of the blade and fits accurately into the profiled part of the blade. It thus insures the accurate spacing of the blades as well as their uniform inclination. After the whole circumference of the disk wheel has been filled with blades the distance pieces are staked so as to give an absolutely firm hold. Then the blade heads are connected by a steel band, which fulfils the double purpose of stiffening the blades radially and creating in the rotating wheel a closed channel for the working steam. The blades of the reversing wheels are built in the same way as the others. After being equipped with blades the wheels are carefully balanced statically, a dynamic adjustment being in most cases unnecessary on account of the symmetric form of the wheels.

Nozzles: The impingement of the steam upon the blades is effected either through guiding channels with parallel walls or through conically diverging nozzles. A longitudinal section through the nozzles of a two-stage turbine is shown in Fig. 27, which also shows how the nozzles are superimposed and with their rectangular mouths give a continuous outlet. As material for nozzles, bronze or nickel steel has given satisfaction. For the form of apparatus which is built for high superheat, a special grade of cast iron is employed. If corroded, these parts can be easily replaced without excessive cost. The ease of exchange is a desirable feature, particularly in cases when the operating conditions of the plant change materially, as when turbines are connected to a new boiler plant with different pressure, or when superheaters are installed.

Regulation: The requirements of electric drive necessitate the accurate maintenance of the normal speed at all loads as well as a small and short deviation from the normal number of revolutions at sudden variations of load. These requirements are more easily met with steam turbines than with reciprocating engines, because the degree of irregularity—using an expression from steam-engine practice—is almost zero, the mass of revolving parts acting like a flywheel toward the balancing of small irregularities. The governing device of A. E. G. turbines is shown in Fig. 37. The vertical governor is driven through a worm gear from the turbine shaft and moves a small balanced piston valve, which opens the ports to the cylinder, the piston of which controls the main steam valve at the slightest deviation from the center position. When the sleeve of the governor ascends the pilot valve descends, thereby opening one channel for the admission and another for the outlet of oil under pressure. The regulating valve proper, a double-seated balanced poppet

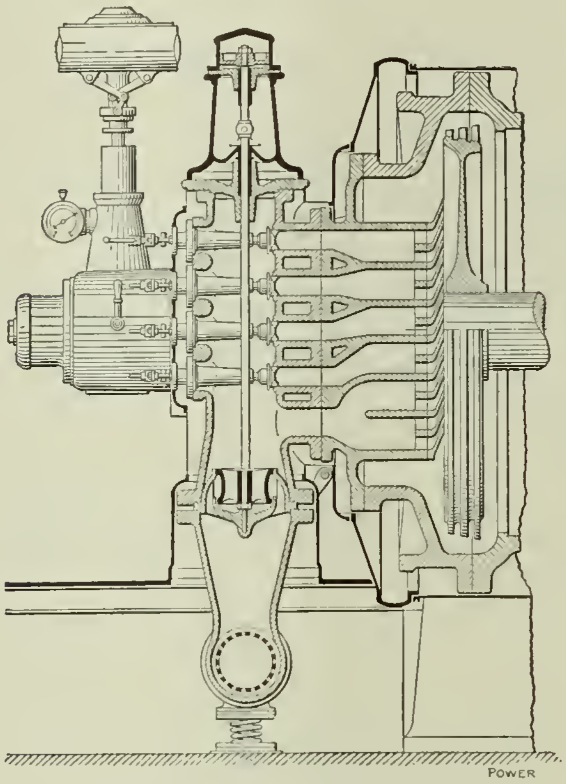


Fig. 38. Arrangement of Nozzles

valve, is rigidly connected to the piston of the controlling cylinder. When the speed of the turbine increases the governor throttles the admission of steam, the downward movement of the piston ceasing when the pilot valve is pushed back into the central position. As the lever has no fixed fulcrum the slide link must be considered as fulcrum. Thus to every definite position of the governor corresponds a certain definite position of the throttle valve. The oil for the pressure cylinder is supplied from the same pump which delivers the lubricant to the bearings under pressure. The advantage of this mode of governing is, of course, that it exercises no harmful back pressure on the governor, the sensitiveness of the latter being therefore quite high. For sudden load variations up to ± 25 per cent. the change in the number of revolutions does not amount to more than ± 1.5 per cent. At sudden drops from full load to no load a momentary increase of 5 per cent. takes place. In the condition of permanence the difference of speed between no load and full load is 4 per cent. Every turbine possesses a device for changing the normal speed by ± 5 per cent. during operation, which is essential for running alternating-current generators in parallel, the device being actuated either by hand at the turbine or from the switchboard.

In the above described system of regulation the governor changes the position of the throttle valve and thereby at the same time the quantity and pressure of the steam supplied from the boiler. This reduction of pressure, however, causes a certain loss of energy, which finds expression in an increased steam consumption per horsepower. The method of partial or graduated admission as employed in A. E. G. turbines makes it possible to transfer regulation of the quantity of steam admitted directly to the nozzles, so that at partial loads the throttle valve may be in a more elevated position whereby losses through reduction of pressure are diminished. The more perfect and differentiated the change of admission the more noticeable is the improvement of throttle governing.

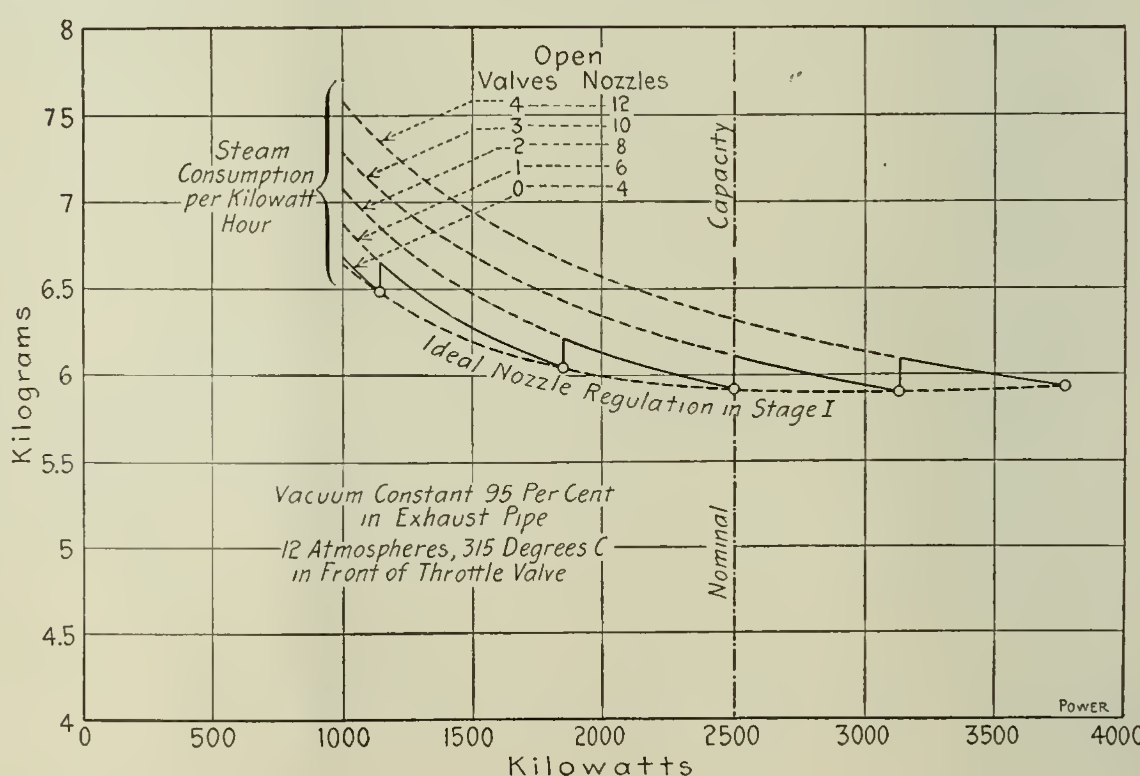


Fig. 39. Influence of Throttle Regulation on Steam Consumption

In the A. E. G. system of automatic nozzle regulation the pressure piston actuates a curved gear by means of which the single nozzles or groups of such are opened and closed through a series of valves. In this case of pure quantity regulation the throttle valve is eliminated entirely. Between complete cutoff and maximum overload the governor attends automatically to the most favorable grade of admission. This mode of regulation is commended wherever rapid load variations in irregular and short intervals are expected to occur, as in iron and steel works, rolling mills, mine hoisting plants, etc. In plants where wide load fluctuations do not occur irregularly, but at certain intervals and gradually, as in central stations and in most factories, it is sufficient to cut off one or more groups of nozzles by hand, according to the momentary requirement, regulation being effected automatically by throttling from the governor. The attendant notes from the gage pressure before and behind the throttle valve when a change of admission is necessary, no order from the switchboard being required. If the pressure difference between the steam coming from the boiler and the steam as recorded behind the throttle valve exceeds a certain measure, it is proof that there is too much loss by throttling and that the time is at hand to cut off one group of nozzles. In turbines of 3000 revolutions per minute, of the total system of nozzles of the first wheel, ordinarily two groups are arranged to be cut off, one of them being reserved for overload, while the other must be closed when the turbine is working on half load. In the larger types the nozzle system is divided into four groups (see Fig. 38), a portion of these always remaining open. Diagram, Fig. 39, shows the favorable effect of this mode of regulation on steam consumption.

The upper limit of load is fixed by the heating of the electrical part, the turbine itself being capable of standing overloads far beyond this limit, and for any length of time. The surplus steam required is admitted by opening additional nozzles. The latter are used also when operating conditions grow less favorable than was assumed for the design, especially when the condensing plant for some reason or other becomes defective and the turbine must exhaust into the atmosphere while the load is being maintained. For two-stage turbines working with atmospheric pressure in the first stage (at full load), there is, of course, no further drop of pressure in the second stage when the condenser is eliminated. The maximum load which under these circumstances can be carried by the first wheel alone reaches 80 to 100 per cent. of the normal full load. In this case the major part of the exhaust steam passes from the first chamber through an auxiliary outlet directly into the atmosphere. For very large units no arrangement of the sort is provided because it is assumed that the considerable quantities of additional steam required for direct exhaust cannot be supplied by the boiler plant, and because in most cases there is always a reserve unit available to take the place of the one whose condensation is defective; but for smaller plants the ability to carry heavy loads with direct exhaust means a great deal, wherefore the provision of additional nozzles is essential.

A COMPARISON OF THE A. E. G. AND CURTIS TURBINES

	A. E. G. Turbine		General Electric Turbine	
Trial number	1	2	3	4
Output, kw.	2,200	4,230	10,140	[illegible]
Pressure in front of turbine, kg. per square centimeter absolute	13.1	13.2	13.4	12.7
Temperature, deg. Cent.	331	330	271	262.8
Steam consumption per kw.-hour, D_e	[illegible]	[illegible]	5.86	5.919
Theoretical heat drop in metric units, H_a	233.5	249	240	220
Theoretical steam consumption, kg. per kw.-hour, D_t	3.90	3.45	3.58	3.907
Efficiency, η_e	62.8	63.6	61.2	66.2
Condenser pressure, kg. per square centimeter absolute	0.018	[illegible]	0.018	[illegible]

Besides the above described mechanism for speed regulation and the devices for securing stability of operation under less favorable working conditions, the A. E. G. turbines are equipped with an independent shaft governor, which serves exclusively for the purpose of preventing racing of the turbine, if the other regulating device should fail to work. The governor which was shown in Fig. 27 is so adjusted as to effect the immediate closing of the main admission valve, Fig. 40, if the speed surpasses the normal by 10 or 15 per cent.

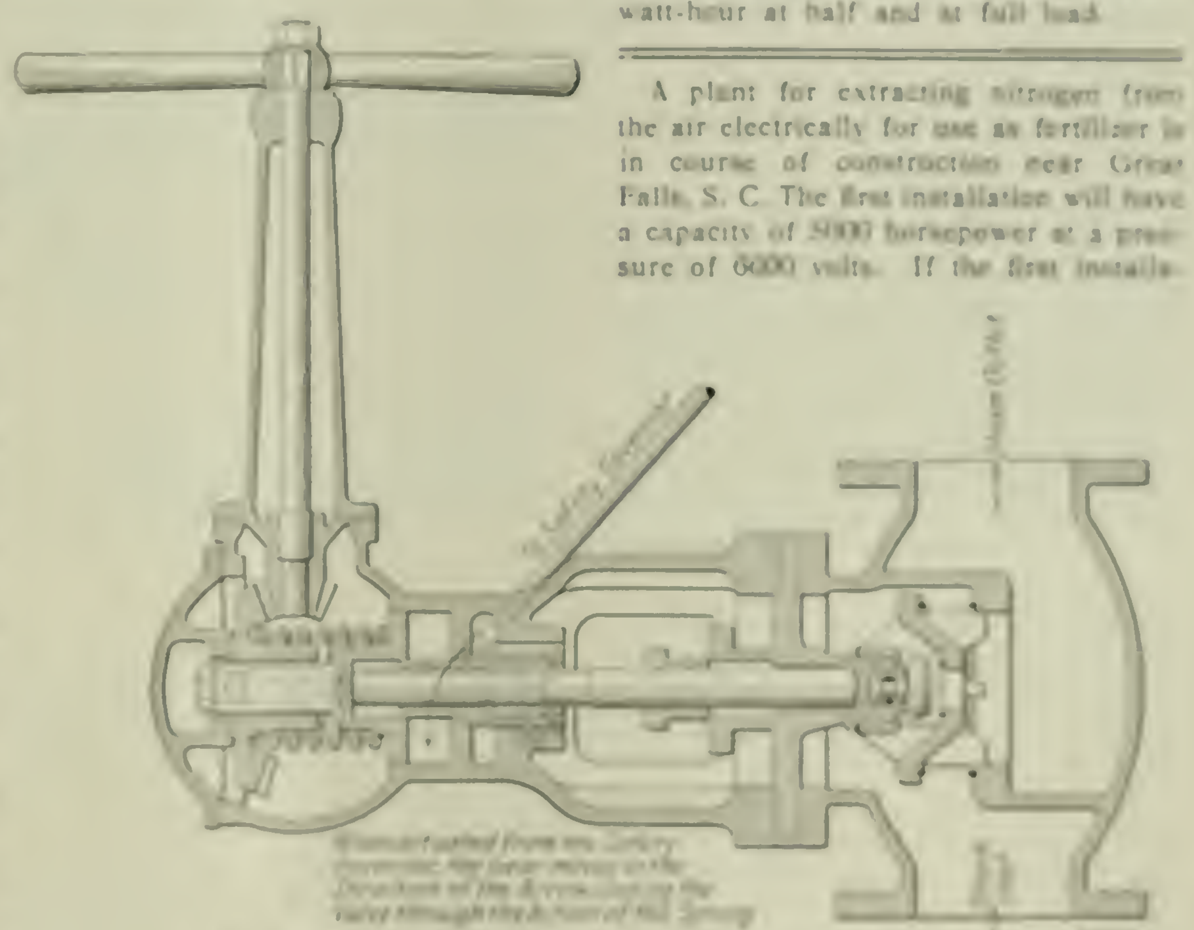


FIG. 40. MAIN ADMISSION VALVE AND SAFETY CUTOFF

In conclusion we give an interesting comparison of tests made on a 4000-kilowatt A. E. G. turbine (Rummelsburg central station), and on an 8000-kilowatt Curtis turbine built by the General Electric Company (Chicago, Fisk Street station), which will serve to illustrate our remarks on thermodynamic efficiency in the last article. From tests 2 and 3 it is seen that the 4000-kilowatt A. E. G. turbine, though having to transform a greater heat drop than the 10,000-kilowatt General Electric turbine, shows a superior thermodynamic efficiency than the latter. If the heat drop was equal in both cases, the comparison would come out even more favorable for the German turbine. How great the influence of heat drop actually is can be seen from tests 3 and 4, made on the General Electric turbine. At a drop of 220 units the efficiency is 66.2 per cent., at a drop of 240 units the efficiency is reduced to 61.2 per cent. Finally, the favorable effect of the nozzle regulation of the A. E. G. turbine is characterized by tests 1 and 2, showing practically equal steam consumption per kilowatt-hour at half and at full load.

A plant for extracting nitrogen from the air electrically for use as fertilizer is in course of construction near Great Falls, S. C. The first installation will have a capacity of 5000 horsepower at a pressure of 6600 volts. If the first installation proves a success additional equipment will be added to the plant later to bring the capacity up to 25,000 horsepower. No details of the process are available at present, but it is reported that the nitrogen is extracted by means of large electric furnaces and absorbed by means of crushed limestone.

Some Experiments with Gage Cocks

By W. H. Wakeman

Some of the methods of attaching gage cocks and glasses to steam boilers, with comments upon the advantages and disadvantages of each arrangement.

The first boiler of which I had charge was of the locomotive type and had three gage cocks tapped directly into the outer head as shown in Fig. 1. There was also a water gage on the same head. This is a very natural arrangement, because each cock is independent of the other; hence if one is disabled it does not interfere with the other two. If the water level, as indicated by the gage glass, agrees with the gage cocks, it is double evidence that the true level of the water in the boiler is known.

Another boiler which I operated was fitted with a water column, as shown by the full lines in Fig. 2. No valves were

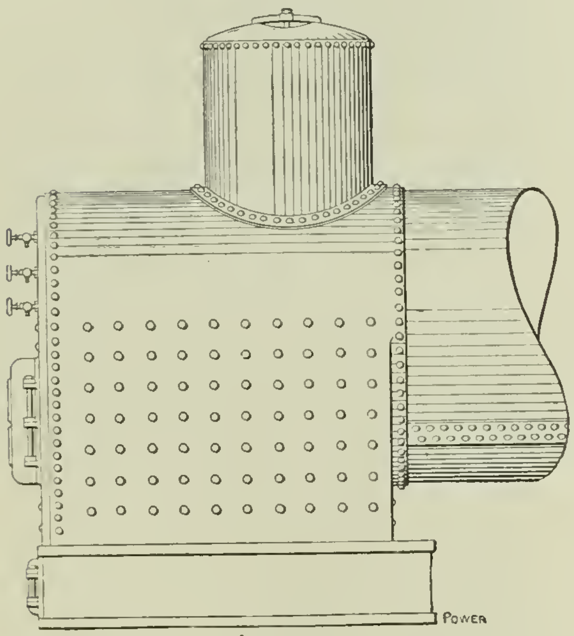


FIG. 1

inserted between the boiler and the gage cocks; hence the water column could not be shut off from the boiler. There was no drip valve connected to it, and this resulted in sediment collecting in the connections and causing trouble.

In another plant the boiler was fitted with a water column as already illustrated in Fig. 2, except that a 3/8-inch drip pipe was provided as shown by the dotted lines. This permitted some of the sediment to be blown out, but the pipe was not large enough to cause a rapid flow of water and steam through the connections, especially as it was not possible to shut off one while creating circulation through the other. When the drip valve was opened the water discharged directly onto the boiler-room floor, and this being far from pleasant, I bored a hole through the side of the building and extended the pipe through the wall. This disposed of the water as far as I was concerned, but there was danger of scalding people who passed the boiler house; hence the pipe was taken out and connected into the ashpit. Having cleaned the boiler front I proceeded to blow down the water column and in a few seconds practically the entire front of the boiler was covered with ashes, although the damper was wide open. Exactly the same result has been secured wherever I have tried a similar experiment; therefore, I consider the arrangement an unmitigated nuisance.

In three other places tubular boilers were fitted with gage cocks connected into the front head but, owing to the combustion chamber or smoke box being located at this point, it was necessary to provide a pipe about 20 inches long for each cock, also for each connection to the gage glass. These are illustrated in Fig. 3 but in the sketch the water gage

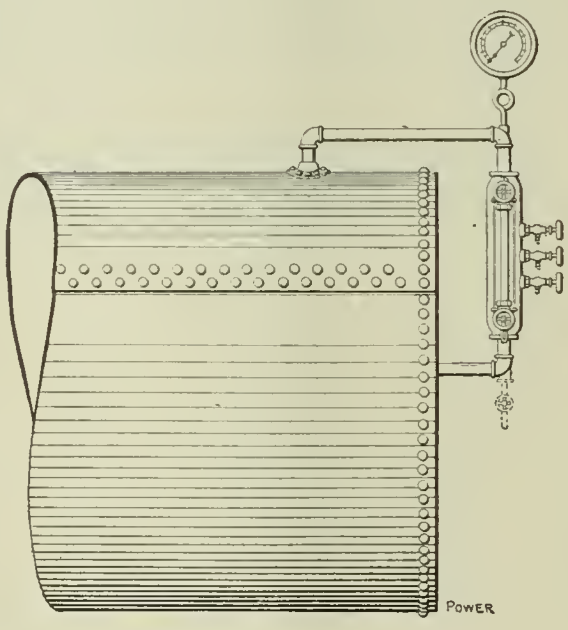


FIG. 2

is extended farther than it actually was in practice, in order to avoid interfering with the cocks. Some of these pipes were exposed to the direct action of the flames and hot gases while others were protected by sleeves consisting of pieces of larger pipes.

All of these connections slowly filled with sediment because the opening provided was not large enough to permit rapid circulation through the connecting pipe when a gage cock was opened. Special attention was given to cleaning these pipes when the boilers were cleaned, and sometimes it was necessary to remove the gage cocks in order to force sediment out with an iron rod. All of it did not bake hard in the pipes but when one of them was filled with a paste-like substance, it effectually prevented proper use of the gage cock. It was my custom to lift the weighted end of a gage cock and run a long wire into the pipe. This opened a passage temporarily, but sometimes it would fill and cease to discharge water before the cock was closed, thus proving very unsatisfactory. Such action always smeared the boiler front with mud.

At another plant the boilers were fitted originally with water columns having connections as shown for the water gage in

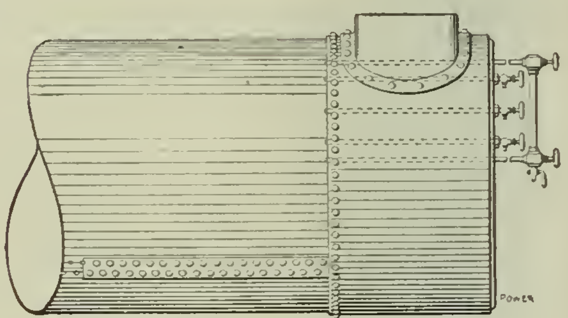


FIG. 3

Fig. 3. Valves were not provided in the connections; hence when anything happened to the water gage, or the three gage cocks attached to the column, it was necessary to remove all pressure from the boiler in order to make repairs. I accordingly altered this arrangement by placing a valve in each connection to the gage; therefore, when a glass broke, steam and water could be shut off while a new one was being put in. In order to prevent trouble from breakage of glasses

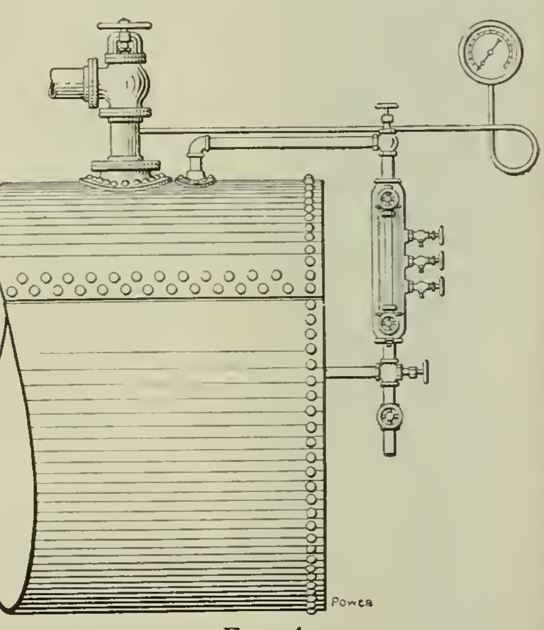


FIG. 4

during the night, the fireman made it a practice to shut these valves before he went home. Of course, this prevented the glass from showing a true water level in the morning, but he was intelligent enough to open them and ascertain how much water was in the boilers before starting the fires, as they were rebuilt every morning. A steam gage was attached to the top of each column, by a very short connection, in which there was no siphon to hold water. Examination of this piping when the boilers were empty, showed that a straight pipe extended down into the column below the water line, protecting the end of this pipe from steam except when the column was blown down to remove the sediment.

Upon taking charge of the boilers in another plant, I found the water columns attached as shown in Fig. 4, the connections consisting of 1¼-inch brass pipe. The drip pipes in this case were carried to the sewer without reduction in size, which proved very effective. These columns were also fitted with high- and low-water alarms. As a rule, I closed the valves in these connections, and opened the drip valves when leaving for the night; but one night I was awakened by a policeman who informed me that something was out of order in the boiler room, and he suggested that I go down and attend to it without delay. Upon arriving at the boiler room I found one of the alarm whistles blowing, as the valves had not been left according to my usual custom.

How do engineers manage to take care of columns fitted with high- and low-water alarms, that have no valves by which to shut them off at night? Do they make arrangements with the local policeman to attend to this duty in their absence, or is it possible to always have the water level low enough to keep one float down and high enough to support the other, and thus always prevent the whistle from blowing? Do accidents ever happen to the floats at night? If so, how are they repaired when pressure cannot be removed from the columns?

Gage cocks connected into these columns never become choked with sediment, the boiler fronts are not bespattered with mud when they are opened, and the connecting pipes are not in danger of filling with mud, nor of being burned by excessive heat. For these reasons one large connection above and another far below the water line, where neither is liable to be rendered useless except by gross carelessness continued for a long time, seem to be much superior to several small and independent connections located where they collect sediment readily, and are liable to be burned by the intense heat.

Flow of Steam and Design of Nozzles

By A. D. Blake

Development of formula showing the velocity attained by a jet of steam in expanding from a higher to a lower pressure and its application to the design of a simple nozzle.

In order to thoroughly understand the action of steam in flowing from a higher to a lower pressure it is first necessary to have a clear conception of the fundamental principles of work and energy. Consider a freely suspended body of mass M being acted upon by a constant horizontal force F. If all friction be neglected, the force F will produce an acceleration of the mass M equal to a feet per second per second; that is, starting from rest, the velocity at the end of the first second will be a feet per second, at the end of the next second it will be $2a$ feet per second, at the end of the third second $3a$ feet per second, and so on. Now let the mass be doubled. In this case it will require a force of $2F$ to produce an acceleration a, or a force F will produce an acceleration of only ½a. Similarly, if the original mass M be acted upon by a force $2F$, the acceleration will be $2a$. From this it is obvious that the force required must vary as the product of the mass and the acceleration, that is,

$$F = M a \qquad (1)$$

Next, consider a freely falling body of mass M acted upon only by gravity. At the end of the first second it will have attained a velocity of 32.16 feet per second; at the end of the next second a velocity of

$$32.16 + 32.16 = 64.32$$

feet per second, and so on, that is, a constant acceleration of 32.16 feet per second per second is produced by a force equal to the weight W of a mass M, and, according to formula (1), this may be expressed as

$$W = 32.16 \times M$$

from which the mass of a body is seen to be its weight divided by the acceleration due to gravity

$$M = \frac{W}{32.16} \qquad (2)$$

Reverting to the first case, that of a mass M acted upon by a force F and producing an acceleration a, at the end of t seconds the velocity V will be

$$V = a t \qquad (3)$$

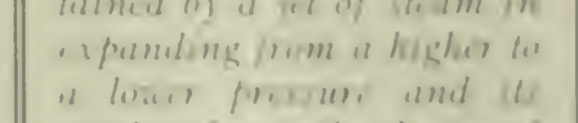
and the average velocity during this period will be

$$\frac{V}{2} = \frac{at}{2}$$

The distance d passed over during t seconds will equal the average velocity multiplied by the time

$$d = \frac{V}{2} \times t = \frac{at^2}{2} \qquad (4)$$

The kinetic energy of a body in motion



Section through Nozzle

is equivalent to the work done upon it, which equals the force multiplied by the distance through which it acts. Denoting the kinetic energy by K,

$$K = F \times d \qquad (5)$$

Substituting the values from equations (1), (3) and (4),

$$K = M \times a \times \frac{at^2}{2} = M \times \frac{V^2}{2}$$

But from (2)

$$M = \frac{W}{32.16}$$

Hence

$$K = \frac{W V^2}{64.32}$$

or the kinetic energy of one pound of any body in motion equals

$$\frac{V^2}{64.32} \qquad (6)$$

Having established this relation between the energy and the velocity of a body the flow of steam may be considered. If steam be allowed to expand from a higher to a lower pressure without doing external work, and its flow is unrestricted, the heat given up during expansion is transformed into kinetic energy, imparting velocity to the steam itself. The expansion in this case is said to be adiabatic and the quality at the lower pressure is less than at the higher. Denoting by H_1 the heat above 32 degrees Fahrenheit in one pound of steam at the initial pressure p_1, and the heat in the same pound of steam after expansion to a lower pressure p_2 by H_2, the heat given up during the adiabatic expansion from p_1 to p_2 is

$$H_1 - H_2$$

Since this heat drop is converted into kinetic energy and since one British thermal unit is equivalent to 778 foot-pounds, the kinetic energy of one pound of the steam may be expressed as

$$K = \frac{V^2}{64.32} = 778 (H_1 - H_2)$$

or,

$$V^2 = 64.32 \times 778 (H_1 - H_2) \qquad (7)$$

In a nozzle the expansion of the steam is not strictly adiabatic since the friction against the walls of the nozzle causes the steam to give up some heat. This heat (neglecting radiation which is small) is not lost but is given back to the oncoming steam and raises its quality; hence the quality at exit from a nozzle is slightly higher than that shown in the steam tables for adiabatic expansion

This heat, however, does detract from that which is convertible into kinetic energy. In view of this, it is necessary to slightly modify formula (7). Assuming the loss due to friction to be 10 per cent., this expression would be

$$V^2 = 64.32 \times 778 \times 0.90 \ (H_1 - H_2)$$

or,

$$V = \sqrt{64.32 \times 778 \times 0.90 (H_1 - H_2)} \quad (8)$$

With this as a basis the following problem may be solved:

What are the proportions of an expanding nozzle having a throat 3/16 inch in diameter, receiving dry saturated steam at 80 pounds gage and expanding to atmosphere? Also, what weight of steam will flow per second and what will be the velocity of the steam at exit?

That portion of a nozzle constituting the throat, for all practical purposes, may be considered as an orifice and the flow calculated accordingly. It has been proved experimentally that when steam expands through an orifice the pressure in the orifice cannot fall below 0.58 of the initial pressure. Furthermore, with the exit pressure bearing approximately this relation to the initial pressure, the flow through the orifice has been found to conform to the expression

$$W = \frac{p_1 A_1}{70} \quad (9)$$

Where,

W = Weight of steam flowing per second in pounds;

p_1 = Initial absolute pressure; in this case 94.7

A_1 = Area of orifice in square inches; in this case 0.02761, corresponding to a diameter of 3/16 inch.

Substituting these values in formula (9),

$$W = \frac{94.7 \times 0.02761}{70}$$

$$W = 0.03740 \ \textit{pound per second}$$

Now considering the nozzle as a whole, to determine the velocity of the steam at exit apply formula (8). From the steam tables or a temperature-entropy chart the total heat in one pound of dry saturated steam at 94.7 pounds absolute is found to be 1185 B.t.u., and after adiabatic expansion to atmospheric pressure it contains 1047 B.t.u. Hence,

$$V = \sqrt{64.32 \times 778 \times 0.90 \ (1185 - 1047)}$$
$$= 2490 \ \textit{feet per second}$$

If allowed to expand adiabatically from 94.7 pounds to atmospheric pressure the quality at exit would have been 89.5 per cent., but taking into consideration the heat of friction returned to the steam the quality at exit would be found as follows. The latent heat of vaporization at atmospheric pressure is 970.4 and the heat of friction returned to the steam was

$$0.10 \ (H_1 - H_2) = 0.10 \ (1185 - 1047) = 13.8 \ \textit{B.t.u.}$$

Then the increase in quality would be

$$\frac{13.8 \times 100}{970.4} = 1.42 \ \textit{per cent.}$$

and the final quality would be

$$89.5 + 1.42 = 90.92 \ \textit{per cent.}$$

Denoting the cross-sectional area of the exit of the nozzle by A_2, the weight of steam flowing by W and the density (cubic feet per pound) at atmospheric pressure and 90.92 per cent. quality by v_2,

$$W = \frac{A_2 V}{144 \ v_2}$$

The volume of one pound of dry steam at atmospheric pressure is found from the steam tables to be 26.79 cubic feet. Therefore, at 90.92 per cent. quality a pound of steam at this pressure would occupy

$$0.9092 \times 26.79 = v_2 = 24.3 \ \textit{cubic feet}$$

The value of W was previously found to be 0.0374 pound and V to be 2490 feet. Substituting these values,

$$0.0374 = \frac{A_2 \times 2490}{144 \times 24.3}$$

or,

$$A_2 = \frac{0.0374 \times 144 \times 24.3}{2490} = 0.0526 \ \textit{square inch}$$

This corresponds to a diameter of 17/64 inch.

The ratio of length to diameter (at the throat) of nozzles differs widely among different manufacturers, but a ratio of 12 to 1 is considered by many to be good practice. Therefore, the dimensions of the nozzle under consideration would be as shown in the illustration.

A New Process of Water Softening

The "zeolites" are distributed pretty freely among the older rocks of the earth's surface, though not entering into the constitution of the rocks themselves. They are found in a crystalline form in amygdaloidal fissures or cavities of trap or plutonic rocks, where they have apparently been deposited from water which has percolated into the cavities, thus probably being products of decomposing nepheline, or felspar, or hydrated felspars themselves. They are composed generally of varying quantities of silica, alumina, lime, soda, potash and water, the silica always largely predominating in all forms, though the other constituents are not necessarily found in all "zeolites." As an example of one form take analcime, which is composed of 54.5 per cent. of silica, 23.3 per cent. of alumina, 14.1 per cent. of soda, and 8.2 per cent. of water. These zeolites have, in contradistinction to other silicates occurring in nature, the property of being soluble, and they also decompose in dilute acids. They have also the very important property of being able to exchange their bases for others.

It has been found that when hard water is allowed to filter slowly through layers of these hydrated silicates of alkalies the lime in the water changes place with the soda in the filtering medium, and the water passes out softened; and this fact has been the means in Germany of instigating a series of experiments during the last two years, which have proved of great value, and which have shown that these zeolites can be produced artificially, with the result that the substance is now made much more regular in its composition and freer from impurities than that found in a state of nature. To these artificial zeolites has been given the name of "permutit," which in a moist condition is of a granular flaky form, and has a luster like that of mother-of-pearl. It has a high porosity, and in the dry state readily absorbs about 50 per cent. of water. It is obtained by fusing together felspar, kaolin, clay and soda in definite proportions, the resultant material being lixiviated with hot water, when permutit is left as a residue. The granular material is freed as much as possible from the final alkaline lye by washing and centrifugal action.

In *Engineering* the use of this material for softening water is briefly described as follows: The total hardness of water may consist of temporary hardness or of permanent hardness, or of the two combined, the former being caused by calcium and magnesium carbonates, and the latter by other salts of lime and magnesia. Boiling at atmospheric pressure precipitates the carbonates and the magnesia, but not the salts forming permanent hardness. In commercial processes at the present time, sodium carbonate is added to water as a means of precipitating the hardening constitutents of the water, there being an exchange of bases between the lime and manganese and the sodium carbonate. In like manner, if hard water be allowed to filter slowly (the slower the better) through layers of permutit, there is likewise an exchange of bases, the lime in the water taking the place of the soda in the permutit, one molecule of calcium bicarbonate being converted (in the case of temporary hardness) into two molecules of sodium bicarbonate, which latter remains in the water, being very soluble. The permutit in the filter will only retain this power so long as any soda remains to exchange with the lime in the water. Permutit suffers practically no loss during use, but when a certain amount of water has been passed through it, its softening powers disappear, but they can easily be restored, and the material can be used over and over again practically indefinitely.

The power of regeneration appears to be the chief novelty of the process; but before it is carried out a few essential points must be attended to. In the first place, the filter must be cleaned. Experience shows that filtration is most effective from the top to the bottom, and that, therefore, cleaning should take place in the reverse direction—namely, from the bottom to the top—so as to loosen the mass and remove any air that has collected in the material, soft water, if possible, being used for the purpose. After washing, the permutit is regenerated by a solution of common salt, the solution generally being of 10 per cent. strength. Previous to regeneration all water is removed from the filter down to the layer of permutit, after which the salt solution is introduced and allowed to flow slowly through the filter for from four to five hours. In addition to this, the brine is allowed to stand for a further four or five hours, just covering the layer of permutit, after which the filter is filled with water from the top, and an outlet cock at the bottom is opened for 20 or 30 minutes, or until the water no longer shows any hardness with ammonium oxalate or with soap solution.

The chemical reaction that takes place during regeneration consists in an interchange between the soda in the sodium chloride and the lime in the permutit (derived from the water which it has softened), calcium chloride remaining in solution in the regeneration water. It may be stated that in practice the most suitable rate for the water that requires softening to pass through the layers of permutit has been found to be from 13 to 17 feet per hour. The permutit is not only active at the surface, but also in the interior, in consequence of its porosity.

From information supplied from Germany it appears that filters using these artifical zeolites have been in practical use during the last two years, treating water for a variety of purposes, including use in boilers and for washing fine textile goods, and a plant has recently been installed in England for the latter purpose with satisfactory results.

In one case where a permutit filter was supplied to a steam laundry in Berlin more than two years ago, it is stated that in about nine months 1,174,800 gallons of water passed through the filter, which volume was completely softened without any apparent loss of permutit. The charge of permutit was about half a ton and about 1050 gallons of water passed over each pound of the material. In this case about 44,000 gallons of water per week were used, and regeneration was carried out twice per week, 88 pounds of salt being used per regeneration, although it is stated that it need not have been done quite so often. The cost of regeneration naturally depends on the price of salt, and on the degrees of hardness in the water. It is stated that water having 53 degrees of hardness has been reduced to 3.7 degrees by the process.

The system is now being introduced into England by Water-Softeners, Limited, 20 Copthall avenue, Throgmorton street, E. C., London.

A Record Breaking Turbine Test

The following results of a test conducted upon a 6000-kilowatt turbine at the Dunston power station of the Newcastle-upon-Tyne Electrical Supply Company are reproduced from *Engineering* of March 10. The turbine is of the Parsons type, having separate high- and low-pressure casings. It was designed to have its maximum economy at 9000 brake horsepower, with steam at 190 pounds gage and at 190 degrees superheat. In the test the superheat did not exceed 178 degrees Fahrenheit, but the vacuum was high, the absolute pressure in the condenser being 0.90 inch of mercury. This is 249.4 B.t.u. per kilowatt-hour with 90 per cent. generator efficiency corrected for condenser leakage which is 76.1 per cent. efficiency referred to the Rankine cycle, and the best of which we have learned. The test was conducted by Messrs. Merz and McLellan, consulting engineers to the Newcastle company.

The official steam-consumption trials of this plant were run on December 16, 1910. The contractors to the company for the complete unit were Messrs. Brown, Boveri & Co., Ltd., London.

Details of the plant are given in the accompanying Table 1.

TABLE 1

Turbo-Alternator:	
Normal output	6000 kw.
Speed	1200 r.p.m.
Turbine:	
Specified most economical load	9000 b.h.p.
Type	Two-cylinder Parsons
Type of blading	Parsons
Arrangement of steam passage	H.-P. cylinder single-flow; L.-P. cylinder, partly single-flow, partly double flow
Specified steam pressure	190 lb. per sq. in.
Specified superheat	190 deg. Fahr.
Alternator:	
Type	Rotating field three-phase
Continuous output	7500 k.v.a. at 0.8 power factor
Voltage (terminal)	6000 volts
Exciter	Direct-coupled self-excited
Condensing Plant:	
Surface	15,000 sq.ft.
Type	"Contraflo"
Diameter of tubes, external	1 in.
Thickness of tube	18 B.W.G.
Circulating water per hour	[illegible] gallons
Specified circulating water temperature	20 deg. Fahr.
Air-Pumps:	
Type	Edwards three-throw, motor-driven
Capacity	[illegible] cu.ft. per barrel
Volume swept through per minute by air-pump plungers	1500 cu.ft. per min.
Evaporator:	
Surface	400 sq.ft.

Preliminary unofficial trials were run on December 14 and 15 at various vacua and at various superheats to determine the corrections to be applied to actual figures in order to enable the actual results to be compared with those specified.

The results of the official trials are given in Table 2.

TABLE 2

Trial	1	2	3
Date	Dec. 16	Dec. 16	Dec. 16
Duration	9 a.m. to 10 a.m.	11.30 a.m. to 1 p.m.	2.30 p.m. to 4.00 p.m.
Output from generator to bus-bars (that kilowatt-hr.)	[illegible]	[illegible]	[illegible]
Speed, r.p.m.	[illegible]	[illegible]	[illegible]
Steam Quality			
Pressure at before side of turbine stop-valve by gage, lb. per sq. in.	192	188	188
Temperature of steam at before side of turbine stop-valve, deg. F.	546	544	536
Superheat, deg. F.	162	160	158
Exhaust			
Pressure (abs.) in condenser, Hg. in.	0.81	0.90	0.90
Temperature in condenser, deg. F.	72	74	76
Circulating Water System			
Temperature, inlet, deg. F.	44	44	44
Temperature, outlet, deg. F.	[illegible]	52	[illegible]
Steam Consumption			
Total water used per hour, lb.	[illegible]	[illegible]	[illegible]
Water used per kilowatt-hour, lb.	[illegible]	[illegible]	[illegible]
Water used per kilowatt-hour corrected for condenser leakage, lb.	[illegible]	[illegible]	[illegible]
Steam consumption corrected for 190 deg. F. superheat and 29.1 in. vacuum, lb. per kw.-hr.	[illegible]	[illegible]	[illegible]

REMARKS

1. *Change of Load.*—An interval of 1½ hours was allowed between changes of load.
2. *Output.*—Measured by integrating wattmeter specially calibrated for the purpose.
3. *Steam Consumed.*—Weighed by the permanent weigh-tanks installed at the power-station.

The total output of the Roumanian oil-fields for 1910 is now stated by the *Moniteur du Pétrole Roumain* at 1,352,300 tons. This is an increase of over 55,000 tons, or 4.3 per cent., over the 1909 figure. The totals of the various companies are of more particular interest. The Steaua Romana fell off 25,800 tons, but still heads the list with an output of 410,250 tons. The Astra Romana comes next with an output of 287,800 tons and an increase of over 20,000 tons; then the Romano Americana with 145,300 tons (increase 24,800 tons). The Concordia fell off by 16,700 tons, but comes fourth on the list with an output of 95,800 tons; and lastly follow the Orion, 61,400 tons (increase 13,700 tons) and the Regatul Roman, 53,800 tons (decrease 28,600 tons).

The Small Turbine in Marine Work

The small turbine is being used extensively for such service as pumping, lighting, ventilating and forced draft, particularly in the United States navy where reliability is equal in importance to economy of space and weight. For forced-draft work the turbine has been especially successful.

On shipboard the space occupied by and the weight of the mechanical equipment are two extremely important factors, more important, oftentimes, than the first cost and economy in operation. Perhaps most important of all, however, is reliability of service. The development of the small turbine has made possible wonderful progress in economy of space and weight besides producing simplicity and dependability in operation. To show the extent to which this type of prime mover is being applied in marine practice, some of the uses to which it is put are specified below.

The Hudson River Day Line boats are each equipped with a turbine-driven centrifugal pump for use in trimming ship. When a boat is making a landing the passengers crowd to one side, causing it to list. This oftentimes seriously interferes with the steering and manipulation of the boat. To keep the boat on a level keel on such occasions two large tanks were built in amidships so that one or the other may be filled with river water whenever it is desirable.

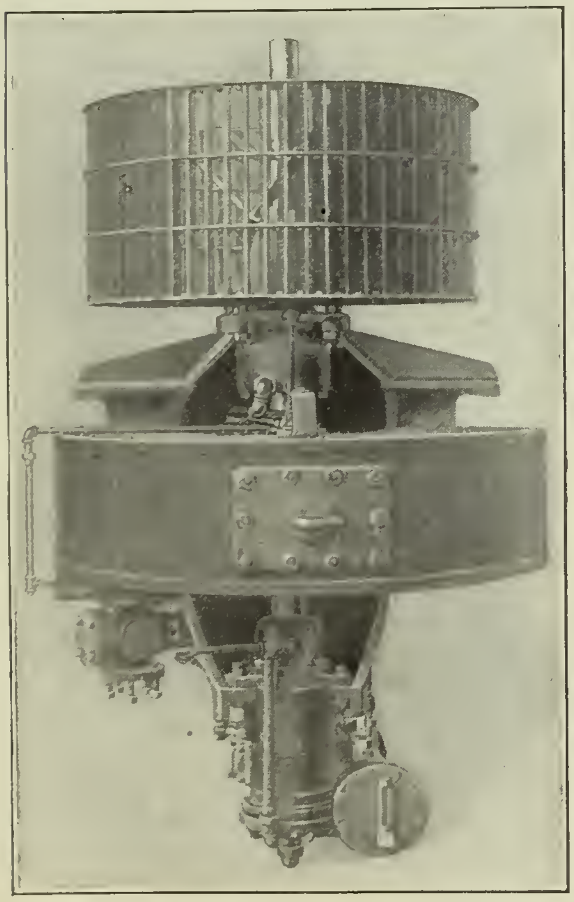


Fig. 1. Forced-draft Set for Torpedo-boat Destroyers

The pump is 8 inches in size and is driven by a 15-horsepower single-stage Terry turbine at a speed of 1800 revolutions per minute. These ballasting sets are guaranteed to develop their full capacity of 1000 gallons per minute within 20 seconds from the time of opening the throttle. The outfit is set down in the hold but it is operated from the engineer's platform so that the engineer may start the filling of a tank the instant that he sees the telltale arrow shift.

A use to which the turbine is now commonly being put is the driving of dynamos to furnish current for lighting, ventilating and other purposes. The United States Navy is particularly progressive in this respect. The flagship "Connecticut" has four 100-kilowatt turbo-generator sets and twelve revenue cutters are equipped with turbo-generators of capacities ranging from five to seven kilowatts.

At Boston the municipal fireboat, "George A. Hibbard" is fitted with a multistage centrifugal fire pump driven by a 100-horsepower turbine.

The most important application of the small turbine in marine work has been its adoption for forced draft. The use of turbines for forced draft has been extensive in the Navy where a continuous and sufficient air supply is always of first consideration. Fig. 1 shows a forced-draft set which is used on the new torpedo-boat destroyers "Roe," "Terry,"

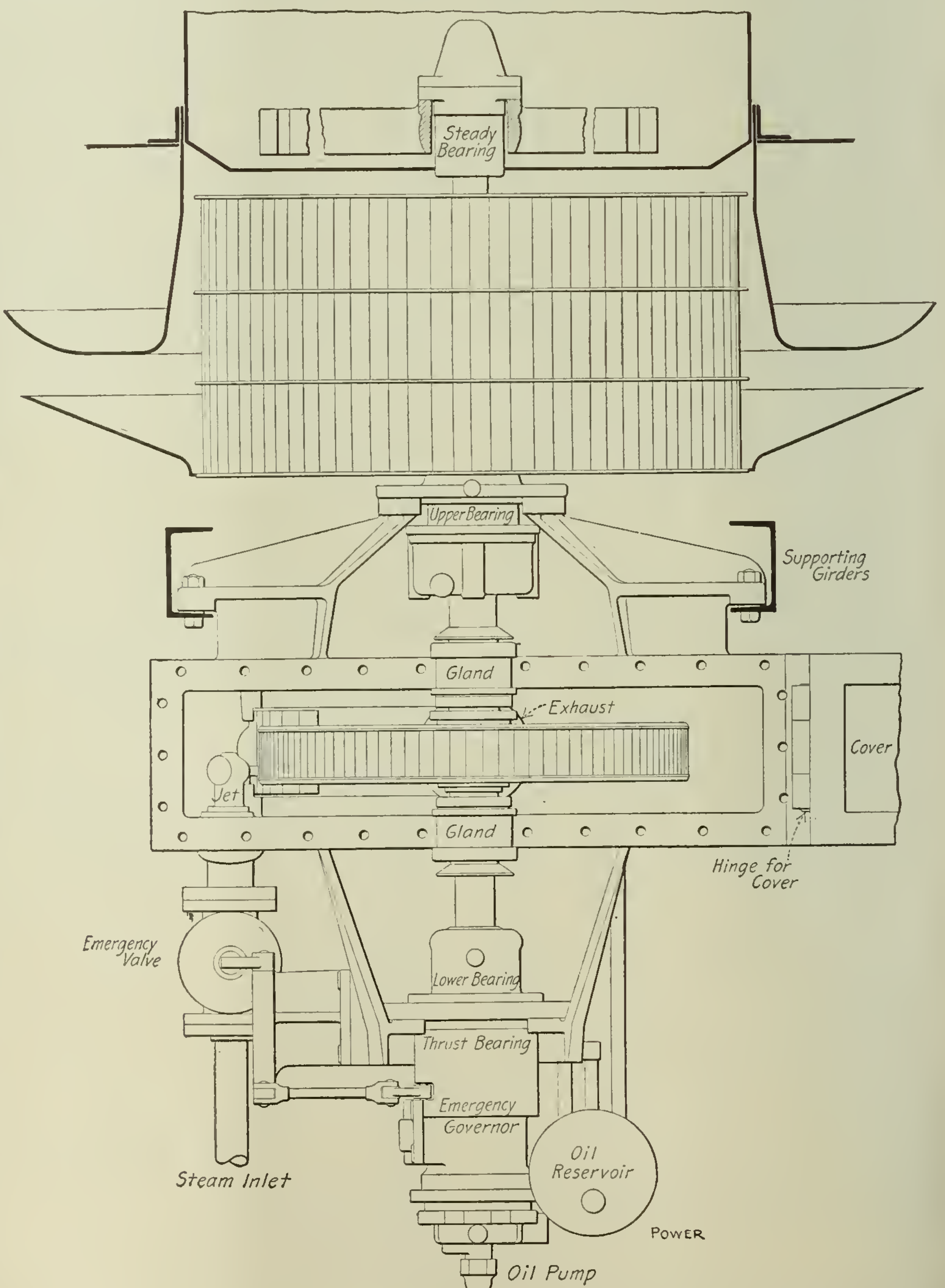


Fig. 2. General Design of Forced-draft Set for Torpedo-boat Destroyers

"Paulding" and "Drayton." The five destroyers, "Monoghan," "Fanning," "Jouett" and "Jenkins" which are now being built will also have sets of the same design. A set consists of a Terry single-stage vertical turbine and a Sirocco fan which has a 30-inch runner. Two sets are placed in each of the two stoke holds and each set delivers from 23,000 to 25,000 cubic feet of free air per minute at a pressure of from 3½ to 5 inches of water; the speed is about 1400 revolutions per minute.

Fig. 2 shows the general design of the set illustrated in Fig. 1. One feature of this design is that the entire unit, completely assembled, can be dropped through the ventilator which is 40 inches in diameter. The whole apparatus is so arranged that it can be mounted on I-beams suspended from the deck or bulkheads. The fan wheel itself is on a line with the deck immediately at the foot of the ventilator. The main casing of the turbine is divided vertically along the center line and the cover is fitted with a hinge so that the casing can be opened without the use of a crane or the removal of any of the parts.

The weight of the whole runner is carried by a ball bearing which is always kept flooded with fresh oil. The step bearing is in the lower bearing housing; below it is fitted an emergency governor of the unstable type which, when the weights fly out, releases a trigger which in turn allows the automatic stop valve to close, the valve being primarily kept open against a powerful spring.

At the extreme lower end of the shaft is fitted a small geared oil pump. This pump consists of two ordinary gear wheels, and is so designed that it will give a sufficient supply of oil to all of the bearings at any speed. A combined relief and bypass valve is placed between the suction and the discharge and set at a given pressure; thus, at low speeds the pump will deliver oil to the bearings at the same pressure as at high speeds. All of the oil is drained back from the bearings to a common reservoir; the position of this reservoir is slightly above that of the oil pump.

On the destroyers "Warrington," "Myrant," "Lawrence," "McCall" and "Burrows" sets composed of the same make of turbine and a special Sturtevant fan are used. The "Patterson" and "Ammen," now building, will be similarly equipped. The fans for these sets are of the standard Sturtevant design, except that the blades have a special contour in order to secure the greatest possible efficiency at the speed used.

It is a noteworthy fact that all of the destroyers which have been equipped with this type of forced-draft apparatus have gone through their acceptance trials without the slightest trouble due to lack of sufficient air or interruption of service from the blowers.

Steam Line Conduit of Low Cost

By Henry G. Pope

In connection with the installation of a steam power-plant equipment, it was necessary to arrange a steam line to connect the boiler house with the pump house shown in Fig. 1. The connection was to be a temporary one, to be replaced ultimately with a permanent and a larger pipe. Methods of carrying the line overhead were considered but were abandoned because of the radiation losses involved and because of the expense of erecting a supporting structure that would be strong enough to be reasonably safe against breakdown.

Several designs of conduit construction were considered, but the one suggested in Fig. 2 was finally adopted because of its low cost and ease of installation. It appeared to be sufficiently substantial to give good service for the few years that it would be in use. The conduit, Fig. 2, was constructed from rough pine planks held together with common steel spikes. Joints between all plank ends were broken and a piece of waterproofed building paper was tacked over each joint in the roof. All of the planks forming one of the sides of the conduit were wider than those forming the other, so that the roof plank would have a pitch to better enable it to shed water that percolated through the soil. In building the conduit, the three lower planks, *A*, *B* and *C*, Fig. 2, were assembled in trough-like sections and lowered into the trench and the ends of the sections were there spliced together. After the pipe had been laid in, the cover plank was nailed on and the trench refilled with earth.

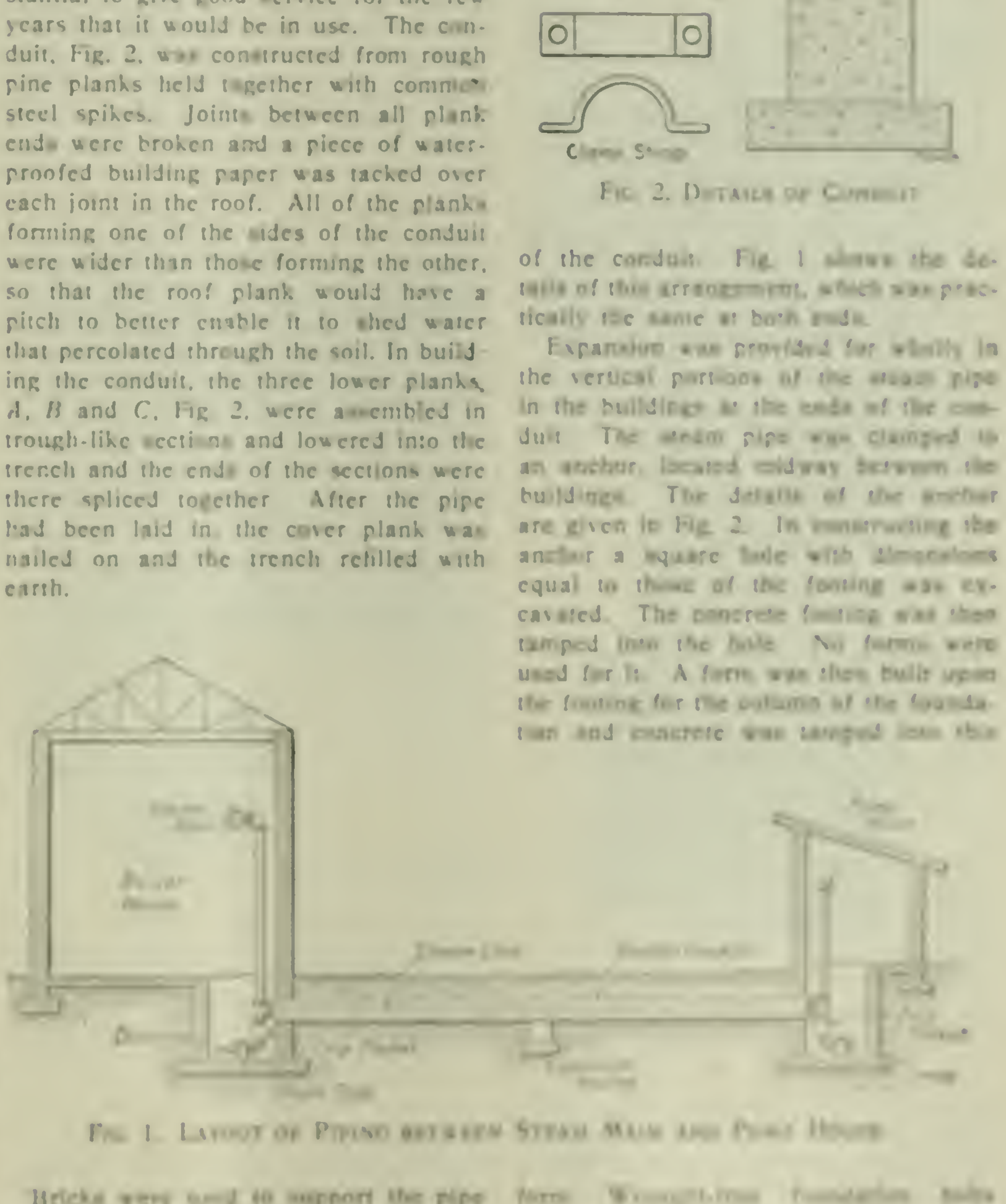


Fig. 1. Layout of Piping between Steam Main and Pump House

Bricks were used to support the pipe in the conduit. Supports of several other forms were considered, but all were abandoned in favor of the brick type because of its simplicity and low cost. Four bricks were used at each point of support, the distance between supports being about 10 feet. Two bricks (see Fig. 2), laid on their sides on the bottom plank of the conduit, prevented the pipe from touching it and two more bricks, each resting on its end, kept the pipe centered laterally. To prevent the bricks from shifting, due to the expansive and contractive movements of the pipe, several spikes were driven into the bottom planks around the bricks.

Although it is not shown in Fig. 1, the pipe line and conduit had a slight downward pitch toward the pump house, so that all condensation would flow with the steam that way. A drip pocket, drained by means of a steam trap of the bucket type, was provided at each end of the conduit. Fig. 1 shows the details of this arrangement, which was practically the same at both ends.

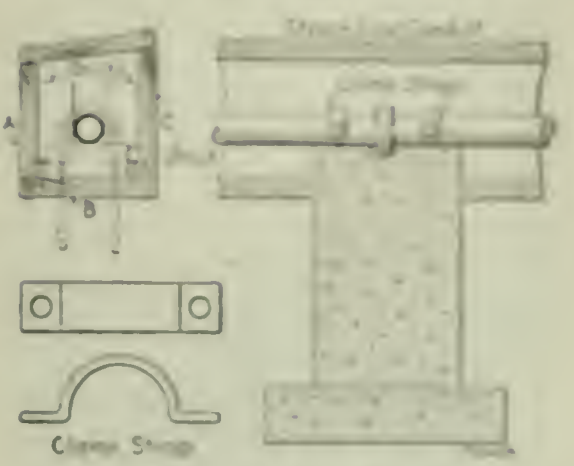


Fig. 2. Details of Conduit

Expansion was provided for wholly in the vertical portions of the steam pipe in the buildings at the ends of the conduit. The steam pipe was clamped to an anchor, located midway between the buildings. The details of the anchor are given in Fig. 2. In constructing the anchor a square hole with dimensions equal to those of the footing was excavated. The concrete footing was then tamped into the hole. No forms were used for it. A form was then built upon the footing for the column of the foundation and concrete was tamped into this form. Wrought-iron foundation bolts were cast in the concrete. Clamping straps, details of which are shown in Fig. 2, held the steam pipe firmly to the foundation and prevented any movement at that point. Ordinary nuts, turning on the foundation-bolt ends, secured the straps.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Automatic Starters for Induction Motors

By R. H. Fenkhausen

Automatic starters for induction motors are much more expensive than hand-operated starters, of course, but there are many installations where the saving in attendance or in other installation and maintenance costs will justify the extra first cost of automatic starters. For the control of a motor-driven pump deliver-

Fig. 1. Three-phase Starter for Squirrel-cage Motors

ing water into a tank in which the water level must be kept within certain limits, or for the control of a motor-driven compressor the receiver pressure of which must be maintained fairly constant, the automatic starter is almost indispensable.

Where motor attendants are unskilled or careless, automatic starters make it possible to limit the starting current and acceleration of each motor, because once the operator has closed the small switch in the control circuit, the starter automatically performs the several operations of starting the motor with a predetermined interval of time between each operation and the operator is powerless to shorten the starting period.

There are many cases where it is not practicable to install a motor near the

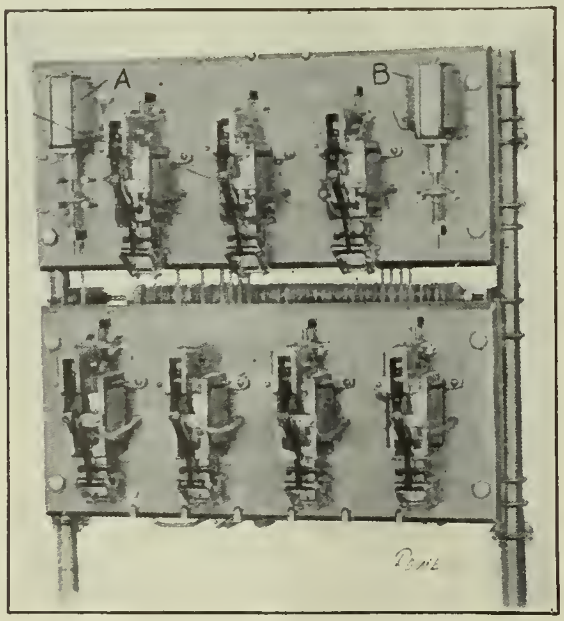


Fig. 2. Three-phase Starter for Wound-rotor Motors

place where it must be controlled and it often happens that the extra expense of an automatic starter is offset by the saving in wiring. When the automatic starter is used, it may be located close to the motor and the actual control accomplished by a small snap switch in the solenoid circuit of the starter. As two very small wires only are needed to connect the snap switch with the starter, there is a considerable saving in installation time and material over that required to carry the main wires from the motor to the control point.

If the distance from the motor to the point of control is very great, there is also a saving of energy due to the fact that there is less wire in the power circuit and therefore less loss due to resistance. This applies particularly to wound-rotor induction motors with external starting resistors, because, in addition to the line wires, these motors require three leads of large capacity from the controller to the collector rings and if the distance from the motor to the controller is very great, the loss due

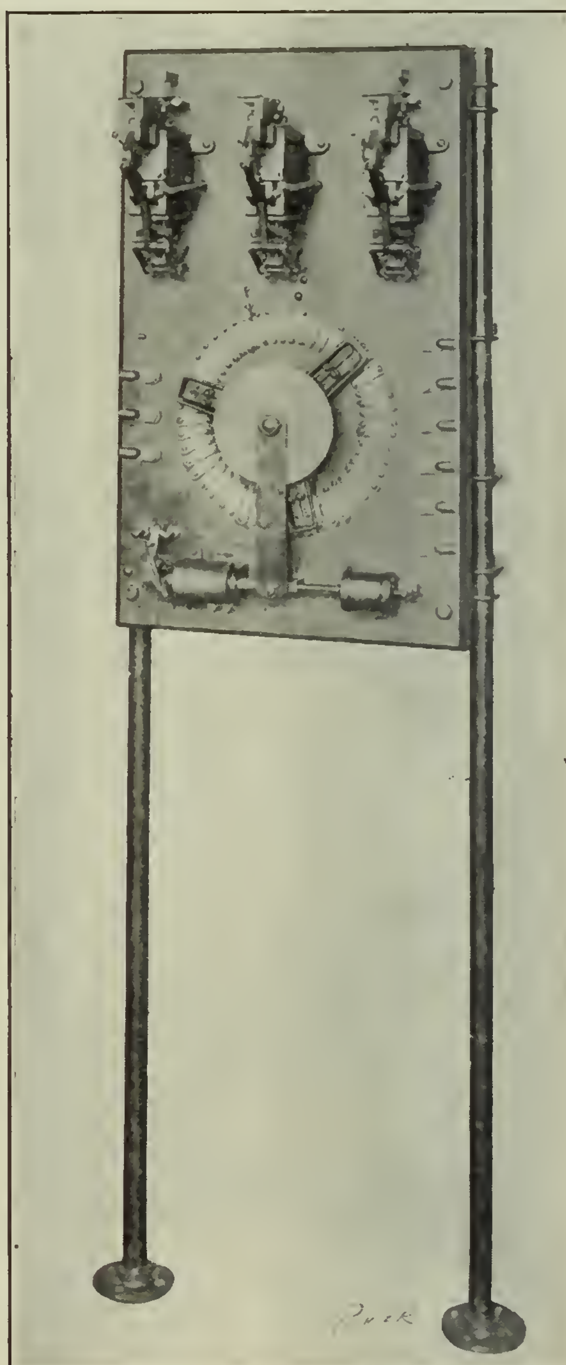


Fig. 3. Automatic Starter for Gradual Acceleration

to the drop in the secondary wiring will be excessive. The use of the automatic starter in such a case not only results in a marked reduction in installation costs but also improves the efficiency and speed regulation of the motor.

General Functions

Figs. 1, 2 and 3 show automatic starters which may be controlled in several ways. For remote hand control a snap switch is placed at the desired control point and connected in the main solenoid circuit of the starter.

Where automatic acceleration alone is required, the main solenoid circuit may be permanently closed and the motor started and stopped by a switch connected in the main motor circuit at any point between the motor and the entrance of the service wires, or the main circuit may be left closed and a pilot switch used as for remote control. The latter method is preferable unless the line switch is of the oil-break type, but the choice between the two methods will naturally be governed by the wiring layout. If the point of control is close to the run of the motor circuit one method is as good as the other, but if the control point is not located near any point on the supply circuit, the saving in wiring will make the use of the pilot switch advisable.

When automatic starters are controlled by float switches or pressure governors,

Fig. 4. Relay for Control by Pressure Changes

these are invariably connected in the main solenoid circuit, because their contacts are small and therefore not adapted for connection in the motor circuit where heavy currents must be controlled.

The pressure governor shown in Fig. 4 consists of a standard bourdon pressure-gage mechanism provided with two contact rings to which adjustable contacts may be clamped at any point. These contacts and the end of the gage pointer are silver tipped to prevent corrosion. The contacts are too small to carry even the main solenoid current of the starter, so a relay is interposed between the gage contacts and the solenoid circuit. When the pressure falls below the lower limit set, the end of the gage pointer makes contact with the sliding block on the inner ring and thereby closes the energizing circuit of the relay solenoid shown at the right, which raises its plunger, bringing the disks into contact with the two pairs of terminals above them; this closes the solenoid circuit of the automatic starter and short-circuits the contact made by the pointer and the inner ring. When the pressure rises to the upper limit, the gage pointer makes contact with the sliding block on the outer ring and short-circuits the relay magnet, which drops its core and opens the solenoid circuit of the starter at the lower disk contacts, shutting down the motor. The gage contacts never break any current, because the upper disk of the relay short-circuits the contact made by the pointer with the block on the inner ring; consequently, when the rising pressure moves the pointer away from the inner

Fig. 5. Complete Tank Switch, Float and Rod

contact, the circuit remains closed at the upper disk. The motor continues to run until stopped as described. (See also the relay connections in Fig. 8.)

Fig. 5 shows a float switch designed to be clamped on the edge of a tank. Adjustable collars on the float rod actuate the switch which controls the solenoid circuit of the automatic starter, and by setting the collars to operate the switch at the desired water levels the height of water in the tank may be kept within the limits of these levels. It is desirable that there be as great a difference as practical between the upper and lower levels in order that the pump and motor shall not be started and stopped too frequently. When it is not possible to locate the float switch at the edge of the tank, on account of exposure to the weather or other conditions tending to interfere with its operation, a float switch of the type shown in Fig. 6 may be used; this is operated by a rope passed over guide pulleys, with a counterweight on the end opposite to the float.

Starter Operation in Detail

Fig. 1 shows an automatic starter for squirrel-cage induction motors in which the various contacts are made and broken by "contactors," or electromagnet

Fig. 6. Float Switch for Operation by Rope

switches, under the control of relays. In the starter shown, the contactors are arranged for submersion in an oil tank for 2200-volt service, but for lower voltages the oil tank is omitted. The operation of this starter is as follows (see Fig. 7):

When the control circuit is closed, the relay A and the contactor magnets 1 to 5 are energized; the contactors connect the autotransformer coils across the line with the motor connected to the low-voltage taps. The relay A lifts its plunger against the retarding influence of a dashpot that is adjustable so as to vary the duration of the starting period of the motor. When the plunger reaches its limit of upward travel the control circuit of the contactors 1 to 5 is opened by means of the small switch shown above the relay in Fig. 1 and another circuit is closed which energizes the magnets of the contactors 6 to 8, which connect the motor directly to the line.

No-voltage protection is provided by the relay A and the contactors 6 to 8, which open on failure of the current sup-

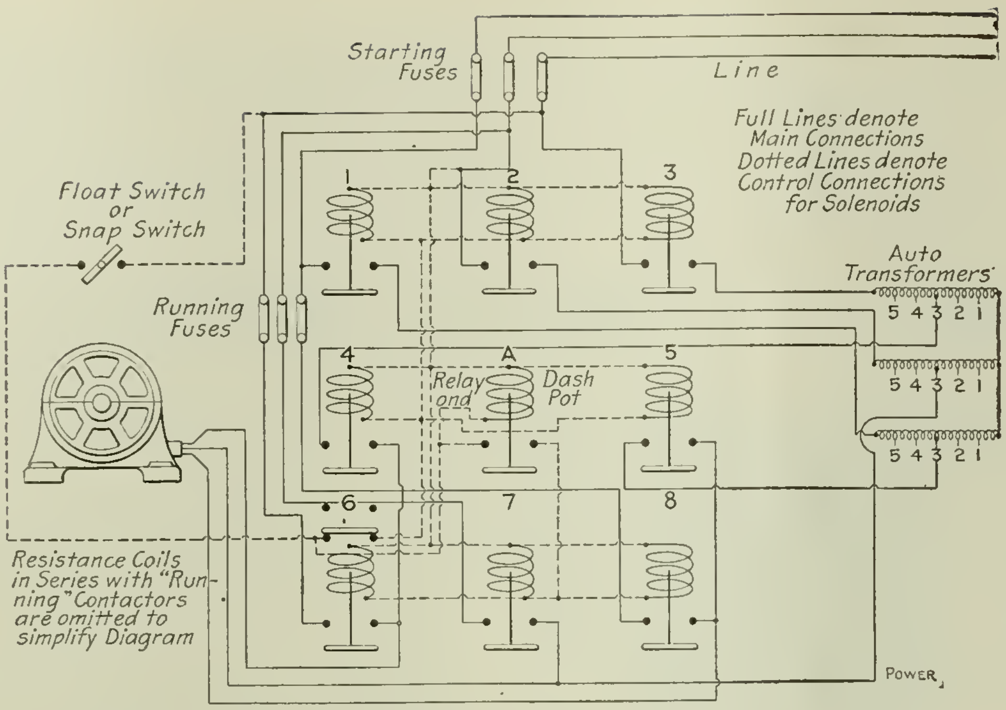


FIG. 7. DIAGRAM FOR STARTER IN FIG. 1 AND FLOAT SWITCH

ply, leaving the starter ready to start up again in the usual manner as soon as the current supply is resumed. The motor is stopped by opening the main control circuit.

The automatic starter shown in Fig. 2 is for use with induction motors of the wound-rotor type. Its construction is similar to that illustrated in Fig. 1, but two starting points are provided by variation of the resistance in the rotor circuit. The operation of this starter is as follows (see Fig. 8): When the control circuit is closed, the shunt coil of the compound-wound relay *A* lifts its plunger, which closes the magnet circuit of the contactors 1, 2 and 3; these connect the stator winding of the motor to the line, leaving all of the resistor in the rotor circuit. The contactor 1, in closing, also opens the shunt-coil circuit of the relay *A*, leaving its plunger held by the series coil. This series winding is proportioned so that as soon as the starting current of the motor falls below a certain value the coil will drop the plunger and close the operating circuit of the contactors 4 and 5; these cut out part of the rotor resistor and the contactor 4 also opens the shunt winding of the compound-wound relay *B*, leaving its plunger held by the series coil alone. When the starting current has fallen below the value for which the relay *B* is designed, this relay drops its plunger and closes the operating circuit of the contactors 6 and 7 which cut out the remainder of the rotor resistor and short-circuit the collector rings of the motor; the contactor 6 in closing also opens the operating circuit of the contactors 4 and 5, which therefore open their contacts. Overload during the starting period is prevented by the setting of the relays *A* and *B* and no-voltage protection is provided by the contactors 1, 2 and 3, which drop out and restore the starting conditions upon failure of the current supply.

The automatic starter shown in Fig. 3 is for use in service requiring a more even acceleration than is afforded by two starting points. A solenoid-operated ratchet switch of the dial form automatically cuts out the resistor in the rotor circuit little by little and the large number of contacts provided on the dial gives a very uniform rate of acceleration.

For small squirrel-cage motors, of less than 20 horsepower, the starter shown in Fig. 1 is often too costly and small self-contained starters of the types illustrated by Figs. 9 and 10 are applicable. The one shown in Fig. 9 is designed for operation by means of a rope connecting with a large float in a tank supplied by a motor-driven pump. The sheave around which the rope passes is loose on the starter shaft and its periphery is slotted through a large arc to permit a considerable movement of the sheave (due to change in water level) before moving the weight arm, which passes through this slot. When the water level falls, the rope attached to the float rotates the sheave in the clockwise direction until

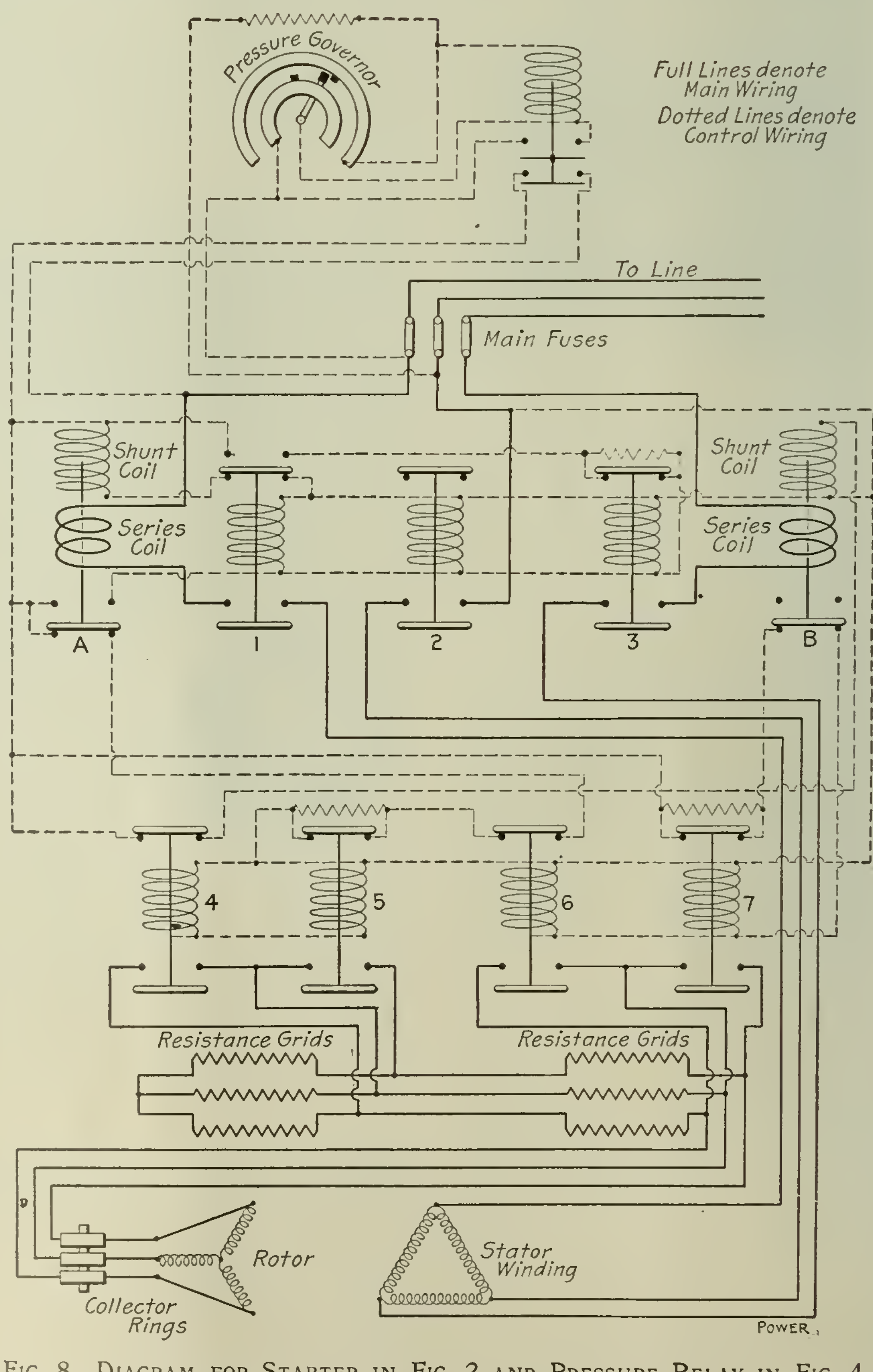


FIG. 8. DIAGRAM FOR STARTER IN FIG. 2 AND PRESSURE RELAY IN FIG. 4

the end of the slot engages the weight arm, which is flexibly connected to the drum switch within the case; continued drop in the water level allows the float to pull the sheave around farther and

FIG. 9. SMALL STARTER ACTUATED BY FLOAT AND ROPE

carry the weight arm over the top center, from which position it falls by gravity, retarded by a dashpot, and operates the starting switch, accelerating the motor at a rate determined by the dashpot adjustment. As the water level rises, the float is lifted, of course, and rotates the sheave in the opposite direction until the weight arm is carried over the top center, from which position it falls quickly, making a quick break at the main switch contacts and shutting down the motor.

FIG. 10. SMALL STARTER ACTUATED BY PRESSURE RELAY

The starter of Fig. 10 is equipped for operation by pressure variation under the control of a pressure governor. When the tank pressure falls below that for which the governor is set, pressure is admitted to the right-hand cylinder of the starter; the piston in that cylinder rises and operates the starter drum within the case, at the same time compressing a spring in the left-hand cylinder. The rate of acceleration of the motor is controlled by an adjustable dashpot in the left-hand cylinder which acts in opposition to the piston in the pressure cylinder. When the tank pressure exceeds that for which the governor is set, the pressure in the right-hand cylinder is relieved and the starter spindle is turned to the "off" position by the spring in the left-hand cylinders; the movement in this direction is very rapid, being unrestrained by the dashpot.

Each of these starters consists of a standard three-point autotransformer and drum switch, with the addition of the control device described. The connections are shown in Fig. 11. It will be noted that two sets of fuses are employed, one for starting and one for running, but there is no protection against failure of the current supply. If no-voltage protec-

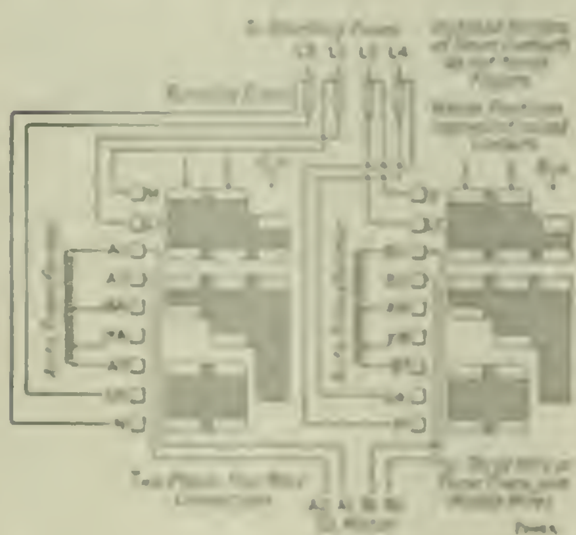


FIG. 11. DIAGRAM OF SMALL STARTERS IN FIGS. 9 AND 10

tion is desired, a circuit-breaker with a no-voltage trip coil, such as shown in Fig. 12, should be substituted for the running set of fuses.

SPECIAL CONTROL

All the automatic starters described in this article are built for constant-speed motors. Automatic control for multispeed motors is seldom used except for the larger sizes of motors. These starters are similar to the one described in connection with Fig. 2 except that the starting resistor is designed for continuous service and more starting points are provided. The contactors are under the control of a master switch by means of which those contactors giving the desired speed are held closed. The rate of acceleration and the starting current are out of the operator's control, however, because a relay set for a given starting current operates when the current reaches that value and opens the control circuit of the master switch, preventing any further reduction of the resistance in the rotor circuits until the starting current falls below the limit value.

An interesting example of automatic control as applied to wound-rotor induction motors is that employed in connec-

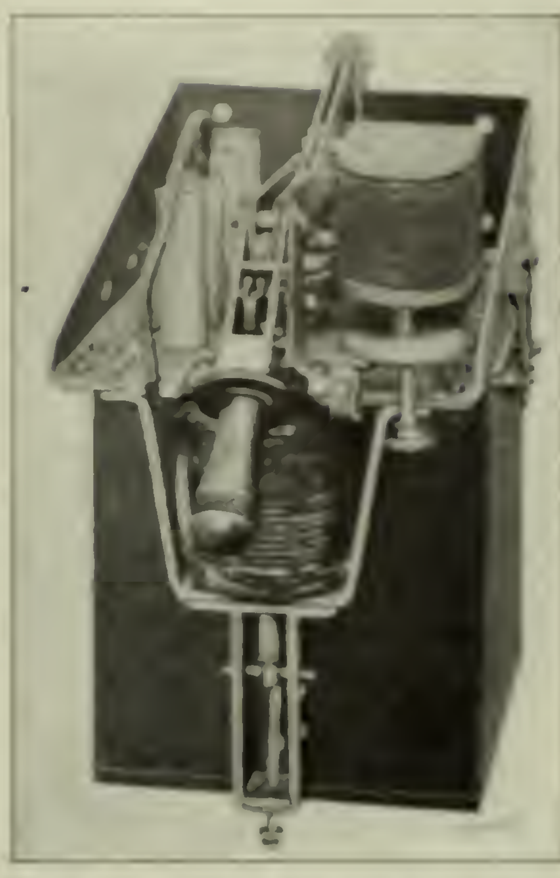


FIG. 12. CIRCUIT-BREAKER WITH NO-VOLTAGE COIL

tion with flywheel motor-generator sets. In order that the flywheel may deliver part of its stored energy to relieve the peak load on the motor, it is necessary that the motor shall "lie down" when the load becomes excessive. This is accomplished by the action of a relay set for a given rotor-current value. As soon as the current reaches the value for which the relay is set, its contacts close and energize a series of contactors which cut in resistance in the rotor circuit and reduce the speed of the motor enough to allow the flywheel to give up part of its energy.

The following instructions for raising steam were issued in the annual Memorandum of the Manchester Steam Users' Association: Before lighting the fires, see that there is sufficient water in the boiler, also watch the water gage while raising steam, for the blowoff valve or the feed-check valve may be so leaky as to pass water as soon as there is any pressure, that there is sufficient water in the boiler, may produce fractures or start leakages. If the boiler cannot be filled with warm water through the economizer, then the firing should proceed very slowly so that the bottom of the boiler may grow as warm as the top. If pressed for time, the boiler may be filled to the top of the water gauge, and when, with rapid firing, the top water has grown warm, discharge the cold bottom water and continue firing the boiler.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Fitting Trunk Pistons for Gas Engines

BY OLAF OLAFSEN

The methods of fitting pistons to their cylinder bores, the allowances used, the methods of securing these allowances and the reasoning involved may be of value to some engineers who have occasion to do this kind of work or to check up the work of a repair shop. With

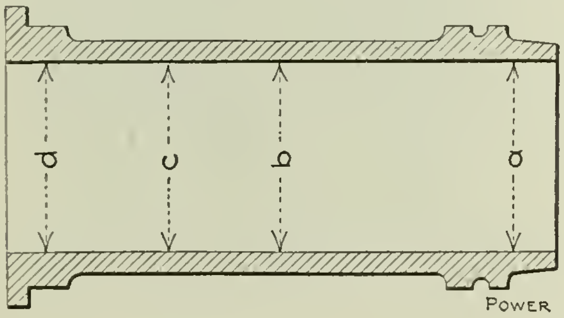


FIG. 1. REFERENCE DIAGRAM FOR CYLINDER TAPER

TABLE 1. CYLINDER TAPER.

Bore, Inches.	Minimum.	Maximum.
3¾ to 10¼	0.001	0.002
10½ to 14½	0.0015	0.003
14¾ to 19¾	0.002	0.003
20 to 26½	0.002	0.004

Referring to Fig. 1, measure the cylinder at the points *a*, 1¾ inches from the crank end: *b*, midway of the length; *d*, 1¾ inches from the head end; *c*, midway between *b* and *d*. The taper is the difference between *a* and *d*.

single-acting trunk pistons there are four sources of possible leakage of compression or of expanding gases: First, due to slight looseness of fit of the piston in a horizontal cylinder during the part of the compression stroke when the connecting-rod thrust is upward, the piston may be canted or cocked in the cylinder bore in such a manner as to disturb the proper bearing of the rings both on their edges and on their faces. Second, if there be a gap between the ends of each ring and if the lands between the rings be reduced too much in diameter, there is an easy passage for the escape of gases under pressure. Third, due to improper proportioning, machining or fitting, the rings may not bear properly over their entire peripheries. Fourth, due to improper machining or fitting they may not have a good bearing on their edges and may allow the gases under pressure to blow under them and out. As a rule, the engineer need consider only the first cause, as the others are due entirely to bad workmanship.

First, consider the expansion of the various parts under working conditions, without attempting to theorize upon the actual temperatures that may occur or the differences of temperature between the piston and the cylinder. It will readily be understood that the piston will be somewhat hotter than the cylinder under full-load conditions; therefore, a greater allowance for the running fit must be made than would be necessary were the piston and cylinder always at the same temperature. It is also evident that the head end of the piston will be much hotter than the other end and will therefore have to be turned somewhat smaller than the barrel. Most manufacturers now do not allow the lands between the rings to bear on the cylinder wall when the piston is at working temperature, although some few still adhere to that practice. It is a mistake to relieve the lands too much as it only adds to the tendency to leakage through the gaps at the ring joints.

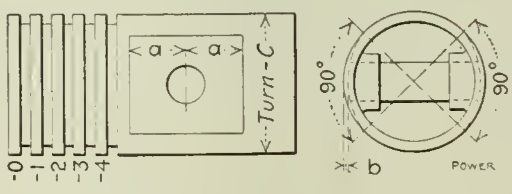


FIG. 2. REFERENCE DIAGRAM FOR TABLE 2

TABLE 2. PISTON TURNING AND FILING SCHEDULE.

Bore, Inches.	Piston Barrel, *C*.	Piston Head, *O*.	Lands between Rings. 1	2	3	4	Dimension *a*.	Dimension *b*.
3.75	0.0010						2.25	0.001
4.50	0.0010						2.25	0.001
5.00	0.0010						2.25	0.001
5.50	0.0010						3.00	0.001
6.00	0.0010						3.00	0.001
7.00	0.0020	0.0025					4.75	0.001
7.75	0.0020	0.0025					4.75	0.001
8.50	0.0020	0.0030	0.0025				4.75	0.001
9.00	0.0020	0.0030	0.0025				4.75	0.001
9.50	0.0020	0.0040	0.0030	0.0025			4.75	0.001
10.25	0.0020	0.0040	0.0030	0.0025			6.00	0.001
11.00	0.0025	0.0060	0.0040	0.0030			6.00	0.001
12.50	0.0030	0.0080	0.0050	0.0040			6.00	0.001
13.75	0.0040	0.0080	0.0060	0.0050			6.00	0.0025
14.50	0.0050	0.0100	0.0070	0.0060			6.00	0.0025
15.75	0.0050	0.0100	0.0080	0.0065	0.0060		6.75	0.0025
16.50	0.0050	0.0120	0.0080	0.0065	0.0060		6.75	0.0025
17.25	0.0050	0.0200	0.0140	0.0095	0.0060		6.75	0.0025
18.50	0.0060	.0.0200	0.0140	0.0095	0.0070		6.75	0.0025
19.00	0.0060	0.0300	0.0175	0.0120	0.0085	0.0070	7.75	0.0025
19.75	0.0060	0.0300	0.0175	0.0120	0.0090	0.0070	7.75	0.0025

Turn pistons to dimension *C* minus allowances as per schedule.

Pistons to be relieved on sides by throwing them out of center on a special turning or grinding fixture.

In estimating "play" of pistons in bore do not fail to consider cylinder taper.

There are two practices in turning the lands; some manufacturers turn them of different successive diameters, according to a schedule, and others, starting at the head and there reducing the diameter a specified amount less than the barrel diameter, taper the diameter for a specified distance toward the open end of the piston.

Obviously the breech end of the cylinder, where all the work is done, will be considerably hotter than the crank end if no special precautions are taken to prevent it. It is now common practice to introduce the jacket water under the seat of the exhaust valve or very close to it and discharge the water near the top of the cylinder head, whether the engine be vertical or horizontal; this allows the water to travel with considerable velocity around the hottest parts of the cylinder and to gravitate slowly toward the cooler ones. In some engines the water is first passed through under the exhaust valve, then through the cylinder-head jacket and finally to the cylinder-barrel jacket, thus supplying the latter with warm water and keeping the open end of the cylinder more nearly at the temperature of the breech end. Besides this, it is always the practice in boring cylinders, when reamers are not used, to start the finishing cut at the crank end; the wear of the tool, slight as it may be, almost always causes from a half to one and a half or two thousandths of an inch taper in the bore, depending on the size and the length of the cylinder. This will be found to be no serious fault; on the contrary, it is usually considered advantageous because the bore will be more nearly parallel when the engine is at working temperature. One manufacturer even goes so far as to scrape the crank ends of all cylinders with a long-handled scraper for a distance inward equal to about three-quarters of the length of the piston, increasing the diameter at the open end by about one-thousandth of an inch. Another builder heats the breech while reaming the bore, thereby making a tapered bore when the cylinder is cold and an approximately parallel one when the cylinder is hot.

Possibly the commonest practice in fitting pistons to cylinders is to turn or grind the pistons a certain schedule allowance less than the cylinder bore and "relieving" them slightly by filing on both sides about the piston pin to insure a bottom bearing of the piston when it receives the thrust of the connecting rod. A less rapid but, it seems to me, better method is to turn the piston one to three thousandths (according to its diameter) larger than desired for a running fit and to put the engine on the test block and run it with the maximum load that it is capable of carrying and at the regular working temperature, with copious lubrication. After a very short run the piston will be heard to "bump," as it is called, and no mechanic will ever mistake this sound for any other than a tight piston knock if he has once heard it. The piston is then removed and the high spots filed off. This process is repeated a number of times until the piston runs free, all "bump" having disappeared even when a full rush of cold water is turned on suddenly after the engine has operated for some time with a cylinder almost too hot for the hand to bear.

Great care and considerable skill are required to do this kind of fitting but if it is properly done a fine job is the result. There is really no occasion for anyone to "freeze" a piston in fitting it this way if he is careful and if the piston is turned to the proper size beforehand. The piston must be "relieved" very slightly on the sides about the piston-pin holes.

In fitting a piston in the manner just described the engine should be run on the fuel with which it is to be used in service because different fuels, producing different cylinder temperatures, will create different expansions. For example, the piston of a natural-gas engine needs greater allowance than that of a producer-gas engine and the piston of a gasolene engine may need a greater allowance than that of a city-gas engine. Engines to be run with gravity circulation of the cooling water should be especially free-running when hot, because they are liable to be run very hot for long periods where tanks are small, as is usually the case.

It is often the practice by mechanics to allow from a sixteenth to a sixty-fourth of an inch of clearance between the ends of piston rings when fitting them to the cylinder. This is unnecessary and only adds to the leakage. The rings will develop end clearance soon enough and I have found that there has never been the slightest trouble when rings are fitted so that they enter without any clearance at the joints.

Table 1 gives a list of cylinder tapers and directions for taking measurements for the piston diameter as practised by one European builder; Fig. 1 illustrates the instructions and Table 2 gives the schedule of allowances to be made in

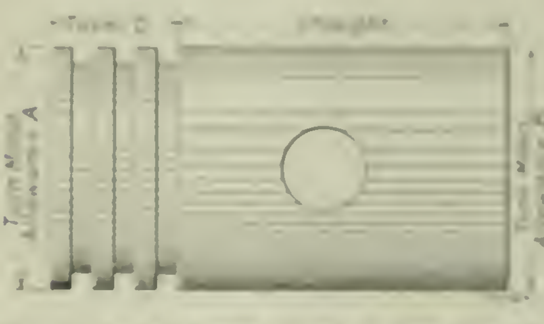


FIG. 3 REFERENCE DIAGRAM FOR TABLE 3

TABLE 3. PISTON TURNING SCHEDULE

[illegible]

[illegible]	A	B	C
9	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]
10½	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]

NOTE—[illegible]

turning the piston. Fig. 2 is the reference diagram for Table 2. Fig. 3 and Table 3 present the practice of a well known American builder who anneals the pistons before finishing but never files them. For the repairman I would advise using Table 3 with the exception that it will be best to diminish the allowance in column *B* by one to three thousandths, according to size, leaving that amount for filing when the engine is started. Where the piston is very short it would be better also to diminish allowance *A*, as sometimes it is desirable to use the bearing between the rings under such conditions. For pistons two diameters long and over, it is advisable to follow Table 3 entirely. In every case, a piston which has not been annealed before finishing should be filed on the test stand as unexpected irregularities are developed when the casting is heated.

No attempt should be made in a repair shop to taper cylinders by a greater amount than that which is accidentally due to the wear of the boring tool, as special tools are required for this work and in most cases good results can be obtained without much taper. One repair man decided hastily that setting over the tailstock while boring with a bar between the centers of the lathe, the work being mounted on the carriage, would give a tapered bore. The result was an elliptical bore, of course.

Those makers who follow the practice of filing pistons are almost all builders of horizontal single-acting engines.

This article should not be considered as applying to automobile engines; the cylinders of such engines are so short that they are bored straight, with no allowances of the kind described.

Make and Break Ignition Troubles

By S. Kirl[illegible]

Trouble is frequently experienced with gas engines having the make-and-break system of ignition due to the contact points becoming corroded or worn down to such a degree that missing fire is frequent enough to cause irregular speed or even a complete shutdown of the engine. When missing is due to the contact points being worn down or corroded it can be quickly proved in the following manner without removing the igniter from the cylinder.

If the engine is small enough to be easily turned by hand, close the switch and hold the blade of a screwdriver or any other iron instrument near the end of the iron core of the spark coil while an assistant turns the engine. If the contact points in the cylinder are in good shape the iron instrument will be jerked to the iron core of the coil by the magnetism each time the engine is turned past the point where the ignition circuit is closed. If the screwdriver is not attracted to the core and if the wiring is in proper condition, it indicates that the trouble is due to the igniter contacts failing to come together, due to their being worn off too much or corroded to such an extent that the battery current cannot pass through them.

Trouble is also caused sometimes by the contact points remaining together due to the pin binding where it passes through the igniter body. This can be detected also by turning the engine over while holding an iron instrument near the coil core and noting whether or not it is jerked to the core each time the ignition point is passed. If it is continually held against the core during two revolutions of the engine, it shows that the ignition points are sticking together and failing to make the spark.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Trip Cutoff Kinks

The prevailing practice on engines handling the releasing-gear type of engine is to set the governor rods so that when starting up, both valves will be released at about the same time.

This method is incorrect, although I have seen engineers change the cutoff after the mean effective pressure had been equalized on both sides of the piston by means of the indicator.

The correct method of setting the cutoff on this type of engine when no indicator is available is as follows: Prop the governor up to where it stands at normal load and turn the engine over slowly until the crank-end trip lets go. Then measure the distance the crosshead has traveled on the backward stroke and turn the engine in the direction of rotation until the crosshead has traveled an equal distance on the forward stroke. Adjust the head-end trip to let go when in this position.

Cutoff will take place at the same part of the stroke, and, although it may not exactly divide the load, it is about the best we can do for cutoff without using an indicator.

A. H. Langman.

Aurora, Can.

Trouble with Steam Radiator

In reference to E. L. Morris' trouble with a heater as described in Power for January 17, I will say that in my opinion there are several causes for this heater not heating up properly. First, the pressure may be too low for the distance this heater is from the boiler; second, the heater may have become air bound; third, the pressure may be unequal and, by closing the valves down on the other two heaters to just a small opening, the trouble may be partially overcome.

I would suggest that a pet cock be placed on the end of the heater opposite to the inlet valve. This would release the air and help the situation, providing all connections are tight and the valve of the heater is open sufficiently wide.

There is but one thing needful to get the heater to warm up and that is circulation. I have had troubles of this sort and I have found most of them to be due to proper circulation failing to take place either from the fact that the heater was air bound or that it did not have sufficient steam pressure.

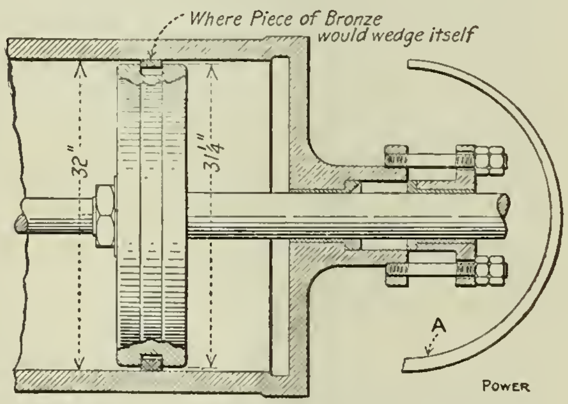
E. F. Strippy.

Washington, D. C.

Bronze Piston Rings

Several years ago, I was employed in a large mill power plant in which there was a large simple steam engine. After the plant had been in operation for some time, the management decided to compound the engine and run condensing, therefore, a new cylinder was ordered from a different firm than had built the engine.

The cylinder and piston dimensions were as shown in the illustration. It will be noted that the cylinder is ¾ inch larger in diameter than the piston. When this cylinder was installed the piston was packed with a well-known type of sectional piston packing, and held out against the cylinder walls by springs.



Design of Piston and Piston Ring

After this packing had been in service for about a year, the engine began to give trouble. To overcome the difficulty the powers that be decided that cast iron was not the thing with which to pack a piston, and that there was but one intelligent method. They decided that a bronze ring of the snap type, cut eccentric, as shown at *A* was the proper ring. Having arrived at this conclusion, the bronze ring was ordered and in due time arrived and was at once put in place.

After very short service the cylinder began to have the time of its life, giving three cheers and a tiger at each revolution.

When the cylinder was opened up, a piece of the thin end of the bronze ring was found wedged between the piston and the cylinder wall. It will be seen that when the piston was centered in the cylinder but ¼ inch of the bronze ring was in the slot in the piston and, as bronze wears away very rapidly when in contact with cast iron, this ¼-inch leverage was very short lived. Consequently, the ring broke about 8 inches from the end and wedged itself as stated.

The "High Grand Mogul" decided "to fight it out along this line if it took all summer," so another bronze ring was put in which shortly proceeded to give a practical demonstration that bronze was bronze and again wedged the thin part of the ring between the cylinder wall and the piston. As there was no idea of giving up our military resolutions, another round of bronze was shot into that cylinder on five occasions, after which the cylinder was again fitted with cast-iron sectional rings.

Amos S. Back.

Waterbury, Conn.

Boiler Inspection Law

Can any reader give a good reason why the legislature of the State of New York has failed to pass a good steam-boiler inspection law or an engineers' license law? True, there is a law in New York State that compels the inspection of locomotive boilers, and the enforcing of this law by the Public Service Commission has compelled the railroad corporations to keep their boilers in good condition.

A similar law should be passed that would make it compulsory to have all boilers used for power purposes examined semi-annually, once internally and once externally, and the boilers to be in charge of competent engineers.

The factory-inspection department sometimes calls for a report on steam boilers, but if it is compulsory to furnish them with a report, the law as enforced is a farce. The owner of a steam boiler can employ any person to make an inspection and send him a report of such inspection to be forwarded to the factory-inspection department, and it is accepted.

I know of many cases where men have made inspections of steam boilers, the reports have been accepted and boilers continued in use, but the men who made the examinations could not figure out the strength of a seam, strength of the braces or stays in the boilers and, in fact, if given all dimensions, they could not figure the steam pressure to be allowed. Certainly such a man could not be held responsible for any accident occurring after his inspection.

The factory-inspection department accepts the report of an examination made by a steam-boiler insurance company's inspector, but there are hundreds of boilers in the State of New York that are not insured. There are boilers in use that are from 20 to 30 years old, carrying the same steam pressure that was carried when they were first installed. Most of these boilers are of the horizontal return-tubular type, lap-seam construction and carry from 80 to 110 pounds steam pressure; they should be in the scrap heap. Some of these boilers are in charge of men who do not know the risk they are taking in carrying such pressures.

In one of the congested business districts in one of the large cities of the State of New York there is in daily use a battery of two boilers carrying a working pressure of 90 pounds that were practically condemned by an inspector several years ago. The boilers are about 60 inches in diameter by 14 feet long. The shell plates were originally 5/16 inch thick, the longitudinal seams are lap construction, double riveted, and the seam will not figure more than 65 per cent. of the strength of the solid plate. The opening in the shell under the dome is almost the full size of the dome and is not reinforced; the boilers are at least 25 years old. Figure what steam pressure these boilers would safely carry when new, and then imagine what is going to happen at this plant some day. The coroner's jury will, if the usual custom is followed, put the blame on the engineer or fireman, both of whom will doubtless have been killed. There are many plants being operated in worse condition.

There were more than 530 boiler explosions in the United States in 1910, and 280 persons were killed at the time of the explosion; there were also many persons scalded and otherwise injured who later died from the effect of their injuries. There were over 550 boiler explosions in 1909 and about 230 fatalities. The lap-seam boilers carried off the "honors" and, no doubt, the lap-seam engineers, referred to in a recent issue, had charge of the majority of these plants.

There should be a law, rigidly enforced, prohibiting the installation of lap-seam boilers and especially that type made up of two sheets with the longitudinal seams running from head to head. No extra expense is incurred in having the boiler built with butt joints. A triple-riveted joint properly proportioned will give from 84 to 87 per cent. strength of a joint and a quadruple-riveted seam from 92 to 94 per cent. There is no record, as far as known, of a boiler with this type of seam exploding.

R. J. WALTERS.

Rochester, N. Y.

Laying Pipe under Water

I recently saw a 10-inch wrought-iron pipe laid under water in a very simple manner. The pipe was to be used as an intake for a pump and extended into a shallow lake some 200 feet.

The method adopted was to connect the pipe lengths together, on skids, on the lake shore. A blind flange was put on one end and a foot valve on the other, the foot valve being fastened in a closed position by a wire. Then the pipe was rolled into the water, three men mounted it and with poles punted it into position. Then the foot valve was opened, allowing the whole to sink gradually onto the piers that had been made for it to rest upon.

F. H. STACEY.

Montreal, Can.

Wood as a Fuel

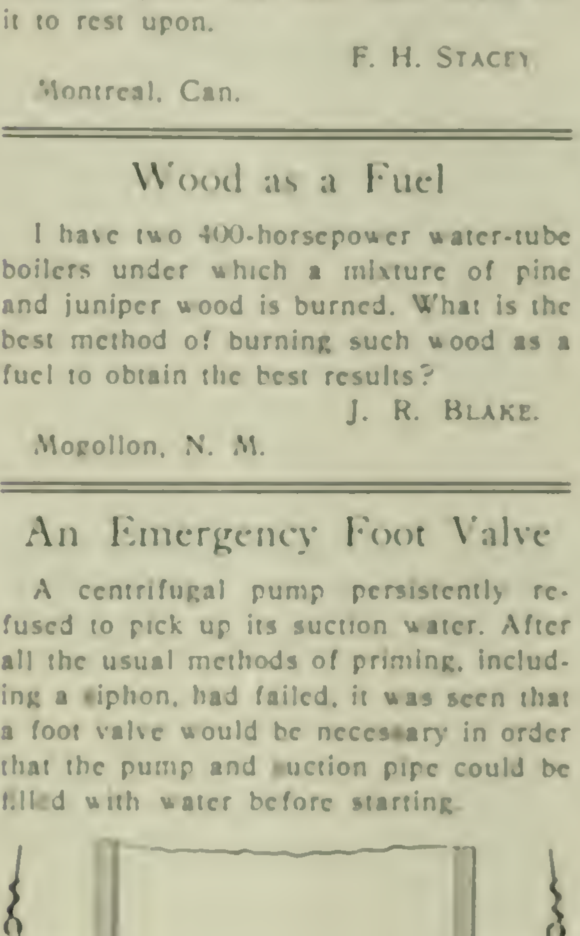
I have two 400-horsepower water-tube boilers under which a mixture of pine and juniper wood is burned. What is the best method of burning such wood as a fuel to obtain the best results?

J. R. BLAKE.

Mogollon, N. M.

An Emergency Foot Valve

A centrifugal pump persistently refused to pick up its suction water. After all the usual methods of priming, including a siphon, had failed, it was seen that a foot valve would be necessary in order that the pump and suction pipe could be filled with water before starting.



DETAILS OF FOOT VALVE

An ordinary galvanized water bucket was made into a foot valve, as shown in the sketch. A 6-inch hole was cut in its bottom and a valve was made from a piece of heavy rubber belting, cut 1 inch larger than the diameter of the hole in the pail. A ¼x1½-inch iron strap was bent to fit the bucket, as shown. A ½-inch thread was tapped in this iron strap to receive an ordinary ½-inch bolt to act as a valve stem.

The foot valve was placed over the bottom of the suction pipe and held in place by wires. It was a success.

F. C. HICKEY.

Yazoo City, Miss.

Overloaded the Engine

In the southern part of Indiana a power plant, supplying power to a large cement factory, experienced considerable difficulty in keeping an exciting set in operation. The plant was of about 1500 kilowatts capacity. Two direct-coupled exciting units had been installed and the prime movers were twin-cylinder compound steam engines. One unit was of 75 kilowatts capacity, running at 350 revolutions per minute, and the other of 35 kilowatts capacity, at 520 revolutions per minute, which speeds are rather high.

Both exciters gave trouble continually and one or the other of them seemed to be down for repairs all the time. The 75-kilowatt unit was naturally used most, since the exciting load alone was about 35 kilowatts and the entire lighting load of about 20 kilowatts was taken from the exciter busbars also. The 35-kilowatt set was kept pretty busy when the 75-kilowatt set broke down.

For this reason duplicate parts for the larger unit were kept on hand so that the smaller unit need not be operated longer than was absolutely necessary. However, even though the small unit was operated but little, the tremendous overload when it was operated soon began to tell on the engine, and after three or four years this engine also became unreliable, but no duplicate parts were ordered for it.

One day the larger unit began to bump and rattle and, before the steam could be shut off, it had completely wrecked itself, everything within the four cylinders being smashed to bits; the 35-kilowatt unit was then started. Some of the repair parts had to be made, which would require a few weeks, and it looked very much as though there would be trouble before they could arrive.

While going over the works the day following the accident, I noticed a band wheel of some sort protruding from a pile of cement and rubbish behind one of the factory buildings, which proved to be a 9x14-inch Atlas side-valve engine that had been used during the building of the factory a few years before. This engine offered the only ray of hope in the solution of the pressing exciter problem, and I decided that it would be able to carry enough of the load to keep the works going nearly full blast day and night.

I knew that these engines were designed for 125 pounds pressure so that perhaps the full boiler pressure of 100 pounds could be withstood if the load demanded such. My greatest fear was that the pressure plate would deflect and bind the valve if a pressure of much over 125 pounds was used.

Timbers were placed in position near the small exciter and the Atlas engine mounted on them in such a way that, should the exciter engine break down, a short shaft could be bolted to the generator shaft by means of a flange coupling and the generator driven by a belt. This arrangement was completed none to soon, for the overloaded exciter engine showed signs of failure a day or two later and had to be stopped.

The shafting was speedily put in place, the belt tightener screwed down and the Atlas engine started on what proved to be a long run. It pounded a great deal and ran hot, and after a half hour's run ordinary lubrication was insufficient so water pipes were arranged to keep streams of water playing on all the bearings. The belt used was of sewed canvas, 8 inches wide.

This outfit ran six weeks, during which time two sets of main bearing parts, three sets of connecting-rod brasses and two belts were used up; crank and wristpins were badly scarred, as were also the main journals. Otherwise the engine as a whole was little harmed. Nothing broke and apparently the cylinder and valve were not touched. The cylinder was lubricated perfectly. The generator was unharmed except that the commutator was slightly burned.

A long shutdown was avoided, contracts were met, and now an exciting set of large size carries the load so easily that one can scarcely realize the supreme effort required by the small 9x14-inch engine to do about 80 horsepower of work.

C. R. Moore.

Lafayette, Ind.

Boiler Insurance

A matter connected with boiler insurance recently came to my notice, that is of more than passing interest.

The superintendent of a power plant, after reading a recent discussion relative to boiler insurance, looked up his own policy to see how it was worded. He discovered that his policy allowed him to carry 110 pounds steam pressure on his boilers, but they were carrying 120 pounds. In case of an explosion the policy would probably have been worthless.

On investigation he found that a former superintendent had increased the pressure 10 pounds without consulting the insurance people and, as a consequence, the policy had never been changed.

This condition had existed fully a year and the insurance-company inspectors had inspected the boilers several times since the change had been made, and presumably had noted the pressure carried. They had not, however, reported the matter to the officials of the power-plant company.

Is it possible that the inspectors had passed in their report without the increased pressure being mentioned, had the increased pressure not been detected or had the insurance company wilfully failed to notify the company, knowing that they could not be held in case of an explosion? It would also be of interest to know if under the above circumstances any insurance could have been collected. The boilers were in first-class condition, designed for 150 pounds steam pressure per square inch, and the insurance people readily changed the policy when their attention was called to the increased pressure carried.

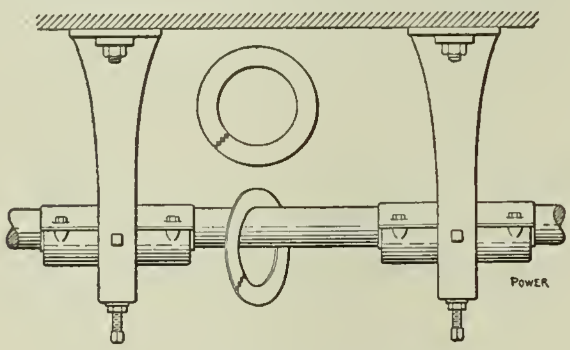
B. Jamson.

Chicago, Ill.

Ring Shaft Cleaner

My little kink, while old, may be of use to some engineer who is obliged to keep his line shafting clean and free from dust and oil.

Make several large rings out of belting, leatherboard or some such sub-



Ring Cleaner on Shaft

stance, having a hole about twice the diameter of the shaft, and the outside diameter about 2 inches larger than the inside diameter.

The ring is cut diagonal on one side, put on the shaft, after which the ends are sewed together with fine wire. The ring will travel from one hanger to the other so long as the shaft revolves.

Thus, the shaft will be kept free of dirt and it will eventually take on a bright polish.

H. A. Greene.

Boston, Mass.

Flushing Pump Valves

Trouble is often experienced with foreign matter getting under the valves of feed pumps.

It is a simple matter to place a barrel at some elevated place, connect it with the suction pipe of the pump and provide a pipe and valve to the discharge line for filling purposes.

When the pump valves hang up, close the valve in the suction line and open the valve in the pipe leading from the barrel which is kept filled with water. This flushes the pump and saves a lot of trouble, time and temper.

Frank Gartmann.

Sheboygan, Wis.

Unsafe Pulleys

Some days ago, I visited a small sawmill and, while looking over the plant, the manager pointed to a pile of cast iron that had once been a pulley 7 feet in diameter. He said it had burst a few days before and killed the sawyer. I did a little figuring and found that the rim speed of the pulley had been 9560 feet per minute.

To my surprise the new pulley was a duplicate of the one that had exploded and was running at the same speed.

I told him that the high rim speed at which the new pulley was running was liable to burst it, but he said the salesman who sold it said that the old pulley had burst on account of a flaw and that he supposed the one he was now running was perfectly safe. I do not know whether he has killed another sawyer yet or not.

H. T. Fryant.

Jackson, Miss.

Adjustment of Crank Pin Brasses

While talking with the superintendent of the company where I am employed a few days ago, our conversation turned to bearings, and I remarked that the crank was running cool, although the brasses were only 0.004 of an inch slack.

"How do you know that?" he inquired.

"Well," I answered, "the wedge tapers 1/8 inch to each inch in length, and the adjusting bolt has eight threads to the inch; therefore, each turn of the bolt will move the brasses 1/64 inch or practically 0.016 inch, so that 1/16 turn of the adjusting bolt will equal a movement of 0.001 inch of the brasses. As the wedge was drawn up so that the brasses were snug against the pin and then slacked back 1/4 turn on the bolt, there is not far from 0.004 inch clearance between the pin and the brasses."

Roy W. Lyman.

Ware, Mass.

Return System

I would be glad to get some information on the following: The drips from the steam main, separators, reheating coils and four engines are collected in a manifold located in the basement. This manifold is 20 feet below the water line in the boiler. The steam pressure in the boiler is 160 pounds. The difference in pressure between the boiler and the manifold is 10.5 pounds.

Is it possible and practicable to return the condensation to the boiler by means of the Holly system? If so, to what hight will it be necessary to carry the return riser? Also, what should the size of the riser be?

At present I am using steam traps, but they do not give satisfaction.

William Bopp.

Washington, D. C.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Water Hammer and Other Phenomena

In reply to J. W. Payler's inquiries in the March 7 issue under the heading, "Topics for Discussion" the following are my opinions on the topics which he presents:

There appears to be a marked difference between water hammer and the contraction and expansion of a steam line when steam is turned on. When steam is turned into a line of piping slowly, the steam coming in contact with the cold pipe is condensed. The condensation collects on the bottom of the pipe. The incoming steam eventually heats the pipe to a temperature practically the same as its own, but during the first part of the process the water lying along the bottom of the pipe causes unequal expansion to take place, the condensed water acting as a heat insulator.

I would account for the origin of water hammer in the following way: First, there must be a collection of water in a pocket or at some point in the line. Under normal conditions the steam passes over this water. But, when suddenly a demand for more steam arises, the steam picks up the water in passing. The water then attains the same velocity as the steam and when the water strikes a turn or other point where change in direction is necessary, the result is water hammer.

Steam entering a pipe pushes whatever air the pipe may contain along until the air is compressed to the same pressure as that of the entering steam. Very little or no interchange of heat takes place between the steam and air. This is illustrated when air becomes trapped in a radiator; until the air is removed the radiator remains cold almost indefinitely.

The water next to the plates or tubes in a boiler is turned into vapor bubbles. The vapor being lighter than the water rushes to the surface. It is this rising of the vapor that causes the agitation of the water. It will be seen, therefore, that steam is generated at the heating surface.

To demonstrate how a large body of water contained in a boiler is turned into steam when a rupture takes place, the following example is submitted. Assume a boiler in which the steam pressure is 160 pounds gage to contain 20,000 pounds of water. The temperature due to the pressure is 371 degrees. The water in the boiler contains, then, about 3,180,000 B.t.u. above 212 degrees. The latent heat of steam at atmospheric pressure is 970.4 B.t.u. Then the sudden reduction in pressure resulting from the rupture of the boiler would cause the instantaneous evaporation of about

$$\frac{3,180,000}{970.4} = 3280 \textit{ pounds of water}$$

H. Prew.

Montreal, Quebec.

Binding "Power"

In the March 7 issue there is an article on filing data after they have been cut from the magazine. This method of preserving data is theoretically perfect, but for practical purposes it seems to me that it could be improved upon. It embraces the necessity of alphabetical indexing, which is a study in itself, and also the problem of what to save.

In a magazine of the scope of Power the matter of the index is in the hands of a specialist. My substitute for filing away individual articles is a scheme for binding the magazines exclusive of their advertisements. It was suggested to me by my boss, C. L. Patch, chief of the estimating division of the hull department of the Boston navy yard.

Fig. 1. Volume Clamped for Drilling Holes

I cut a narrow board to the length of the magazine and mark it for holes. The holes are then drilled from the marked side. Then several magazines are held between this board and a plain unmarked board by a clamp in the manner shown in Fig. 1. Next, the holes are drilled with a breast drill of 7/64 inch diameter. The holes are made about ½ inch from the back of the magazine. When the holes are drilled, all the leaves of one volume are sewed together with ordinary wrapping twine and a sailors' needle. For covers several leaves from the advertising section are sewed on in front and at the back and the whole covered by a paper or cloth covering. By the use of mucilage between the several leaves, front and back, the effect of a flexible cover is secured. The outside covering of cloth or paper hides the stitches and gives a finished appearance. The cost of the whole is only a few minutes in time and a few cents in money. The only expense is for the outside covering. By treating the magazines in this way a handy record is kept, not only of what you thought you might want to use, but also a vast amount of matter which you just glanced at, never thinking you would need it until the occasion suddenly arose.

J. F. Wentworth.

Quincy, Mass.

I have noticed several men's ideas for preserving back numbers or interesting articles. I think that it is a poor policy to attempt to outdo the publishers in the matter of indexing—time is too valuable—a particularly useful article can be referred to in a card index or checked in the regular index. The idea of preserving only what seems at the present time to be the useful parts of each issue is a poor one, for one can never tell what will come next, providing he is in a live part of the world and what today is a waste of time to read may be of permanent value tomorrow or next year.

Fig. 2. Volume Ready for Cover

I do not make a practice of reading everything in each issue, but I save all articles which are apt to be of value till such time as I can get the issues bound with the complete index. Then when any question arises I have a very useful library at my disposal which is broader in scope on any subject covered than most of the engineering books published. The cost of binding is usually from $1.50 per volume, up.

C. W. Bell.

Taylor, Penn.

Stress in Boiler Sheets

Regarding the editorial under the above heading in the February 28 issue, it seems to me that a confusion has been made about the line of least resistance. However, the question brought up will make a large number of readers do some thinking, and for that reason it will be valuable.

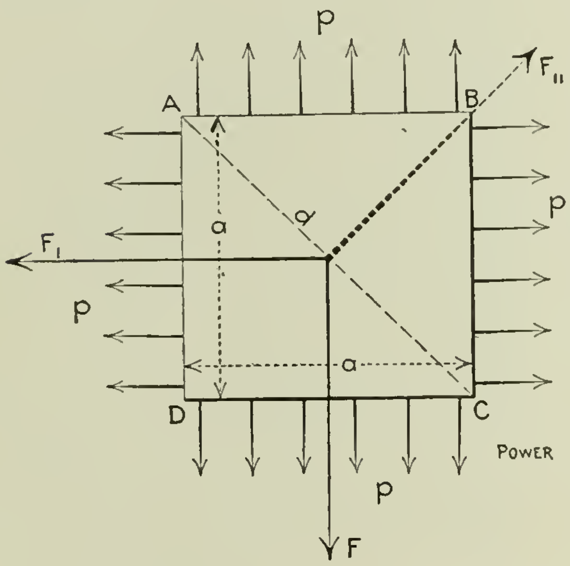


Diagram for Specific Solution

In the first place, the fact should be noted that when testing cylinderical shells by bursting them, the rupture invariably takes place lengthwise of the cylinder. The reason for the split being lengthwise and not either circumferentially or slantwise is because the least resistance is along this line, least resistance because there is the least material to withstand the stress. Thus, the stress per unit length on the line A of Fig. 1 is $\frac{PD}{2}$

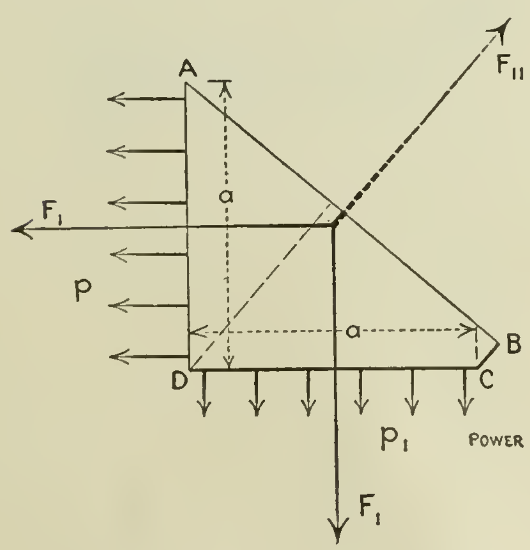


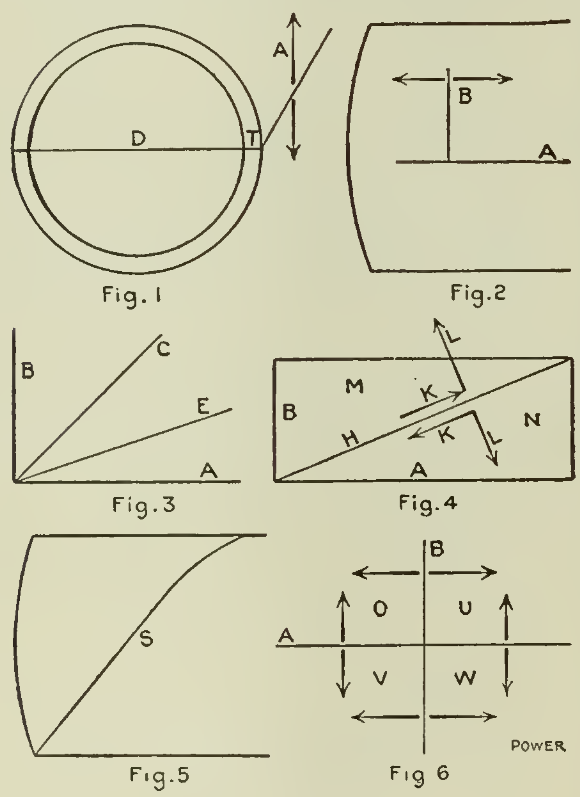
Diagram for General Solution

and the material to withstand this stress is T. At right angles to the stress on the line A of Fig 1. the stress tending to tear the plate along the line B of Fig. 2 is $\frac{P\pi D^2}{4}$, and the material to withstand it is $\pi D T$. As, based on the thickness alone, the stress in Fig. 2 is

$$\frac{P\pi D^2}{4} \div \pi D = \frac{PD}{4}$$

being half as much as in Fig. 1; on the other basis, there is twice as much material to withstand the stress in Fig. 2 as there is in Fig. 1; hence, the section in Fig. 2 is stronger and less liable to split. It follows then, that at any other locations, C and E, Fig. 3, between these two lines A and B of minimum and maximum strength, the strength will be less than at B and greater than at A.

It can be shown by an elaborate mathematical demonstration how that two stresses, one half the other, acting at right angles, will give a resultant diagonal H, Fig. 4; and, further, how some of this stress K is lengthwise of H and some L at right angles to it. The action of K is to shear the plate into two triangles M and N, while that of L is to tear them apart. This mathematical treatise will give any engineer good mental exercise. It will lead him, though, providing he does not get lost in the thicket of figures and symbols, to the same station



that the experimental facts have long since located. Rupture does not take place along the helical seam S, Fig. 5, nor does the plate separate into four rectangles O, U, V, W, Fig. 6.

F. Webster.

Scranton, Penn.

Blowoff Pipe Protection

I noticed in the issue of March 21 an account of the bursting of a cast-iron elbow in the blowoff of a 135-horsepower boiler. No cause was given for the failure of the elbow.

I was once called to take charge of a steam plant in which the blowoff pipe of the boiler was screwed into the front head of the boiler alongside of the handhole and a hole was drilled in the boiler front, through which the pipe passed just far enough to screw on a valve, short nipple and an elbow. The blowoff then passed through the wall of the boiler house and connected with a blowoff tank in the yard. The boiler-house wall was used for the side wall of the boiler setting. Where the blowoff went through the wall it was bricked in solid. I consider this very unsafe as I contend that all blowoff pipes should be left free so as not to be affected by expansion or by any settling that may take place.

Edward Hamilton.

Ridgefield Park, N. J.

Slipping Latch Blocks

In Power for February 28 and March 28 are letters on the subject of "Slipping Latch Blocks," giving useful instructions as to what to do to prevent or overcome trouble from this source.

The design of the valve gear has a great deal to do with the amount of this trouble and in selecting an engine care should be taken to select a design of gear that will give the least trouble.

We had an engine that gave us a great deal of trouble in this respect, the latch blocks having to be turned once in two or three weeks. After running for several years the gear became so badly worn that it was replaced with a gear of different design. Since that time we have had to change the blocks only about once a year. The difference is not in the blocks, for we tried several different steels with the old gear and made the blocks as hard as it was possible to make them, but even the hardest would slip in a short time.

W. O. Perkins.

Bristol, Conn.

Central Station versus Isolated Plant

The editorials in the issue of March 28 entitled, "Will an Isolated Plant Pay" and "The Marginal Principle," strike the nail squarely on the head and put the matter in the plainest possible way. I wish they could be read by every power user. The fanciful and exaggerated charges saddled upon the steam plant when the central-station man is swelling his list to show the awful waste only go to show his desperation in working for business that he sees slipping from him. Could this be any better illustrated than in Mr. Parker's paper on "The Cost of Industrial Power," reported in Power for March 21? Conceive, if you can, a plant of 150 kilowatts capacity with a $12,000 manager, devoting one-twelfth of his entire time to the power equipment! And, this not being enough, the cost is still further padded to the extent of $150 per year for one hour daily clerical work. This generosity is not shown in the purchased-power table, where the wear and tear on the manager and clerks, due to the heating plant, is fixed at $25 per year, surely low enough in comparison.

Again, in this paper the "emergency service" is given at $936 per year. This is based on four days' shutdown per month. Does anyone know of a power plant, working under ordinary conditions, that is shut down on an average of four working days per month? If so, will the engineer please stand up and, if it is not a worn-out, obsolete plant, tell us how long he expects to hold his job? A charge for emergency service is, of course, proper if, as is usually the case, the power user wishes to retain the central-station connections for such use, but there is a lack of fairness in placing it at an extravagant cost, merely to make the right kind of a showing. If this cost were correct, emergency current would be a highly profitable part of the central station's business, inasmuch as it is at a rate nearly three times the amount per kilowatt-hour of the regularly furnished current in the other table, which figures out 2.47 cents. It would be equitable to credit back the coal that is not used during the 48 days per year that the plant is supposed to be out of business, but no such credit appears.

It appears that in the isolated plant 300 horsepower is installed for a demand load of 140 kilowatts, fully 25 per cent. more than necessary, but this makes the estimate item of supplies and repairs higher, and all goes to swell the total cost.

It is to be regretted that comparisons of this kind, figured out by central-station representatives, can only be made with a view of obtaining patronage, for it would certainly seem that they are not made with a desire to arrive at true and correct results. There is plenty of business for the central stations in public lighting, railways, etc., as well as in many isolated plants where exhaust steam has little or no value, especially in small units where the labor item is a very large percentage of the whole. But, no amount of argument can prove that purchased power is cheaper than that furnished by the isolated plant in the majority of cases where use can be made of all or a considerable portion of the exhaust steam, which is a most valuable byproduct. This means with every legitimate item of cost figured in, but not the "amortization" of the manager and his clerks, unless we also estimate, on the other hand, how much his monthly quarrel with the central station over the current bills shortens his life. Nor will we include a charge for the amount of money the cost of the power plant *might* have earned if he played the stock market and struck it right, which is just as consistent as the item of "profit rates."

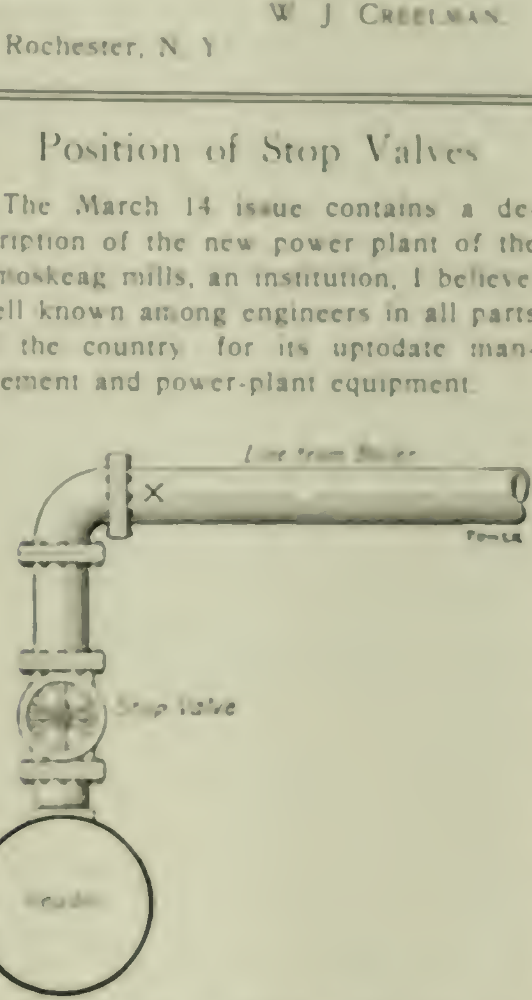
In the city of Buffalo, within 20 miles of the much touted Niagara Falls power, steam plants are in use by the hundreds and new ones going in constantly, where careful investigations have shown the lower cost for power in the isolated plant. And, in this connection, it may not be generally known that at least one power-equipment company is installing steam plants in whole or in part, and taking its pay in the saving made over the cost of purchased power. I know of several plants that have been purchased in this way, and all are making good. One of these is a $20,000 plant that paid for itself inside of two years. When an engineering company is willing to take business on these terms, we can hardly wonder that the central-station companies work up the kind of papers that are read before engineering societies, biased as these papers are in favor of purchased power.

W. J. Creelman.

Rochester, N. Y.

Position of Stop Valves

The March 14 issue contains a description of the new power plant of the Amoskeag mills, an institution, I believe, well known among engineers in all parts of the country for its uptodate management and power-plant equipment.



Present and Proposed Positions of Valve

I may have been asleep while some new things in steam piping were being promulgated but, never having been shown differently, I must still hold the opinion that the proper place for a stop valve would be in the horizontal pipe, as at X, instead of in the vertical connection. With the valve at point X the possibility of a slug of water lying above the valve and the necessity of a drain pipe above the valve are eliminated. But, as it is inconceivable that an institution of such reputation should make such an installation without every detail being "exactly right," there must be some very good reasons why the stop valves were placed in their present positions. I would like very much to be enlightened.

F. C. Holly.

Yazoo City, Miss.

The Benefit of Organization

I have read Mr. Goldstein's letter in the March 14 issue and would say that what he has said with reference to engineers' wages is a fact that we cannot get away from. The solution does not rest upon forming an organization with a resolve to stick together, but rather on the basis that an organization be formed with a view to raising the individual standard along educational lines in order to be able to present the matter to the owners of plants in such a way that they cannot refuse an increased wage when it is requested.

We have at the present time any number of engineers' organizations but each has its own ideas of doing things.

I venture to say that it would be far better and more beneficial to all concerned if they would all come together under one name and for one purpose, and that purpose to be the uplifting of the men who are running the very heart of the great industries of today. After all said and done, what would an office building, factory, mill, hospital or apartment house be without a competent man to operate intelligently the machinery that is necessary to run its elevators, supply its light, water, etc.?

The time is now ripe for the men in this most important branch of industry to look around them and wake up to the fact that something is slipping away from them, get busy and start a movement that will make it necessary for the central-station solicitors do some mighty hard work before they can earn their salaries.

H. H. B[illegible].

Brooklyn, N. Y.

Reduced Grate Area at Light Loads

I have just read the editorial, "Reduced Grate Area at Light Loads," which appeared in the issue of March 21, and feel moved to write of a recent experience of my own along these lines.

Two of my friends, owners of the local steam laundry, sought my advice as to the possibility of reducing the coal consumption in their plant.

On visiting the plant I found a 50-horsepower return-tubular boiler, very much underloaded, the engineer's chief difficulty being to prevent the safety valve from popping. This was accomplished by a damper in the stack and by the occasional opening of the firing door.

I had the grate surface reduced by bricking off [illegible] inches on each side of the firebox, and as a result the coal consumption was reduced from four and a half to three tons per week.

This is perhaps an extreme case, but it illustrates a possibility which is often overlooked.

[illegible]

McCook, Neb.

Interest and Sinking Fund

In the issue of March 21 in an editorial under the above caption a line of reasoning is followed from which I venture to dissent.

Referring to the discussion of the subject, "The Cost of Industrial Power," which took place at the recent joint meeting of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers, the editorial contains the statement that "one of the central-station solicitors maintained that it was not right to reduce the sinking-fund charges because inquiry upon his part had revealed the fact that nobody invested the money thus charged annually to the plant at compound interest," and the writer of the editorial then proceeded to show why, in his opinion, a sinking-fund charge based upon compound interest is justifiable.

The accumulation of a sinking fund with the assistance of the accretions due to compound interest appears attractive upon its face, but it is not in accordance with established methods of finance. The fiscal considerations which are involved in present-day commercial activities are confined—so far as the profit and loss account is concerned—to the limits of a single year or, in some cases, to a period of even shorter duration. If this were not so, or if the compound-interest theory were applied—as it logically could be—to all expenditures, a decidedly involved condition of affairs would result. For example, suppose that a man should view his personal expenditures from the compound-interest point of view and, instead of striking a yearly or monthly balance between his income and his expenses, he should look upon the expenditure required for a cigar or for a drink, not as the sum directly involved, but as the amount which the expenditure would amount to at compound interest at the end of a certain number of years. A few calculations of this nature would doubtless cure many of the smoking habit, and would tend to make the "water wagon" more attractive to many than it is at present.

There is another point of view from which, in the writer's opinion, the compound-interest theory is untenable. If we consider that the natural function of money—or capital—is to bring a yearly return to its owner, and that when it is not so doing a direct loss results to its possessor, equal in amount to the interest which could have been obtained (not necessarily the highest rate of return which could have been obtained, but a fair average rate), it is evident that the accretions to a sinking fund in the form of interest are as much of a burden upon the person who is accumulating the fund as contributions of equal amount paid directly into the fund. In the one case a direct payment of, say, a comparatively small amount is made yearly to the fund and the interest for the preceding year upon the accumulated portion of the fund is added. This interest, therefore, cannot be withdrawn (inasmuch as "one cannot eat his cake and have it too") and, in this sense, it is lost to the owner of the fund, thereby making the final result no different than if the owner had withdrawn his yearly interest (a normal condition, the reverse of which only signifies a loss) and then paid an equal amount directly into the fund. On the other hand, under straight-line depreciation, with equal and larger amounts paid yearly into the sinking fund, the owner may withdraw his yearly interest and the equal yearly amounts paid into the fund become his only burden. In either case, the final result is the same: at the termination of the estimated life of the equipment the owner will have paid (in one case partly in the form of lost interest) an amount equal to the original value of the equipment.

E. F. Tweedy.

New York City.

Feed Water Treatment

In regard to Mr. Utz's letter in the January 31 issue and Charles H. Taylor's well grounded letter in Power for December 6, 1910, relative to feeding solvents to steam boilers, the opinions contained therein certainly make an interesting contrast. Each of them, from the standpoint of a practical critic, if it be possile to assume such a rôle, deviates considerably from the straight and narrow path which practical experimenting has blazoned through the dense forest of obstacles confronting users of "solvents," or "boiler solvents." In a great many cases the latter term is not a misnomer, for certainly the most significant point in Mr. Utz's argument is that he has been using a "boiler solvent" instead of a treatment to neutralize the troublesome elements carried in his boiler-feed water. Most certainly if the solvent he is using scores the pump lining and rods and destroys the packing, it will continue its havoc through the entire feed-water system and, consequently, in the boiler where pitting and corrosion must naturally result; and this, if continued, is not only a financial loss, but tends to intensify the dangers naturally prevalent in steam-generating sets.

It has been my experience that in order to use a treatment for boiler-feed water, it is necessary first to ascertain the mineral contents of the water used. Not having the apparatus for this purpose, we have always sent a representative sample of the water to a well known Chicago firm which makes this matter a specialty. It then selects from one of its numerous formulas (if necessary, it will specially prepare one) a compound that will neutralize the salts, etc., carried in the water. I have used one of its formulas for a number of years, introducing the compound into the boilers by placing a solution of it in a tank placed above the discharge section of the hotwell and allowing it to drop continuously into a ½-inch pipe leading down and looking into the feed-pump suction. In this way the compound is thoroughly mixed with the water and passes through the pump. We have never experienced the least ill effect from the use of this compound, which has always been fed through the feed pumps.

A. Lee.

Honolulu, T. H.

Dashpot Troubles

Referring to Mr. Green's article under the above caption in the March 21 issue, I have found that the greatest trouble, as Mr. Green has mentioned, is given by Corliss valves of the multiported type equipped with the combination vacuum cushion dashpots. After they become slightly worn the trouble begins and is manifested mostly by the engine racing when suddenly it loses the load. The indicator diagrams show a constant reaching of the governor or a hunting for the point of equilibrium and the average engineer looks for a slipping governor belt and a poorly working gagpot as the cause, without suspecting the real trouble. Most of these double-ported valves have very little or no lap and require careful adjustment else they will admit steam at the back edge when they are supposed to be closed.

There are many kinds of dashpots, and each has advantages and disadvantages peculiar to its type and the engines upon which it is used. The vacuum-cushion dashpot used on some types of engine consists of a central vacuum chamber surrounding the piston or plunger, in which are the valves of the cushion chamber. The cylinder of the vacuum chamber is in the center of the cushion piston and is, therefore, hard to keep lubricated. The outlet-air valve of the vacuum chamber is on the upper end of the cylinder above the cushion piston.

The following is a case from my experience. For some reason the dashpot would bounce and continue to bounce as the engine increased in speed. After placing my foot on the dashpot and forcing it shut with my weight, I removed the cover and put engine oil on the air valve of the vacuum chamber. There was a sharp hiss as the air passed through this valve, and the dashpot operated normally for about two hours. Then the treatment had to be repeated. At the end of the day's run I removed the gummed oil and dirt from the small holes in this valve seat and found that the seat and valve disk were worn enough to admit air to the vacuum chamber which was so dry that it also drew air in from the cushion chamber past the piston, thus forming a cushion in the vacuum chamber. As a result of the 1/16-inch holes being almost entirely stopped up, there was not enough opening through which this larger volume of air could escape. Adding this cushion to that of the cushion chamber it required but little to make the piston bounce. Placing some quartz under the disk on the seat and putting a bit-brace screwdriver into a breast drill, I ground the valve in and smoothed the roughness off with pumice stone until the valve was air tight. I then cleaned out the four 1/16-inch holes, and smearing the vacuum plunger with oil, reassembled the dashpot, and it gave no further trouble except when the vacuum plunger ceased to get the oil at the bottom to keep it air tight.

Mr. Green spoke of connecting the vacuum chamber to the condenser. This would insure a more perfect vacuum and positive cutoff, but on heavy loads when the dashpots lifted to the full hight it would be apt to cause much pounding on the cushion valves which, if made of leather, would soon give out. Then, too, the greater the vacuum the harder it would be to open the steam valves, thus bringing more load on the eccentric which would be apt to heat.

R. A. Cultra.

Cambridge, Mass.

Proper Use of Tools

In a recent issue I came across an article by H. A. Greene showing how to use a pipe wrench without crushing the pipe. He could have added lots more to his article.

It is certainly interesting to hear a steamfitter tell how an engineer should be "fired" for using a monkey wrench as a hammer, while he on one side and his helper on the other of a piece of 2½-inch pipe are yanking and jerking a new cutter (of the one-wheel kind) backward and forward over about one-half the circumference of the pipe, tightening the cutter at each jerk and then forcing it over the remainder of the circumference of the pipe that is not yet cut. After several pipe lengths have been cut in this manner, the engineer finds his new pipe cutter strained or twisted out of shape and really unfit for further use.

While on the subject of tools, a point that I would like to mention is that of wrench handles. Why are they not longer? Considering the way in which the majority of men use a wrench, it seems to me that it is high time for manufacturers to change the lengths of pipe-wrench handles. For instance, the present 18-inch wrench might have its handle lengthened to 36 inches, and the handles of other sizes of wrench might be changed in a like manner. This certainly would save an enormous amount of time for it would be unnecessary to stop to look for a piece of pipe of the right size and length to go over the wrench handle.

Just a few days ago I saw a new 48-inch pipe wrench ruined by a chief engineer (who is usually very particular). He got three heavy men to swing on a piece of pipe 6 feet long on the end of the wrench. Pipe wrenches 48 inches in size cost money.

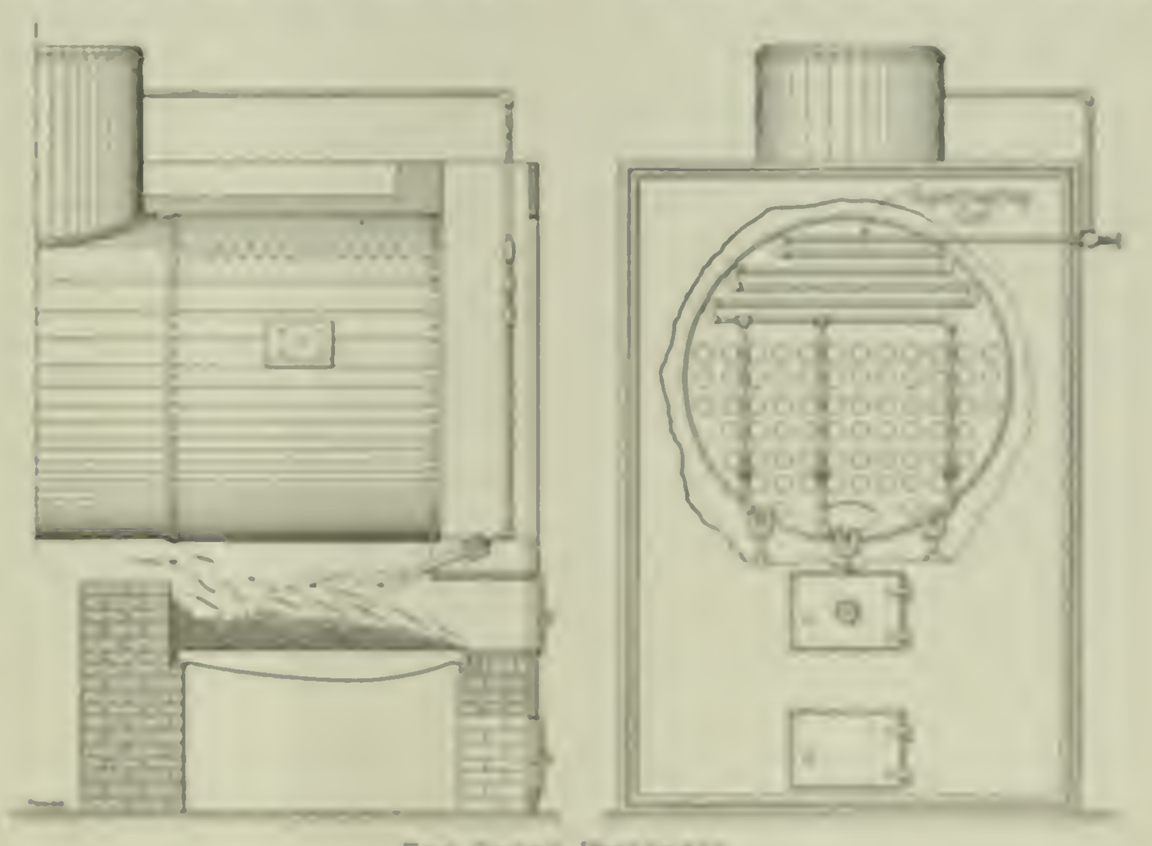
Roman S. Wilhelm.

Indianapolis, Ind.

Furnace for Bituminous Coal

Referring to Mr. De Motte's letter in the March 21 issue, I would advise him to install a smoke preventer similar to the one described in the January 10 number. I have one in use and can say that it accomplishes results very satisfactorily.

Of course, to give good results the device must be properly adjusted. In the installation which I made, the pipe from the boiler to the superheating coils is ½ inch in size. The outlets from the coil to the nozzles are of ½-inch pipe. The castings for the nozzles are 4 inches in size each way and open on two sides, as shown in the figure. One side of each casting was drilled and tapped for a piece of a 1¼-inch pipe which was cut



The Smoke Preventer

long enough to extend over the fire about 2½ inches. Opposite this pipe a ½-inch pipe drawn down so as to have a 1/16-inch opening was screwed into the casting. The tip of the latter pipe comes within ½ of an inch of the 1¼-inch pipe.

The boiler under which I use this device is 60 inches in diameter and 18 feet long. With a 72-inch or larger boiler it might be well to use four nozzles instead of three. I find that when the steam inlet valve is opened only about one third of a turn, enough steam is admitted to secure good results. A little experimenting will enable Mr. De Motte to decide what the necessary quantity of steam is and to regulate the inlet accordingly.

Fred Smith.

Port Clinton, O.

Effect of Discharge Pipe Size on Motor Load

Referring to Mr. Lee's letter in the March 14 issue, probably the reason why the 3-inch bushing was put in the discharge pipe was to produce a greater velocity in the discharge pipe. A pump having the suction and the discharge pipe equal in size will work successfully only in low-pressure systems.

Mr. Lee should have given both the suction and the discharge head so that a more accurate analysis of his problem could be made.

J. E. Stephens.

Yuma, Ariz.

Change of Cutoff

H. Jones has a letter under the above heading in the March 21 number. I think that he is mistaken in the directions which he gives for changing the cutoff on a Brown engine.

The point of cutoff may be changed by changing the boiler pressure, the back pressure, or the load on the engine. The cutoff is controlled by the governor which regulates the volume of steam according to requirements. If the cutoff is uneven between the ends it may be evened by adjusting the clipper pin or the nurl screw at the head end.

The question looks to me as though it might have been asked at an engineers' examination to determine whether the applicant fully realized that the governor controls the amount of steam admitted.

Laurie A. ...

West Fitchburg, Mass.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Clogged Gage Pipe

Two recording-pressure gages are connected to the same water main, but they do not record the same pressure. I have been told that the pipe of one is clogged which prevents it from giving the true pressure. How can I find out if this is a fact?

P. C. G.

One of the gages is incorrect and perhaps both are. They should be tested by comparison with a gage known to be correct. No amount of clogging in the gage pipe unless it stopped it entirely would affect the reading unless there is flow through the stricture. The gages must, of course, be at the same hight so that the effect of the columns of water in the pipes leading to them will be equal.

Weakest Part of Boiler

Where is the weakest part of a vertical fire-tube boiler, and why?

W. P. B.

The weakest part of any tubular boiler is the longitudinal seam. It is not possible to make a joint as strong as the sheet and the stress tending to pull the metal apart along its length is only one-half that which is exerted to separate it circumferentially.

Cooling Hot Bearings

I have an engine bearing that frequently goes hot at short notice and without any apparent cause, and I have to stop until the bearing is cool. Is there any preparation that will cool a hot bearing while running?

H. C. B.

Before the days of graphite a mixture of lard oil and flour of sulphur was the standard remedy for hot boxes. Graphite and good lubricating oil in proportions of ten parts of oil to one of graphite will usually reduce the friction of a troublesome bearing until it will run cool.

Pitch of Steam Pipe

Should the steam pipe incline toward the engine or toward the boiler, and why?

P. S. P.

It is better to have the pipe incline toward the engine. Then any water which condenses in it goes along with the steam and is passed off a little at a time. If the inclination is in the other direction, the flowing water is opposed by the current of steam and may accumulate into a large volume which will go over all at once.

Low Speed in a Motor

A shunt-wound variable-speed motor rated at 1350 revolutions per minute, maximum, will not run faster than 1000 revolutions per minute. What is the probable cause, and can the speed be increased by adding to the resistance in the starting box?

E. C.

The voltage may be low or the field section of the speed regulator may be partly short-circuited. The speed can be increased by increasing the resistance in the field section of the controller, not in the starting section, which is in the armature circuit.

Net Diameter of Bolts

How much greater is the diameter at the root of the United States standard thread than in the case of a V or sharp thread of the same pitch?

R. E.

In the standard thread the diameter of the bolt at the bottom of the thread is ¼ the hight of the thread greater than in the case of the V or sharp thread.

The diameter of a bolt at the bottom of the standard thread, in inches, is

$$\textit{Dia. of bolt} - \frac{1.299}{\textit{Number of threads per inch}}$$

For the sharp thread the diameter is

$$\textit{Dia. of bolt} - \frac{1.733}{\textit{Number of threads per inch}}$$

Indicator Springs for Given Boiler Pressure

What number of spring should be used in an indicator for 100 pounds boiler pressure?

E. A. S.

For ordinary conditions a spring which will make a diagram 1¾ inches high will be found satisfactory. With 100 pounds boiler pressure a 50 spring will give approximately the desired hight, as the pressure in the cylinder never equals that in the boiler.

High Temperatures in Gas Engine Cylinders

Will it injure a gas-engine cylinder to run it very hot, provided the maximum temperature is not high enough to decompose the lubricating oil?

F. E. W.

Probably not, but the advantages due to high temperatures are not worth the risk of experimenting in that direction. The temperature of the cooling water at the jacket outlet should not be more than 100 degrees (Fahrenheit) higher than the temperature of the entering water.

Rotor Current of an Induction Motor

a. What is the usual ratio between the stator and rotor currents of an induction motor?

b. What would be the probable rotor current of a 75-horsepower 240-volt three-phase motor?

L. J. G.

a. There is no definite relation between the stator and rotor currents. The rotor current depends only on the rotor slip, the field strength and the resistance of the rotor circuit.

b. About 180 amperes, regardless of primary voltage and phases.

Air Compressor Capacity

What is the free air capacity of a compressor?

R. E. M.

The cubic feet of free air it can handle per minute, hour or other unit of time. That is equal to the piston displacement in cubic feet multiplied by the number of piston strokes per minute or hour or other period. "Free" air is air at atmospheric pressure and temperature.

Three-phase Power Measurement

Can the power in a three-phase circuit be figured from the switchboard instruments without a wattmeter?

R. E. M.

Yes; if you have a power-factor indicator and the circuit is balanced. Multiply the voltage by the amperes per phase; multiply the product by the power factor and that product by 1.732; the final result will be the watts in the circuit. Example: Volts, 2300; amperes per phase, 50; power factor, 80 per cent. Watts $= 2300 \times 50 \times 0.8 \times 1.732 = 159{,}344$. If the circuit is not balanced, add the currents in the three legs and divide the sum by 3; take the result as the current per phase. This is approximately correct.

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Contents

Governmental Control of Water Power

The conservation movement as applied to water powers, and which is now receiving so much attention, may be summed up as follows:

The development of high-tension transmission has made possible the utilization of water powers which, owing to their remote location far from any market for power, have heretofore been unavailable. The promoters, knowing that more or less risk is involved in the development of most water powers, wish to obtain the privileges upon practically their own terms. On the other hand, the people, having more than once been the victims of monopolistic control, have called a halt until they can see their way clear to grant the use of these water powers upon equitable terms.

One fact is agreed upon by all parties concerned; this is that the present laws regarding the point at issue are inadequate, being for the most part cumbersome and involving a division of authority. This is especially true where the rights of several States are jointly involved. In view of this it would seem desirable to centralize the authority and simplify the laws, at the same time making them flexible enough to fit each particular case.

The main point of difference between public opinion and the views of those promoting water-power developments seems to center about two points: First, whether the Government shall be paid for the use of the water; second, whether it shall be limited or unlimited tenure. Regarding the first point, the promoters argue that the public will receive power at cheaper rates if the power company does not have to pay a tax upon the use of the water; furthermore, that due to uncertain conditions of flow, as well as uncertain markets for power, it is often impossible to reap a fair return upon the capital invested; therefore they should not be taxed upon this investment. The former contention will probably be found to have very little effect upon the selling price of power unless the rates are controlled by the people as through a public-service commission, and the latter is well founded. Obviously, it would not be fair for a power company to pay a tax based upon the maximum development of fifty thousand horsepower when six months out of the year they were deriving only twenty thousand horsepower from this source. However, one way out of this difficulty would be to base the tax upon the actual power developed.

As regards limited or unlimited tenure, the power interests claim that it is hard to finance a project involving a limited tenure, and that limited tenure also necessitates an additional amortization charge. It is hard to see why this contention should hold true if proper provisions are made for safeguarding the property at the expiration of the franchise. J. G. White, at the recent conference held under the auspices of the National Electric Light Association remarked that he had yet to learn of a single case in which the right of revocation had been exercised where the business had been carried on in good faith. From the viewpoint of the public, conditions are constantly changing; hence, why should we tie the hands of future generations by granting unlimited tenures?

The recent conference undoubtedly accomplished much toward a better understanding of both sides of the question, although perhaps still more would have been gained had the papers been less general and more specific in character.

Recording Instruments

"Knowledge is power."

In steam engineering and in other branches of industrial endeavor this truism may be revised to "Knowledge is more power," in which the term power is used in the literal sense. In the "good old days" this was not so well and widely known as it is now. Even in these improved times it is not as thoroughly understood as might be desired.

Only a few decades ago pig iron was manufactured by the crudest of hit-or-miss methods. The proportions of ore, limestone and coke or charcoal were determined entirely by personal judgment based on the experience of the operator. When an "off cast" or a batch of bad iron was made, which occurred with distressing frequency, the operator would blaspheme his luck and hope for better things.

The condition of the furnace was guessed at; the operator would hold his hand over its top and take a look through a peek hole or two, and by the degree of heat that he felt and light that he saw, would decide that "she" needed another charge, more "wind" or something else, as the case might be.

Competition grew keen. The more progressive iron makers began to study their business in a thorough and scientific manner. Chemists were employed to investigate the chemical phases of the problem of refining iron cheaply and with control over the quality. The influences of the temperature and the air supply in the furnace were determined with exactness.

With the acquisition of exact knowledge came the necessity of and, consequently, the demand for means of accurately measuring the variable factors in furnace operation, such as the blast pressure and temperature, the top-gas temperature and the quantity of the air supply.

It has been alleged that "Necessity is the mother of invention." It proved so to be in the present instance, for closely following the demand came the supply of suitable recording pyrometers, recording pressure gages and engine-speed recorders. By the aid of such equipment, the furnace man can tell at what temperature, in what quantities and under what pressure the air supply is going into the furnace. Further, he can compare today's conditions with those of yesterday or a year ago, for he has the records.

In the power plant education and competition are fast creating conditions similar to these in the iron-refining business. Success demands that accurate and complete knowledge be acquired of what is going on in the boiler and the engine room.

Although this is truest of the operations in the boiler room, progress there has been slowest.

How idiotic it would seem to attempt to operate a boiler today not equipped with a steam-pressure gage and a water column. Yet, there was a time when such was "all the fashion"—in the days of "haystack" boilers. A platform encircled the boiler at a convenient hight and when the fireman wanted to gratify a curiosity as to where the water level stood he would mount said platform and give the boiler sundry kicks amidships which, by the process of elimination, eventually established the point in question. When the steam pressure rose too much the safety valve rectified conditions—when it fell too far, the engine served notice and the fireman did the rest.

It is not improbable that the time will come when it will seem similarly foolish to operate a boiler plant without such things as feed-water meters, automatic fuel weighers, recording draft gages and thermometers, CO_2 records, etc.

In many quarters a demand already exists for accurate recording devices. When the manufacturer places on the market instruments that are reasonably low in first cost and upkeep, simple and substantial in construction and accurate and reliable in operation, he will lend a great aid to the right kind of progress in steam engineering. Great possibilities lie in this field.

Not A Rival

From the public utterances of a number of prominent members of the National Association of Stationary Engineers, it would seem that the Institute of Operating Engineers is regarded as a rival organization, the growth of which is to be discouraged. This is a misconception. The Institute is a school for the systematic education of engineers and machinery operators and is no more a rival of the National Association than any other educational movement. It proposes to do in a thorough and orderly way that which fraternal organizations can only handle in an incomplete and desultory manner.

The fireman and his helper, the oiler, and all other power-plant employees, however ambitious and able, are denied membership in the fraternal organizations of the aristocrats of the vocation, while the doors of the Institute are open to all, and the future standing of any member will depend entirely upon his mental and manual attainments. Instead of being a rival, the Institute will become a source of membership of the highest quality to the fraternal bodies.

Indexing Engineering Literature

The literature committee of the Institute of Operating Engineers is sending to the members of that society digests of articles in the leading engineering papers. The digests are classified by subjects, three of the articles upon boilers being abstracted as follows:

BOILERS

Boilers and Piping of Wieboldt Building. Osborn Monnett. Giving some very good ideas on piping layout as to size, showing clearly that a much smaller pipe can be used for the run by placing a good-sized receiver at throttle on engine.
1½ pp. 5 ills Power, Feb. 7, 1911

Modern Boiler Plant of Holyoke, Mass. Warren O. Rogers Illustrating how a great saving was made by building a central station to do the work formerly done by several plants. Method of coal conveying and handling, damper regulation, feed water measuring, results of boiler tests, etc.
6½ pp. 15 ills. Power, Feb. 14, 1911

Firing Boiler with Pulverized Coal. W S. Worth. Giving the performance of a 300 h. p. boiler fitted with the Blake system of pulverizing for period of 200 days, with full details of how a proper mixture of air is attained.
5 pp. 3 ills. Power, Feb. 14, 1911

The above is a reduction, the original size being such that it may be pasted upon a regular 3x5-inch index card and these cards filed either alphabetically or by subjects as the user may prefer. The persistent following of this system would result in a card index which would point to where the latest information upon power-plant subjects could be obtained, and if the articles are filed or the papers containing them saved and the index card is made to point to their location, a veritable encyclopedia of the business would in time result.

A Record Breaking Turbine Test

The reported performance of a Brown, Boveri turbine at Newcastle-upon-Tyne, particulars of which will be found upon page 599, beats the record so far as we know of published actual accomplishment in British thermal units per kilowatt-hour referred to the total work done by the turbine with an overall efficiency of ninety per cent. There are turbines which have made records under other conditions of pressure, superheat and vacuum which, could they be reduced to these better conditions, would better this performance, but for actual accomplishment this is the best so far reported.

The United States Supreme Court has sustained the commodity clause in the Hepburn rate bill, forbidding coal-carrying railroads from owning coal mines. Just notice how much difference this will make in the price of coal.

There are some engineers who are "old fashioned" enough to believe that the more simple a power plant is in design the more economical it is in operation. They have no use for frills and at that some of them are getting results.

Have you seen helpers who could not, or would not, learn the lesson of obedience? They consider it degrading to a free-born white man to take and obey orders.

An engineer cannot expect to accomplish much unless he has self-confidence.

Some managers employ cheap help and use cheap material, and are surprised that they get poor results.

Have you noticed that some engineers keep an open tin filled with cylinder oil in a warm spot so that dust from the coal, ashes and sweepings can readily settle into it?

When a power-plant owner is losing money and does not know it, it does not worry him.

It isn't so much what you do as the way you do it that counts toward success.

Do it now; tomorrow may be too late—too late even to be sorry.

Have you ever taken the trouble to personally examine the inside and outside of the boilers in the plant where you are chief?

Activity is contagious. Therefore, a lazy chief engineer cannot blame his assistants if they follow his example.

An honest man is respected by all; a grafter by none.

Government Control of Water Powers

The conference was held at the United Engineering Societies building in New York City on April 8. Walter L. Fisher, Secretary of the Interior, and a large number of prominent engineers and water-power men from various parts of the country were present. Chairman H. L. Doherty opened the meeting with the following remarks:

A summary of the papers presented at a public conference on "The proper attitude of the National and State Governments Toward the Development and Utilization of Water Powers," held under the auspices of the power transmission section of the National Electric Light Association.

The National Electric Light Association is an organization of corporations and individuals engaged in the electric-light and power business, which now exceeds 7000 members and represents over 80 per cent. of the money invested in the electric-light and power business in this country. It was organized to encourage the development of electric service from central-station plants along broad and comprehensive lines, which will bring benefit to the members of the organization and to the public.

According to the last census there is 37,000,000 horsepower available in the United States in water power which can be developed at a cost comparing favorably with that of steam. Of this amount about 1,600,000 horsepower has already been developed electrically and approximately 1,900,000 horsepower has been developed for industrial purposes through means other than electrical, leaving approximately 33,500,000 horsepower still available. To develop even the smaller amount of power named would require over $7,000,000,000.

It is interesting to note that the undeveloped water powers of this country exceed the total amount of power now generated by all known means. However, the bulk of these powers is located in mountainous regions, while the great bulk of all the power now generated is along the populous sea coast and plains districts and often far away from these water powers. The question of electric transmission of power is purely one of economy and reliability. Given enough money for the equipment, it would be possible to transmit power from San Francisco to New York with no greater loss of energy than now occurs on many ten-mile transmission lines. Power is already being successfully transmitted over distances of more than 200 miles.

At present over $200,000,000 worth of fuel is being consumed annually which might be saved by the development of our water powers. In the movement toward the conservation of our natural resources it must be evident to all that the resource which is greatest in danger of exhaustion, and which should be conserved, is the fuel supply. It is interesting to note that under the teachings of this so called "conservation" movement the National, and to a large extent the State governments, have assumed an attitude which has almost completely discouraged the development of water power and is causing every day an unnecessary and flagrant waste of the fuel supply. The development of our waterpowers represents an enormous source of available wealth to the community as a whole, but it does not promise the reward to the promoters and backers of these enterprises equivalent to that which is promised in almost every ordinary line of business.

The Government cannot give title to a water-power site that would warrant the erection of a $600 miner's hut. Undertakings requiring millions of dollars are expected to accept such a title to the property which is to be improved, and yet the title can be revoked at will, even on caprice of a governmental agent. The National Government has committed itself to a policy of limited tenure of grant, which is contrary to the opinion of all of the advanced thinkers in the school of economics, and a policy which is wrong in principle.

It has been suggested that this controversy may be partially due to an unrecognized difference in the fundamental premises which have been unconsciously assumed without careful analysis. By this is meant that one class, taught by the more recent and impractical school, assumes that the public lands are the absolute property of the Government, intended only to enrich the treasury of the Government without regard to other considerations; while the older and more practical school assumes that these lands are held in the nature of a trust and should be used for the settlement and development of the territory where they are situated, and thus contribute to the development of the entire country. The latter school is in accord with the precedents which actuated the Government through many decades, and although precedent alone should not govern in matters of this sort, there is a consideration which precedent in this case has reflected, and which is of prime national importance. The Government has from time to time dealt out vast areas of these public lands under the guidance and advice of the early statesmen of this country, selling or giving away these lands for a mere fraction of what their ultimate value would prove to be, believing that the benefit of quick settlement would bring about by earlier use vastly more in the development and prosperity of the country than to permit these lands and opportunities to lie unproductive for many years.

This policy had the support of all the great statesmen of all parties from the country's birth until in the last few years, but it may be that the men we reverence who formulated and executed these policies lacked the wisdom of our later-day magazine-made-hero statesmen, but in spite of this later-day wisdom why does not fair play demand that the public lands and opportunities of Oregon, Washington and Colorado be utilized to develop these sections rather than to have the public lands of these and other States treated as public property, owned in fee simple by the Federal Government and used to enrich those States that have already had distribution of their public lands according to the policies of the old school.

Conservation of Water Powers and Their Development for the Public Good

By Sidney Z. Mitchell

The real conservation of water power means its use. The only methods of producing this power are (a) through the consumption of coal, oil, gas, wood and other fuels which exist in limited quantities and cannot be replaced, and which are being consumed and exhausted at a rapid rate; and (b) through the use of water powers.

Under the first method, natural resources which cannot be replaced are consumed. It has been estimated that there are now being annually used in the United States more than four hundred and eighty million tons of coal, worth, on an average, $2 per ton, or a total of about $960,000,000 annually, to say nothing of the annual consumption, in addition, of millions of dollars' worth of oil, natural gas and wood. In many places entire forests are being denuded to obtain the fuel supply for local uses when the same purpose could be better served by the development of hydroelectric power from nearby streams.

By the second method, that is, by the use of water power, this frightful wassumption of coal, wood and other fuels can be minimized and in many cases wholly obviated, and in that way the natural resources, which are limited in quantity and which are now being so rapidly exhausted, will be conserved.

The distinction between water powers operated for private purposes and those operated for public purposes seems to me so logical and so important that it must be recognized in future legislation. Too much emphasis cannot be laid upon the radical difference between the pulp mill or factory type of water power used entirely in a private business and the water power used for the generation and distribution of light, heat and power. The latter is the servant of a widely scattered public, serving, without distinction, all the people, including manufacturers, domestic consumers, traction lines and municipalities. In the truest sense of the word it a public-service business, and as such there can be no doubt of the power of the Government to exercise over its service and charges the most minute and continuous supervision and control. The only restriction upon this power is that there must not be confiscation of the property in which capital has been invested.

There has been a great deal of discussion as to the relative legal rights of the Federal and State governments as bearing on water powers. These I will not attempt to discuss. So far as I have been able to ascertain, the majority of investors have no particular preference in the matter; but are vitally interested in having their public-service investments regulated by only one authority. And it seems to me that the possibility of having one government passing laws that the officers of a corporation shall conduct a business in a certain way and in no other, and another equally potent government passing laws requiring these same officers to conduct the public-service company's business in a different way, and in no other, needs only to be stated to show that such conflict of laws would be fatal.

Contrary to the general belief the charges which the Government, State or Federal, may make for the privilege of using the water powers is not a matter of material importance to the power companies, so long as such charges are not so great as to make it impracticable for the power company to compete with steam- or gas-producer plants, or with other water-power companies exempt from such special tax. It may seem desirable to the Government that an annual charge be made. To my mind this is merely one of the methods of providing State or Federal revenues at the expense of the particular community served. I believe that so long as the charges are not so high as to prevent the substitution of water power for fuel-consuming power, the matter is entirely one of equitable taxation, in which the only interested parties are the Government and the local community paying the tax. For, if made, such charge must be taken into account in the regulation of rates, and will proportionately raise the limit below which prices to the consumer cannot constitutionally be reduced.

It is important also to bear in mind some of the undesirable complications which may grow out of this method of taxation where the power developer is forced to construct and donate to the Government expensive locks at the rapids of so called navigable streams. This large initial investment is in effect a lump sum tax upon the particular community served. It must necessarily be paid at the outset by way of construction costs. Without being unduly burdensome, however, it cannot be shifted upon the consumer in a short period. To minimize the sinking fund or amortization charges necessitated by this unusual and to my mind unwise expense, it is necessary to spread it over a long series of years. And to the extent that the spreading out of the charge is made impossible by the short tenures imposed by Congress in authorizing the building of the dams, to the same extent will these amortizations bear harshly upon the consumers of power and often prevent the substitution of water power for fuel-consuming power apparatus. In many cases this lump-sum method of tax is undoubtedly too much for a new industry to bear, and thus defeats the desire that all these water powers should be built.

Many of the largest and best unused water powers today are upon the so called navigable streams. An investor is asked by the local people to join in providing capital to develop such powers. He is at once confronted by the necessity of securing an act of Congress authorizing the construction of a dam across the rapids of the so called navigable stream, rapids over which in many cases no boat has ever passed, nor probably ever will pass until locks are constructed. In demanding that the power developer shall construct and present to the Government an elaborate system of locks as part of the construction of the dam, the Government overlooks the fact, not only that such construction must ultimately be paid for by the community served by the power company, but also that the very building of the dam across such rapids will relieve the Government of the great expense of creating the necessary pond over the rapids. If it should thereafter desire to make the rapids navigable it need pay only the then much smaller cost of building locks sufficient merely to put the boats into the pond created at the expense of the power builders. As a rule, water powers of this character involve the handling of large quantities of water at low head. This of itself makes development expensive and in many cases more or less unreliable, unless supplemented for short periods by steam, owing to the fact that extreme high and low water affects such development more seriously than high-head developments. These great burdens to the investor are increased many fold in most cases by arbitrary legislation, restrictions and limitations. These restrictions and harsh requirements, from a navigation standpoint wholly unnecessary, are today holding back the development of hundreds of thousands of horsepower, the operation of which would save millions of dollars' worth of fuel which is being consumed each year.

In some of the Eastern, Southern and Middle Western districts where coal is cheap, it is frequently difficult for engineers to decide whether it is more economical to develop water power or use the ever-improving steam and gas-producer power apparatus. Waterwheel construction has so advanced that it is not possible to materially increase the water efficiency. On the other hand, the efficiency of steam and gas-producer apparatus has been wonderfully improved in the past two decades, and will undoubtedly be further improved from year to year.

Where there is this close competition between the relative economies of water-power and fuel-consuming apparatus, and where the adoption of steam, oil or gas means a large unnecessary consumption of nonreplaceable fuels, is it not a pity that every possible power at the command of the Government, Federal, State and local, is not exerted to the utmost to secure the adoption of the water-power system and thus save the fuels? Very frequently the omission of all Governmental restraints (other than the power of regulation and those necessary to protect navigation) or a small difference of cost amounting to not more than the value of one or two years' fuel consumption by the equivalent steam or gas-producer plant, will turn the balance in favor of the water power.

The investor of today knows that his property on Government lands is inadequately protected. He demands permanent, tangible and specific rights; the mere shifting and changing permits now in effect scare off all but the most speculative class. At present the rights of the hydroelectric companies in the Forest Reserves, for instance, are subordinated to operators under the mining laws. If I am correctly informed, it is possible for a mining company to start placer or other mining operations, at the very dam or canal intake of the hydroelectric company, and to so interfere with the company's structures as to render the operating plant inoperative and, therefore, useless.

Moreover, under the present law, there is a question whether the Federal officials have power to grant or sell to the hydroelectric companies any rights as against subsequent homesteaders, scrip locators or other entrymen, who may obtain title at any later time when the lands involved are thrown open to settlement. If there is no such authority, then any future scrip locaters, homesteaders or other entrymen on such lands have the right to take possession thereof as if the plant and property of the hydroelectric company had never existed. And in States which do not give hydroelectric companies the right of eminent domain, there would be no way to protect such investments against the arbitrary action or unreasonable demands of the subsequent scrip locaters, homesteaders or other entrymen, who would thus have the absolute power to eject the hydroelectric developer from the premises and thereby render inoperative his entire plant and investment.

Limited tenures may be well enough in the case of the development of a water power in connection with a private business which the Government has no right to regulate; but advanced thinkers on the subject, I believe, all agree that, next to revocable permits, limited tenures are the most fallacious and harmful of all the present-day popular notions, when applied to a water power, or any other development made for the public benefit.

A power developer may have three or four times as large an investment in his distributing system (entirely off the Government domain) as in the generating station on the Government domain. The whole distributing system would necessarily be made inoperative and useless by the failure to secure a renewal of the original limited tenure for the generating station, and is thus unduly jeopardized by the mere possibility that some Government official, actuated by political exigencies of the day, may fix the renewal terms on such an onerous basis as in effect to confiscate the power system as a whole. There is always the theory that these limited tenures will be renewed on some terms, but what these terms will be, what is the significance of the so called but very indefinite "preference right" of renewal, and, in fact, what is to become of the entire generating and distributing property at the end of the 50 years, no one seems to know.

We know that population and general business, particularly in the western sections, are growing by leaps and bounds. The requirements of the people both as to quantity and quality of service, including new uses of electricity, are daily increasing. Consequently, capital investment must be increased from day to day and from year to year if a corporation is to do its duty properly as a public servant and as the law requires. Who ever heard of a public-service corporation in the West, or even in the East, needing less plant and equipment and less facilities for serving the people from year to year as time goes on?

Why should any of our local communities be taxed with high rates from month to month in order to create a large amortization fund to pay for and present to the Federal Government at the end of 50 years or other limited tenure its local power developments? Why should the present generation be forced to pay exorbitant charges for service, to create this amortization fund, so that the property may in two or three generations revert to someone else?

If an amortization charge at the rate of so many cents per kilowatt-hour and so many dollars per horsepower-year for the entire plant capacity is necessary for the money invested during the first year of the 50-year tenure, then what must this rate be on every additional million dollars invested during, say, the twentieth year and during the thirtieth or fortieth year? And how it is possible for the consumer to pay a high enough rate in, say, the forty-fifth, forty-ninth and fiftieth years of the tenure, to return the investor at the end of the 50-year period all of his capital put in during these last few years and devoted to serving the people? Unless the investor receives positive and satisfactory assurance on this point, is he likely to come forward, particularly toward the end of the tenure, with the cash to provide the equipment and plant necessary for proper service of the people?

In the water-power business, without providing anything by way of an amortization fund, it usually takes, over a term of years, from $5 to $10 actual cash investment in plant and distributing system to get $1 per year gross revenue at such normal service rates as will provide a reasonable return on the investment and be commercially obtainable in competition with steam. Evidently, therefore, it is not only impracticable, but I can tell you from experience it is absolutely impossible, to charge only normal and reasonable rates for service, and devote all the earnings to providing for the growth, not unusual in the West, of 15 per cent. and upward per year, and at the same time have anything whatever left for interest and dividends. The cash required to provide facilities for such growth will, over a term of years, more than absorb the entire net earnings. How much more impossible, then, does the problem become if additional money put into the property toward the end of an expiring tenure must be gotten back through the creation of an amortization fund by raising the rates to the consumers?

All of us who have lived in the West, and who have had dealings with the farmers in the arid communities, have had forcibly brought to our notice still another fatal feature of the limited tenure theory. There are in the West many millions of acres of arid land which is the most fertile in the world when properly irrigated, but which is worthless without an adequate and reliable source of water supply. The lower levels of land are being supplied from Government or other irrigation canals, but fully as many acres of land on the higher levels can be commercially irrigated only through the use of hydroelectric power, the bulk of which is being furnished by public-service corporations in connection with their general light and power business. This arid land would be of no use without an unfailing water supply. But how is it possible for the power company to agree to furnish water in perpetuity for irrigating these lands, if there is the slightest chance of its source of supply being arbitrarily cut off under the present revocable-use agreement or limited tenure systems? Will there not inevitably be recurring periods of expiring tenures to cause complete stagnation of all productive effort dependent upon water power, disastrous alike to the community and to the power developer?

To my mind the only way this water-power question can be promptly and correctly solved, as a fuel conservation problem or otherwise, is by so educating the people on every phase of the subject that they will not only support and approve, but will insist upon the adequate and sane legislation now so much needed. The objects of this association are largely educational, and I know of no way in which it can better serve the people, including its members, than by taking a leading part in this educational campaign for true conservation.

Discussion

Several other papers and discussions of a more or less general nature were presented before the meeting. Space is not available in this issue even to give a summary of much of this material. Some of it, however, not included in the following, will be given attention in a later issue.

Walter L. Fisher, Secretary of the Interior: Fundamentally there is no conflict between the State and Nation in this matter, but no correct solution of the subject will be reached until all possibility of real conflict, justifiable conflict, has been removed. I believe that the State and Nation should be coördinated in a solution of this problem, and that they can be and will be when the correct solution is reached.

The expression has crept into the remarks of the chairman that there is existing a Governmental policy which seems to be subject to some criticism, or at least some dissatisfaction. I think that is a fundamental mistake. As I understand the existing situation, there is no Governmental policy, and that is the chief fault of the existing situation. What the Government has been doing, as I understand it, is merely to maintain the existing status until a policy can be developed.

To my mind, the most essential thing in this whole matter is that we do get together, that we do try to understand each other, and then that we act. The time has come when discussion is useful as a basis only for forward action, and I welcome this meeting as one of the first steps in that direction.

J. G. White: It seems to me, from the ordinary business point of view, that conservation properly means "saving what is otherwise going to waste," and that would necessarily mean utilizing the water powers instead of throwing hindrances which either prevent or divert such utilization. Every hour that any particular stream on which water power could be developed is allowed to go without such development, a certain amount of energy is being wasted, and being wasted beyond recovery. On the other hand, the coal which may be used from time to time to develop the energy, in place of the water power, might rest in the ground for a decade, or a century, or any time, with little or no deterioration. If the Government officials could all, as most of them do really, think of it as a fundamental proposition, from a practical and businesslike point of view, and then see how they could help to enlighten members of Congress on the subject, seeking to arouse their interest in a study of the subject, and others who perhaps for the sake of currying favor with the political elements, or whatever their object may be, could be gotten to take a businesslike point of view on this proposition, and then all work together to the end of arousing the interest of the Government officers in charge to look at it from a business point of view, I have no doubt that most of these problems could be settled along sane lines.

While the so called water-power privileges might be given in the shape of Government permits, with the right to revoke such permits, I do not believe, unless there should be a wholesale change in the tenor of affairs, that that authority would be used to the detriment of the people who had invested their money in good faith; but in spite of that, it is my thought that there should be a clear and businesslike appreciation of this general problem, and it would seem to me that some resolutions, either advocating the appointment of committees to give special consideration to the problem, and to make a report to Congress, or having a report from the Government engineers to Congress, for the consideration of Congress, looking toward legislation which would be along business lines, should be advocated by this body.

John H. Finney: A policy that makes for continued nonuse does not fit the true definition of conservation, which is wise use, and for much of this the power companies are themselves to blame, just as the railways have been to blame for radical legislation directed against themselves. The time for the "public be damned" attitude, for frenzied finance, for secrecy of operation, for extravagant profits, for unrestricted perpetual rights and franchises, is past. The time is here and now for the exact analysis of all these things; the sooner it is recognized by capital and exploiters, the sooner will we get that better understanding that will make wise use and fair dealing possible. I am no prophet, but it seems to me that it is clearly possible that fair dealing and wise use may in time rest not on the Government control of navigation, which is now wrongly considered by the Government as the paramount use of water, but on the broader public-welfare clause of the constitution, which will consider the larger and more important and valuable water power, made possible by a well considered and coördinated plan of river development, as the important thing concerning which the people require education—I do not know anything upon which Congress would require more expert knowledge than in dealing with these matters, and the function of this body should be wisely directed toward the education of Congress to the importance of water power now, and the supreme importance of water power in the future.

Charles F. Scott: The relations of the public to water powers, the rights of the public in water powers, it seems to me is something that changes from time to time. It has been pointed out that the rights in early days, when there was no use of water except along the banks of a stream, were such that the rights were granted entirely to those who occupied the borders of the stream; and later, when water began to be useful for irrigation at a distance of a mile or so from the banks of the stream, then the people occupying the adjacent country were found to have rights in the stream because they were found to have a use for the stream which never existed before. Likewise, when people fifty miles away have use for the power which the stream can develop, then rights, generally moral rights, and later legal rights, are created which did not before exist; and it is to meet new conditions of that kind, for which our laws are obviously inadequate—not that there has been a fault in the past, for it would be as impossible for the legal machinery of our Government to have anticipated these conditions twenty years ago, and provide for them, as it would have been for the electrical engineers of that day to have laid out the power plants of the present day—it is a matter of normal evolution, brought about through these new scientific and engineering developments.

If we were in a few words to state what is the real problem, the general problem now before us, it seems to me it would be this: To formulate a constructive policy by which water powers may be made available to the public at fair and equitable rates. I think when we consider for a moment the various phases of the questions that have come up, that all of them resolve themselves finally down to that simple proposition—how can this power be made available in the most efficient way to the public at fair and equitable rates? The great public cry, I believe, is against "interests" getting hold of water powers in such way that they may extract an undue profit. If, therefore, we can insure by Governmental control that that power shall be made available to the public at fair rates, we have accomplished the purpose which we want to accomplish.

D. B. Rushmore: My feeling toward the Government is that it is not an opposing force—it is fighting for us, it represents us, it is ourselves, and we want the Government to help us, the people, to carry out these enterprises. A sudden brake has been put on, partly because people do not understand, and they wanted to stop it until they got the thing right.

Very few individuals now question the right or desirability of public supervision and public regulation, but they want it in a fair-minded way, and engineers ask that it be done in an understandable way. Now, when a supervising body states that on a certain system the current and the voltage must be kept at a constant value, twenty-four hours in the day, it appears absolutely ridiculous, and we know at once that the men, with the best of intentions, making these rules, do not know what they are talking about. The result of conferences like this, and future conferences for interchange of opinion, will be that the people who will have the control and supervision of these enterprises, will be able to exercise this control and supervision in an understanding way.

Resolution Adopted

At the close of the meeting the following resolution was read and adopted by the society:

Resolved, That it is the sense of this meeting convened at the instance of the power-transmission section of the national body, that the National Electric Light Association should offer its coöperation with the legislative and executive branches of the National and State governments for the formulation of a definite constructive policy which will encourage the prompt and fullest development of our water powers in the public interest; and

Be It Further Resolved, That to this end it is recommended that the officers of the National Electric Light Association appoint a committee or committees, with power to act in the premises, and to invite the coöperation of such engineering, commercial and other bodies as they may deem expedient.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Indicator Spring Tester

This apparatus, which is made by the Schaeffer & Budenberg Manufacturing Company, Kent and De Kalb avenues, Brooklyn, N. Y., consists essentially of a closed vessel made of cast iron, capable of resisting internal steam pressures up to 200 pounds per square inch. The steam pressure in the vessel is measured by a gage of special construction consisting of a piston, of ½ square inch area, which is free to move in a cylinder.

The lower portion of the piston is pointed and rests in a yoke which is suspended on the knife-edge of a pair of scales mounted on top of the closed vessel. If the scales are previously balanced, before admitting steam into the vessel, it is evident that the reading of the scales will give the pressure acting on each element of the vessel equal in area to that of the piston. The scales are graduated to fiftieths of a pound, which permits very close readings. The device is shown in Fig. 1.

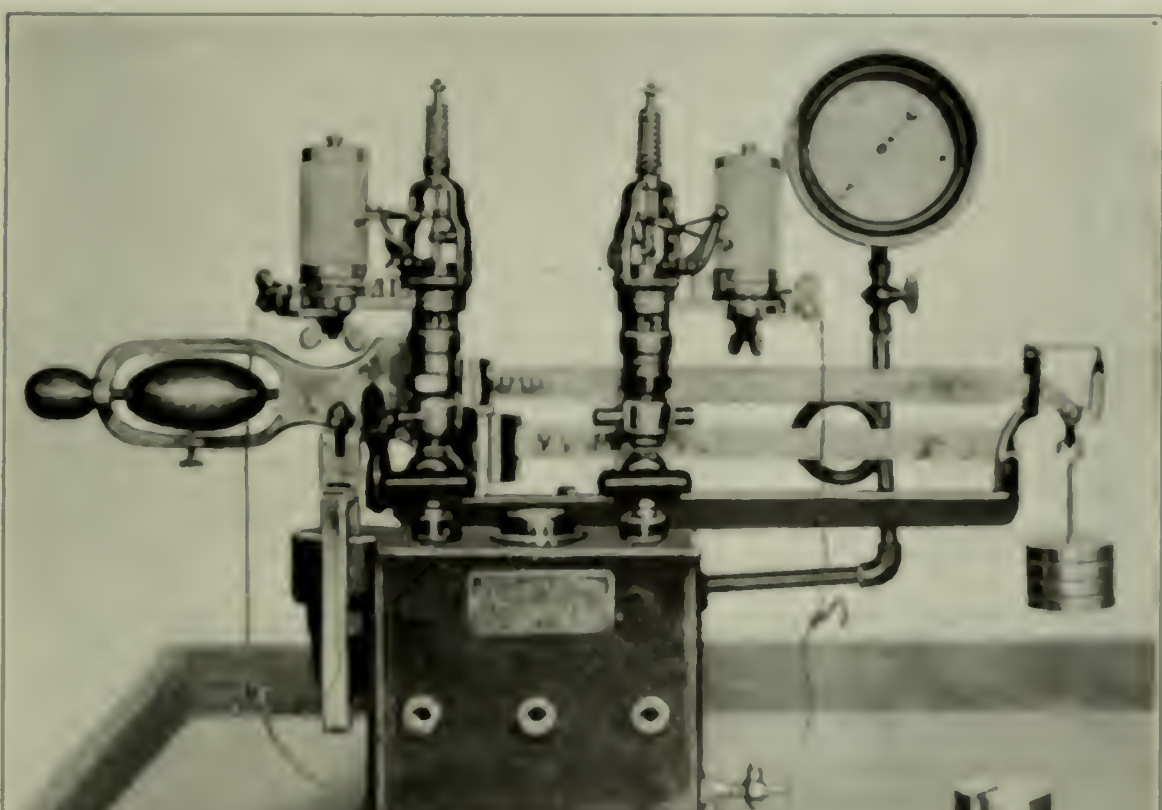


Fig. 1. Indicator Spring Tester

In testing indicator springs, steam is turned into the vessel to gradually warm it and is allowed to blow through the connections and indicator cocks to remove any particles of dust or grit which may have accumulated therein. Steam is then shut off and the indicator put in its place and paper put on the indicator drum, on which paper two vertical lines are ruled as shown at the lines *A B* and *C D* in Fig. 2.

The indicator pencil is pressed against the drum and a horizontal line *Q Q* drawn at the point thus marked. The poise of the scale is set at say 5 pounds, and steam is admitted to the vessel, gradually rising in pressure until the scale floats. When the pressure is exact, the line *R R* is drawn, and so on for successive pressures of 5 pounds until the limit of the scale is reached. During this operation the motion of the indicator pencil is continuously kept upward and if at any moment the pressure rises too high it is lowered by manipulating the valve below the required amount and then gradually raised to the desired point.

When the indicator pencil has reached its highest position the steam pressure is allowed to fall gradually and a series of similar lines, as *W W*, *X X*, *Y Y* and *Z Z*, are drawn during the descent of the piston, the motion being continuously downward. The distance between any two of these lines, as *Z R*, *Y S*, indicates the loss due to the friction of the indicator.

This testing apparatus also serves for testing pressure gages which can be connected to the three openings in the front side of the vessel provided for that purpose. The readings are verified by the indications on the scales and the test gage shown in Fig. 1.

Fig. 2. Lines Showing Loss Due to Friction

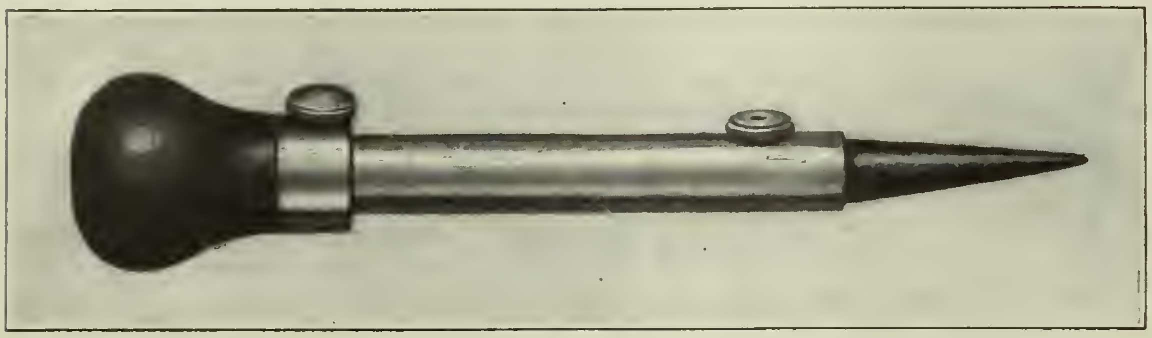
Belt Lace and Leather Cutting Tool

This tool is 7 inches long and has a body ½ inch in diameter. It consists of an adjustable knife blade for cutting belts and belt lacing. On one end of the body an adjustable gage can be attached for cutting lacing of various widths from rawhide skins.

The opposite end of the knife is made in the shape of a half-round reamer, pointed at the outer end. This serves the purpose of cutting about 40 different-sized holes in a belt and is extremely useful when lacing wide belts.

In starting a hole in a belt with the reamer, it is turned to the right and left with a gradual pressure exerted on the handle until the reamer has been pushed through the belt. Then a full turn is made until the desired size of hole is obtained.

The reamer or knife can be used by reversing the detachable handle, which is held in place by a thumb screw. This device is manufactured by the Kane & Christie Manufacturing Company, 118 Greene street, New York City.



Belt Lace and Leather-cutting Tool

"Model B" Rochester Lubricator

This force-feed lubricator is built substantially the same as the standard Rochester lubricator, the difference being in the arrangement of the driving gear. The stock size of the "Model B" lubricator holds three pints but other sizes having capacities of from ½ pint to 2 gallons can be furnished. It is designed for high-speed engines running from 200 up to 400 revolutions per minute.

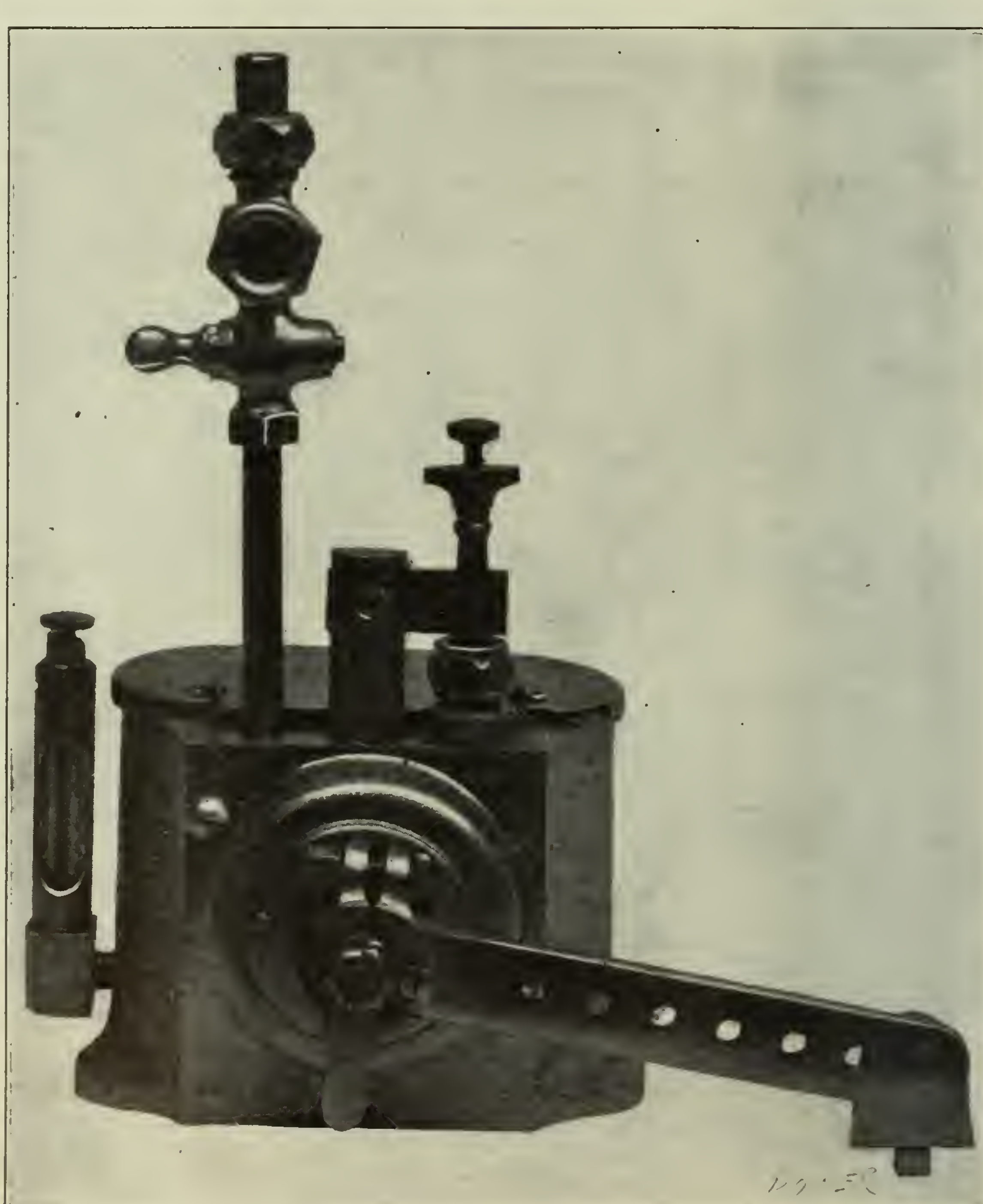
The oil reservoir is fitted with a gage glass to indicate the hight of the oil, which is drawn from the main reservoir and forced to the steam pipe leading to the engine by means of a small plunger pump that is actuated by an arm attached to a vertical shaft. This shaft receives its motion from a cam that is driven by means of two hardened-steel ratchet wheels, which are cammed together and cammed apart by the action of the actuating arm. These ratchet wheels operate a series of cog wheels which in turn operate the main shaft of the lubricator.

By means of these cog wheels the outside ratchet gear revolves 10 times to one revolution of the cam driving the pump plunger. This feature makes the lubricator capable of doing good work on high-speed engines. A special advantage is that the reduction of wear and tear in the lubricator is greatly reduced over what it would be with the standard arrangement, operating at high speed.

The driving mechanism is inclosed in a dust-proof steel cover. The motion to the ratchet gears is obtained from the lever which is connected to a reciprocating part of the engine.

There are three methods of adjusting the amount of oil fed to the engine. One is by changing the position of the adjusting arm, which is made by loosening the bolt in the actuating arm and moving the arm to the right or left as desired. This causes more or less lost motion between the cam on the lever and the ratchet gear; therefore the teeth of the ratchet wheels are engaged for a greater or less portion of the stroke.

Another adjustment is accomplished by a screw in the top of the plunger, shown in the accompanying illustration, and a third adjustment is made by changing the position of the rod connection on the actuating arm, for which purpose holes are provided.



View of "Model B" Rochester Lubricator

By changing the inner ratchet wheel and substituting one that is not filled with cog gears a "Type A" lubricator can be had, the difference between the two types being that the plunger of the latter makes one stroke for each revolution of the ratchet gear. In other respects the "Model A" is identically the same as that of the "Model B" lubricator.

These lubricators are manufactured by Greene, Tweed & Co., 109 Duane street, New York City.

The H. and B. Steam Drier

The H. and B. steam drier, manufactured by Edward C. Garratt & Co., 25 South Clinton street, Chicago, Ill., is designed to separate excessive moisture from steam before it leaves the boiler, and the water, thus separated, remains in the boiler and permits the steam to pass into the steam piping in a dry state.

The accompanying diagram, Fig. 1, is a partial sectional view of this steam drier, as installed in the dome of a boiler; it is placed directly under the main stop-valve connection, where the steam must pass through it when leaving the boiler.

Steam passes through the drier as follows: Entering at the top, it travels

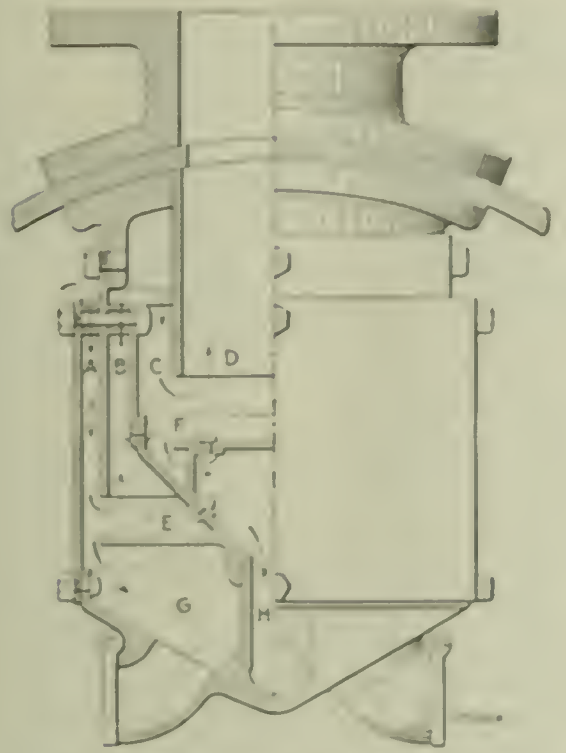


FIG. 1. SECTIONAL VIEW OF DRIER

downward through the passage *A*, as shown by the arrow, traveling at the same velocity as it rises, thus separating some of the excessive water that has been

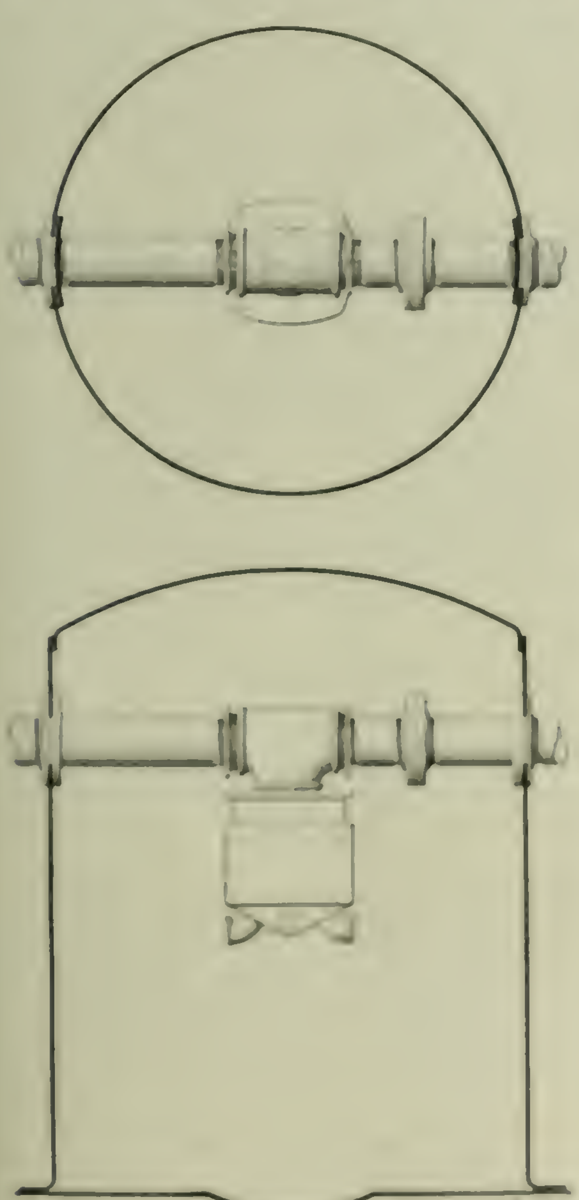


FIG. 2. DRIER CONNECTED TO STEAM PIPE

drawn in by the steam and throwing it under the baffle plate *E* causes it to return to the water level through the drains *G*. The steam passes through a similar process at *C* and *D* and baffle plate *F*, where any moisture that might have passed *E* is expelled through the smaller drain *H*.

The manner of installation varies according to the design or type of boiler.

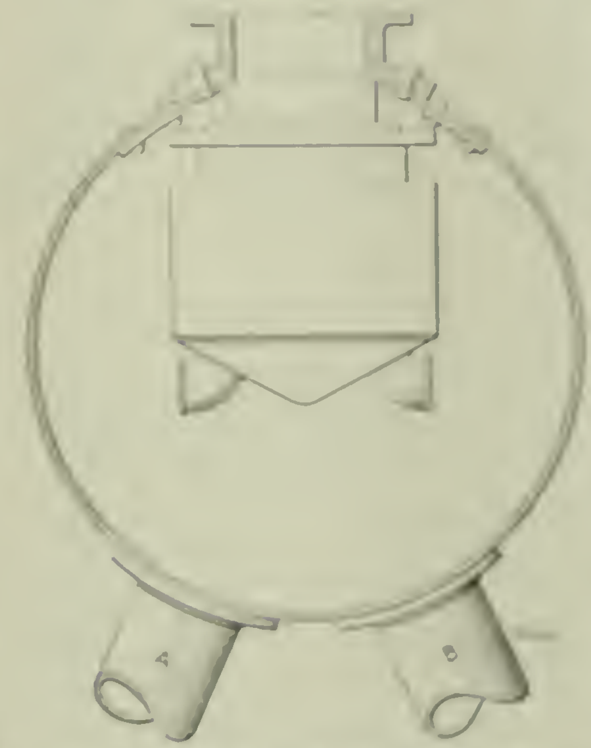


FIG. 3. DRIER PLACED IN A RECEIVER

In some cases the drier is connected direct to the piping, as shown in Fig. 2, and all of the steam used from the boiler, either to the main engine or auxiliaries, passes through the drier.

Fig. 3 shows a drier installed in a drum that acts as a common receiver for two boilers and takes care of the moisture in the steam passing through the two supply pipes *A* and *B* from the boiler.

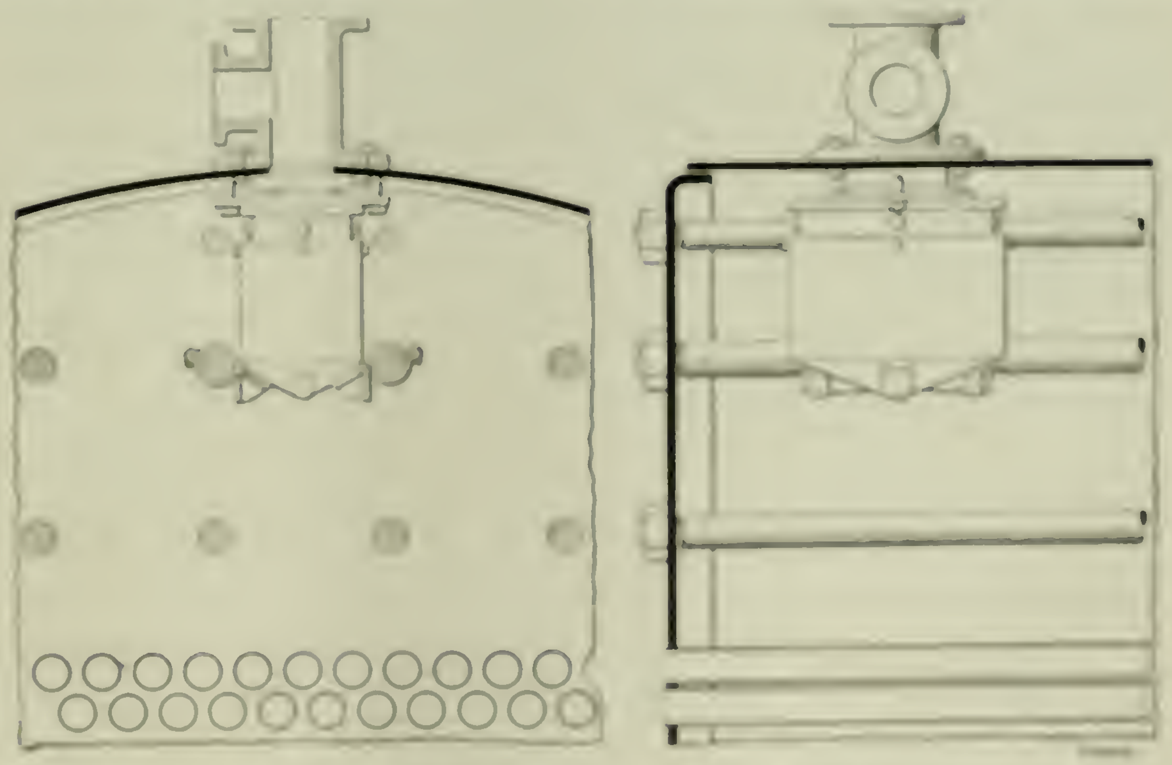


FIG. 4. DRIER INSTALLED IN SCOTCH BOILER

Fig. 4 shows the drier installed in a Scotch marine boiler. In case the longitudinal stays in the boiler are close together, the drier can be built oblong in shape to get the required areas; sufficient areas are always allowed, in the various steam passages of the drier, to prevent the steam from being wiredrawn.

Atlantic Mills at Providence Enlarge Plant

With the object of concentrating their power plant and eventually operating all their machinery by electricity, the Atlantic Mills of Providence, R. I., have just completed a large addition to their boiler house. Eight new boilers, 200 horsepower each, of the Manning type, built by the Dillon Steam Boiler Company, of Fitchburg, Mass., have been installed within the past year, four being used for the first time two weeks ago, and it is planned to add eight more, with an additional turbine. The scheme is to derive power from two turbines, one condensing and the other noncondensing, using the exhaust steam from the noncondensing unit for heating and manufacturing purposes.

The company believes that by centralizing the plant and using turbines they will save money and labor, occupy less space and also save exhaust steam.

At present the mills are being operated from three power houses, one containing a 1500-horsepower Corliss cross-compound engine with a 32-foot gear driving the jack shaft instead of belting. This engine is run by seven boilers of 200 horsepower each. In the second there are two belt-driven generators of 800 and 350 kilovolt-amperes capacity. In the station where all the units are to be assembled, there is a 1500-kilovolt-ampere Westinghouse Parsons noncondensing turbine.

A new 175-foot radial-brick chimney, built by the M. W. Kellogg Company, of New York, has been erected to serve the additional boilers.

Boiler Explosion at Mt. Washington, Kentucky

One person was instantly killed and four others were hurt, two probably fatally, when a boiler of a traction engine operating the sawmill of Brumley & Jones exploded on Thursday, April 6, at 10:15 a.m.

The accident occurred in the woods, on the farm of John Cornell, on Drake branch a mile below Whitfield in Bullitt county. The explosion was heard for miles around and caused much excitement. The injured members of the party summoned assistance from the nearest farm houses and physicians hastened to the scene. The young man who was killed was standing beside the engine, of which his brother, who was the engineer, had charge, when the boiler let go. His body was literally torn to pieces.

The engineer was scalded about the face and internally injured. It is feared that his eyesight will be permanently effected.

A laborer employed in carrying lumber from the mill was frightfully scalded and it is thought that his injuries will prove fatal.

The boiler let go without the slightest warning and caught the crew entirely unaware of the impending danger. Pieces of the wreck were picked up hundreds of yards from where the accident occurred. It is said that the engine was comparatively new and the cause of the explosion remains unexplained.

Joint Meeting of Machinery Dealers and Manufacturers

With an attendance of nearly 600 the annual triple convention of the Southern and National Supply and Machinery Dealers' Associations and the American Supply and Machinery Manufacturers' Association was held at the Seelbach hotel, Louisville, Ky., April 3, 4 and 5.

Opening addresses were made by Gov. Augustus E. Willson, William Heyburn and Pendleton C. Beckley upon behalf of Kentucky and Louisville, while Edward C. Hinman, W. M. Patterson and S. P. Browning responded for the associations.

Executive sessions occupied most of the daylight hours, during which were discussed important matters connected with the business end of the various manufacturing establishments represented.

Entertainment of the most hospitable kind was not lacking and all the visitors will be heartily in favor of Louisville as the scene of another annual convention in the not far distant future.

On Thursday the convention left in a body for a visit to Mammoth Cave, this trip constituting one of the most enjoyable social features of the meeting.

Officers were elected as follows: For the American Supply and Manufacturers' Association, Willard Parker, president, Spring City, Penn.; N. A. Gladding, first vice-president, Indianapolis, Ind.; D. K. Swartwout, second vice-president, Cleveland, O.; C. H. Jenkins, third vice-president, Louisville, Ky.

Officers for the Southern Supply and Machinery Dealers' Association: W. P. Simpson, president, New Orleans; S. M. Price, first vice-president, Norfolk, Va.; I. F. Young, second vice-president, Birmingham, Ala.; Alvin M. Smith, secretary and treasurer, Richmond, Va., reëlected.

For the National Supply and Machinery Dealers' Association: W. L. Rogers, first vice-president, New York City; J. O. Herron, second vice-president, San Francisco; Thomas A. Fernly, secretary and treasurer, Philadelphia, Penn.

Representatives of Norfolk, Va.; Asheville, N. C.; Dallas, Tex., and other cities presented invitations for the joint triple convention to meet with them next year. Complimentary references were made to all of these cities. The selection of a meeting place, however, will not come up until later. Asheville seems to have a shade the better of the argument, judging by the expression of the delegates.

PERSONAL

Frank T. Clarke, M. E., who has been located at Los Angeles, Cal., has opened an office as consulting engineer at Honolulu.

C. M. French has been transferred from the Deane Steam Pump Company, at Holyoke, Mass., to the Cleveland office of the International Steam Pump Company.

C. H. Pearson, formerly with the Noera Manufacturing Company, of Waterbury, Conn., has accepted a position in the hoist department of the Yale & Towne Manufacturing Company. Mr. Pearson's field of operation will be in the West.

On Monday evening, April 4, twenty-five of the officers and members of Colorado No. 1, National Association of Stationary Engineers, tendered James Merrick a surprise and farewell banquet in the Albany hotel in Denver. Mr. Merrick has filled practically every office in the association during the last five years with credit to himself and honor to the fraternity. He was this year filling the office of vice-president of No. 1, which he has resigned, as well as his position as chief engineer of the Denver Gas and Electric building, to accept a position on the sales force of the Dearborn Drug and Chemical Company, taking charge of the Salt Lake City office.

OBITUARY

James C. Bradford, who built the boiler for the "Monitor" during the Civil War, and who has been engaged in other lines of the business since that time, died at his home in West Medford, Mass., on April 10. He was 82 years old. Mr. Bradford was in charge of the Rhode Island Locomotive Company's plant for several years and was master mechanic of the Providence-Springfield Railroad Company during the period of its building.

He was a direct descendant of Governor Bradford, who came over in the "Mayflower" and headed the Plymouth colony. He was born in Taunton, where he received his education. He learned the machinists' trade in Boston in the Old Colony Railroad shops. He left this company to take charge of the building and development of the Fairhaven-Boston Railroad.

Just prior to the Civil War he started a boiler business in New Bedford, Mass., and continued in it for nearly 15 years. While there he built the boiler that was used in the "cheesebox on a raft"—the "Monitor"—and did much other Government work during the war. From New Bedford he went to Providence, R. I., to take charge of the Rhode Island Locomotive Company's plant, and remained there until he took a position as master mechanic of the Providence-Springfield railroad, which was absorbed by the New York, New Haven & Hartford Company.

SOCIETY NOTES

The eighteenth annual convention of the Oil Mill Superintendents Association will convene in Galveston, Tex., May 25, 26 and 27.

At Philadelphia on April 22 a meeting of the American Society of Mechanical Engineers will be held at the Engineers' Club. The subject for discussion will be "The Recent Work of the United States Fuel Testing Plant."

On April 21 the Boston sections of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers and the Boston Society of Civil Engineers will hold a joint meeting at which a paper will be presented by B. R. T. Collins, with the Stone & Webster Corporation, Boston, on "Oil Fuel for Steam Boilers." The paper deals with the possible use of oil fuel for steam-generating purposes in the Atlantic coast States, its safety and permanency of supply, as well as conditions under which it may have special advantages over coal.

BOOKS RECEIVED

PRINCIPLES OF MACHINE WORK. By Robert H. Smith. Industrial Education Book Company, Boston, Mass. Cloth; 388 pages, 4¾x8 inches; 434 illustrations; indexed. Price, $3.

ELEMENTS OF MACHINE WORK. By Robert H. Smith. Industrial Education Book Company, Boston, Mass. Cloth; 192 pages, 4¾x8 inches; 204 illustrations; tables; indexed. Price, $2.

POWER

NEW YORK, APRIL 25, 1911

THERE is probably more attention, intelligent and otherwise, being given to the boiler room of the modern power plant today than to any other one department.

In the production of power the cost of the fuel is in most cases the largest single item in the expense account, and any percentage of reduction in this means more than an equivalent saving made in any other way.

Power plants are operated for the profit there is in the business, and any plan or suggestion that seems to point toward a possibility of increase in profits will be given more or less consideration by the man or men most directly interested.

It, however, seems strange that men who use good business judgment in every other department of their business are so indifferent to the results obtained in the burning of fuel.

In chemical industries certain materials are changed from one form to another. Measured quantities of different substances are mixed or treated with known weights or measures of still other materials for the purpose of enhancing their value to mankind. The results are accurately observed and any departure from uniformity is made the subject of special investigation.

Untrained and careless men are not given responsible positions in such industries because it does not pay to employ men who are potentially wasteful. The product costs money and carelessness or ignorance on the part of one man may possibly waste the wages of many in inferior product or restricted production.

The burning of coal, wood, gas, oil or any other fuel in a boiler furnace is a chemical process on a commercial scale. It is industrial chemistry.

Air, carbon and hydrocarbons are mixed and the product goes up the chimney. But the fact that the product is wasted and that the provisions for wasting the product mean an investment does not lessen the importance of knowing the ratios of the elements in this waste to each other, nor the value of the ability to keep this ratio constant and at its best.

Too much air cools the furnace; too little wastes the fuel by poor combustion; too thick a fire restricts the draft and hinders combustion, and too thin a fire may have holes and will pass too much air anyway.

What is wanted is such a mixture of air and burning fuel that the highest possible percentage of carbonic acid gas will be held in the gases which go up the chimney.

Expert firemen are industrial chemists of no small degree of skill, and the plant manager who fails to recognize this and secure the best in preference to ordinary unskilled labor, whatever may be the difference in labor market rates, is standing in his own light.

What is wasted by an untrained, careless fireman will, if saved, in most plants more than pay the wages of the highest priced man about the establishment.

The Coal Problem Analyzed

By A. Bement

In which attention is given to the proper usage of significant coal terms, the analysis of coal, its size, the ash content, and features over which the producer has control. A number of illustrations of trouble frequently met with in the burning of coal are also given.

Under this title an attempt will be made to discuss certain features of coal and its utilization, and it is believed that the following may be of assistance toward a better understanding of a difficult and complicated problem.

Attention will be first directed to the matter of definition of words and terms, as there is no agreement in the use of them, neither is there a sufficient accepted vocabulary to enable one to give clear and definite expression to his meanings. This leads to various people using the same word or term in a variety of ways and for the purpose of indicating things of different character. Therefore, in the following, attention is directed to certain terms which have special significance.

Terms of Special Significance

Coal: There is no definite agreement as to what is implied by the use of this word, whether it refers to the coal itself or to the fuel mixture. According to the best defined meaning, coal is a solid fuel and it is something which enters combustion and produces heat. Therefore, none of its components can be ash or moisture, because neither of these take part in the combustion process nor do they develop heat. It therefore follows that coal is that part of the fuel minus ash and moisture, sometimes known as ash- and moisture-free coal, for which the term pure coal has been devised. Thus the first equation of Table 1 illustrates the

TABLE 1. ULTIMATE COMPOSITION OF COAL.

Pure coal = (Carbon, Hydrogen, Sulphur) + (Water of Combination, Nitrogen).
Dry Coal = Pure Coal + Ash.
Moist Coal = Dry Coal + Moisture.

composition of coal proper, in other words, pure coal, and the second and third portions show the dry and moist fuel mixtures. It is, of course, true that only carbon, hydrogen and sulphur take part in the combustion process developing heat, so it might appear that water of combination and nitrogen are not constituents of the coal. But there should be no conception of coal, strictly speaking, other than in its chemical aggregate, thus nitrogen and water of combination cannot be considered independent from the coal without implying a destruction of its chemical aggregate. The view that coal fuel is composed of an aggregate of coal, ash and moisture is a definite one, having undisputed application in practice, for it is known that the moisture is immediately evaporated from the mixture because this fact is observed in the laboratory. It is also a fact that the ash is found on the fire grate or in the ashpit after the coal has been burned. Therefore, it is desirable to consider that coal, according to a strict definition, is that portion of the fuel which is neither moisture nor ash. Thus, it is well, in making use of the word coal to avoid misapplication. In certain instances it must necessarily be used to a great extent as a general term, but when a specific statement is involved it is desirable to adopt a more exact definition. The matter is further illustrated by Table 2.

TABLE 2. PROXIMATE COMPOSITION OF COAL.

Pure Coal = Combustible Elements + Noncombustible Elements.
Dry Coal = Pure Coal + Mineral Matter.
Moist Coal = Dry Coal + Water.

Pure Coal: This is a convenient term which has been quite extensively used to denote that portion of the fuel mixture which is coal, as discussed above. It means the same thing as ash- and moisture-free, but is a more convenient expression.

Fuel Mixture: By this is meant the aggregation of coal, ash and moisture. The acceptance of such a definition is desirable because it tends to avoid confusion and misunderstanding. For illustration, assume that two different lots of fuel are derived from a single coal seam, from the same coal mine, if you will. One is carefully prepared, low in ash; it may be referred to as good coal. Another lot, high in ash and dirty, will be referred to as bad coal, when, as a matter of fact, the coal in each case is absolutely the same. The trouble is entirely apart from the coal and one which concerns the fuel mixture. Yet, the impression conveyed is that the coal itself is of poor quality, not realizing that the trouble is with the larger amount of ash which makes an unsatisfactory fuel mixture. The equations of Table 3 serve to illustrate this feature.

Clean Coal: Properly prepared lump coal, for example, consisting of fuel in which there is no visible ash, or, in other words, consisting of clean, black pieces, accompanied by no slate or other dirt, is very often referred to as pure coal, the inference being that there are no visible impurities with it. This, however, is not a good definition, because ash, although not visible, is one of the components of the lumps. Therefore, the coal is not pure. It contains ash combined in the structure, notwithstanding the fact that it may not be accompanied by pieces of rock or slate. Thus, the expression, clean coal, is a more definite and exact one.

Dirty Coal: An expression often used to denote a fuel mixture containing a large amount of fine fuel, as "slack" or "duff." But is not accurate because these very small pieces of coal are coal to just the same extent as the larger pieces. This term should only be used as applying to a fuel mixture containing foreign matter such as rock, slate, fire clay, etc.

Size: Is, with some fuel, a feature which requires more recognition than it receives, because the size of the pieces have an important influence on the value of fuel coal, as will later appear.

Kind of Coal: This expression is often used with no definite application. The following examples will serve to suggest appropriate application: Anthracite, semi-anthracite, bituminous, semi-bituminous, subbituminous, lignite, coking coal, gas coal, blacksmith's coal, gas-producer coal, pure coal, unit coal, dry coal and moist coal.

Grade of Coal: Thus, it appears from the foregoing that anthracite or bituminous, for example, are not grades, but kinds. The application of the term grade is shown by the following examples: Mine-run, lump, egg, range, nut, buck-

TABLE 3. COMPOSITION OF THE FUEL MIXTURE.

Coal (Pure) = (Fixed Carbon, Volatile Combustible, Sulphur) + (Water of Combin't'n., Nitrogen).
Dry Fuel Mixture = Coal + Ash.
Moist Fuel Mixture = Dry Fuel Mixture + Water.

wheat, raw screenings, slack, washed coal, washed screenings, washed slack and washed nut.

Interpretation of the Analysis

This is a feature of the coal problem in which there is confusion, not only of understanding but of expression. In the usual laboratory treatment, coal is considered as an unknown substance to be analyzed, and the results reported in the terms of the entire weight of the sample, in other words, in terms of the moist-fuel mixture. Thus, for example, a chemist may report the percentage of volatile matter as being less in one sample than in another, the inference being that the two samples, as far as the coal itself (the pure coal), is concerned, differ, when in fact the coal in each sample may be identical, the difference on the moist-coal basis being due to a greater or less percentage of ash or moisture in the fuel mixture. Thus for the quantitative analysis of the constituents of the pure coal, or, in other words, the real coal, to be comparable one with another, they should be stated on a pure-coal basis.

TABLE 4. CLASSIFICATION OF COMPONENT PARTS OF AN ASSUMED COAL FUEL MIXTURE

Combustible Elements in Coal		Noncombustible Constituents Chemically Combined with Coal		Noncombustible Constituents in a Physical Combination with Coal	
Carbon	61.0	Water of			
Hydrogen	3.[illegible]	composition	5.2	Moisture	12.0
Sulphur	3.0	Nitrogen	1.1	Ash	11.3
Totals	67.[illegible]		6.3		2[illegible].3

Combustibles	67.[illegible]
Chemical noncombustibles	6.3
Physical noncombustibles	2[illegible].3
Total	100.0

This reasoning applies to the ash constituent of the fuel mixture, because, if expressed on a moist-fuel basis, it will appear as a variable depending on the amount of moisture present. For this reason the amount of the dry, not the moist ash, is the significant quantity. Thus it is necessary to consider the object required. It is true, of course, that the proper measure of heating value of coal, as bought and sold in commerce, is expressed on a moist-coal basis, because it is the moist-coal fuel mixture that is bought and sold. No mine produces dry or pure coal. Ash and dirt, as well as moisture, always accompany it, but if it is desirable to know whether the ash content of one fuel mixture is greater or less than another, the values must be reduced to a dry-coal basis, and if desirable to make comparison between the coal of two or more fuel mixtures, heat value must be given in terms of the pure coal.

TABLE 5. RELATIVE COMPOSITION OF AN ASSUMED FUEL MIXTURE

Constituents	Chemical Symbol	Per Cent.	Character
Carbon	C	61.0	[illegible]
Hydrogen	H	3.4	[illegible]
Sulphur	S	3.0	[illegible]
Moisture	H_2O	12.0	[illegible]
Water of composition	H_2O	5.2	[illegible]
Nitrogen	N	1.1	[illegible]
Ash		11.3	[illegible]
Total		100.0	

In the application of the analytical data to the use of fuel in connection with its combustion, in fires under boilers, for example, it is an assistance to consider the matter from its actual relation to the process. In this connection, Tables 4, 5, 6 and 7, will be of service.

Table 4 presents the fuel mixture in three groups, illustrating the relation of the combustible and noncombustible elements. In Table 5 is shown a quantitative classification of constituents. Table 6 illustrates the combustion process and disposal of the products of combustion.

In applying analytical data to problems in practice, it is desirable to simplify the matter as much as possible. Thus in the foregoing, it appears that the entire hydrogen content is not treated as combustible, yet it is so given in the results of practically all ultimate analyses which have been reported up to the present time. But, according to our conception of the matter, oxygen must necessarily be chemically combined with some other element, and the assumption that this combination is with hydrogen, is the most reasonable one. Therefore, all of the oxygen of the coal is combined with hydrogen, as it must enter the combustion process as H_2O and leaves it in the same condition. For this reason, in calculating a heat balance, it is not only undesirable to consider this water as separate elements of hydrogen and oxygen, but doing so leads to confusion if the standard code for steam-boiler trials of

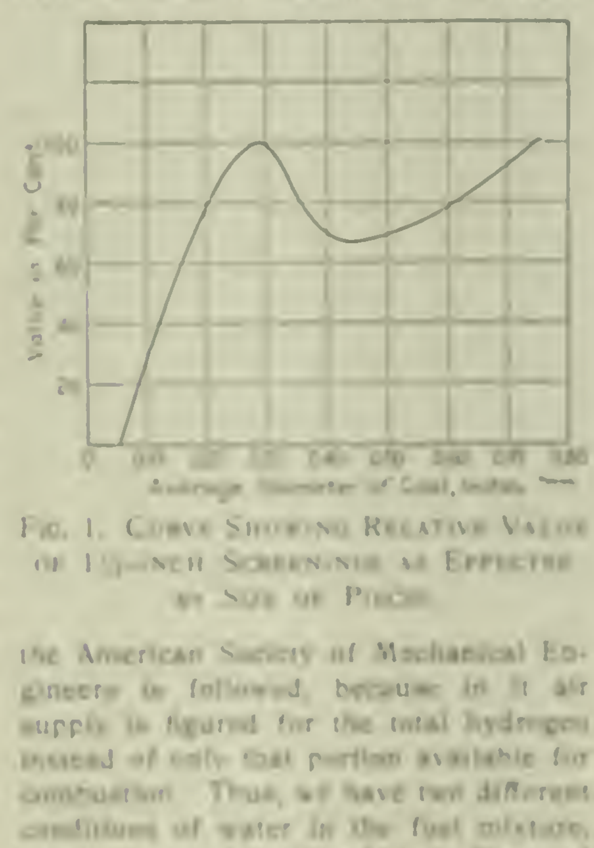


FIG. 1. CURVE SHOWING RELATIVE VALUE OF 1¼-INCH SCREENINGS AS AFFECTED BY SIZE OF PIECES

the American Society of Mechanical Engineers is followed, because in it air supply is figured for the total hydrogen instead of only that portion available for combustion. Thus, we have two different conditions of water in the fuel mixture, one in the coal itself, which is liberated by the combustion process, and the other in a free condition, which is dispelled as soon as the coal is heated and before combustion begins.

CONSIDERATION OF THE SIZE

To the present time fuel coal has been valued entirely upon the basis of its chemical analysis and price. It has, however, been observed that there are two other very significant features which may have even greater influence than that of chemical composition. One of these is size of the pieces, the other the ash content. For example, assuming that best coal fuel has a heat value of 15,000 B.t.u. and the poorest 9000, the ratios are as one is to 1.66. It has been found, however, that in practical conditions of operation, coal may be of so small size as to give a zero result in use, in other words, to have no value whatever, or again, of such large size, that the practical value of the fuel is largely reduced, yet the results of analyses might be the same in each instance.

This matter is illustrated by Fig. 1,

TABLE 6. COMBUSTION PROCESS

As Entering Combustion	Result of Combustion	Character and Disposal of Products
Carbon	CO_2	Gas to chimney
Hydrogen	H_2O	Steam to chimney
Sulphur	SO_2	Gas to chimney
Moisture (H_2O)	H_2O	Steam to chimney
Water of composition (H_2O)	H_2O	Steam to chimney
Nitrogen	N	Gas to chimney
Ash	Ash and clinker	Ash and clinker to the ashpit

showing the value of stoker fuel for steam boilers. It shows very plainly that the feature of size is one of great significance. An explanation for the formation of the curve is that, as the average diameter of the pieces increases, a point is reached at about 0.28 inch where the amount of dust and small pieces is just sufficient to properly fill the spaces between the larger pieces, after which time the decreasing percentage of small size causes enlargement of the vacant spaces in the fuel bed, with a result that the value decreases rapidly until at about size 0.43 where the average diameter of the pieces has become great enough to insure that in a measure they fit together in harmonious compact. As the average diameter still increases this condition develops, so that at size 0.75 it has again attained maximum value. In other words, the uniformity in size approaches that of nut coal, forming a desirable fuel bed, although if absolutely uniform, the fuel would have a much greater value than illustrated by the curve of the diagram, which is confined to 1¼-

TABLE 7. FORMS OF ULTIMATE ANALYSIS OF AN ASSUMED COMPOSITION

	As Usually Stated	As Proposed in Practice
Carbon	[illegible]	[illegible]
Hydrogen	[illegible]	
Available hydrogen		[illegible]
Oxygen	[illegible]	
Water of composition		[illegible]
Nitrogen	[illegible]	[illegible]
Sulphur	[illegible]	[illegible]
Total	100.00	100.00

inch screenings. The value assumed as 100 per cent. illustrates the best element from 1¼-inch screenings. Upon this basis it is apparent that factors may be devised by the use of which the value of fuel may be determined by calculation. For example, if the average diameter should be 0.10 inch, multiplying the heat value by 0.25 would give the actual value, or if the size is 0.30 inch, multiplying the heat value by 1 would leave it unchanged.

Variations in thickness of fire with lowchanical stokers is a matter which in itself has an important influence, and values such as those shown by the curve would be more or less modified by adjustment of the fire-bed thickness, or, should hand firing prevail, the result may be influenced through a wide range, by skilful hand manipulation. Thus, fine dust, which would not make a useful fire with a stoker, could be placed in a hand-operated fire, either by sprinkling it lightly over the surface or by allowing it to become coked and then broken up. The tests from which the curve is plotted were all made with one thickness of fire, and uniformity of conditions, except that of the fuel itself. Thus the foregoing shows that the feature of size is of greatest significance as affecting value, especially so, if auxiliary influences, such as hand manipulation, are not employed.

Consideration of the Ash

According to the conception that coal fuel is composed of an aggregate of coal proper (pure coal), ash and moisture, it is found that the coal may differ in quality, due to a greater or less amount of water of combination, sulphur or nitro-

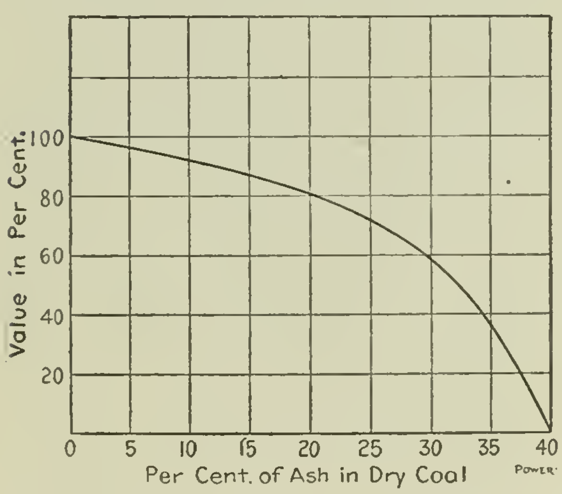


Fig. 2. Value of Coal as Effected by Ash Content

gen. These influence its heat value and in slight measure the loss of heat in the chimney gases, but do not affect or interfere with the combustion process. Neither does the presence of the moisture affect combustion except to cause a lower initial temperature and to increase loss in the escaping gases. Thus the water of combination and the moisture pass freely to the chimney and in no way obstruct action of the fire. With the ash, however, the case is quite different, as it remains as a solid residue, which does obstruct combustion to a very serious extent, as shown by Fig. 2, which, according to best present knowledge, illustrates the effect of ash content for any kind or grade of fuel. From this curve it is possible to devise a set of factors which will compensate for various ash content. Thus, if ash percentage is 20, multiplying the heat value by 0.79 determines the actual value.

A definite and clear conception of the ash with its relation to the fuel mixture is useful. To this end Table 8 gives ash content in three groups.

Referring to the first group, it is known that when a lump of clean black coal, having no visible evidence of ash associated with it, is burned, a residue al-

TABLE 8. ASH GROUPS IN COAL FUEL.

1. Ash in the coal itself.
2. Ash in the coal seam distinct from that in the clean coal.
3. Ash associated with the fuel which becomes mixed with it during mining, but not derived from the seam.

ways remains. This is the ash in the clean coal. In all coal seams distinct stratas of rock, slate, pyrites, etc., prevail to a greater or less extent, as well as impurities, in other than stratified form. These impurities of the seam are distinct from the impurities actually associated with the coal itself. In addition to the impurities of the second division, there are others which emanate from a source entirely outside of and distinct from the seam, such as from the roof and floor of the mine, in the form of fire clay, rock, etc., the matter being further illustrated by the equations of Table 9.

It will be observed in the foregoing that ash is considered as being only the residue remaining after combustion. It is a fact that certain ingredients of the ash mixture, such as fire clay, for example, contain volatile components, as water of combination. Thus, the true ash is the residual quantity, plus the volatile amount. This is true as far as it affects the displacement of pure coal in the fuel mixture. It, however, has no application in practice because it is the residue only which interferes with and affects the combustion process.

Upon the basis of values as displayed by Figs. 1 and 2, Table 10 has been prepared showing values in 1¼-inch coal screenings for maximum ranges of size and ash content. It is, however, not implied that 1¼-inch screenings may be as small as an average diameter of 0.06 inch, but the range has been carried thus far for purposes of illustration.

Relation of the Producer and Coal Users to the Problem

Within recent years it has become customary to purchase coal under specification, with an agreement as to quality, with bonus or penalty in case the fuel delivered is superior or inferior to the requirements. Many difficulties, however, have been encountered owing to the complications involved. Probably the matter may be illustrated by quoting what somebody is supposed to have said, "that it is not so bad to be ignorant, as it is to know so many things which are not true." This very aptly illustrates the position of the coal consumer. On the other hand there exists an equal lack of positive knowledge on the part of the coal producer and dealer. The relation of producer and consumer to the problem will be better understood when the manner is explained by which the producer may fail to furnish proper fuel. When the matter has been analyzed, it appears that the features over which the producer has control as affecting the quality of the fuel, are as follows:

Features over Which Coal Producer Has Control

1. Locality and seam from which the fuel is taken.
2. Size of the pieces of the fuel.
3. Amount of the ash content.

It may appear strange that the producers' power is so limited when many specifications give much prominence to volatile matter, sulphur, fixed carbon, heat value, etc. But when the matter is duly considered, the facts become apparent; for example, it is now well known that a particular coal seam or definite locality in a seam is of a constant and uniform quality, as far as the coal itself is concerned. Therefore, this being true, it follows that fixed carbon, volatile matter, sulphur or other components are constants and need only be determined once. It also follows that the composition would be the same from any mine.

TABLE 9. DETAIL GROUPING OF ASH CONTENT.

Group.	
No. 1.	= Ash in clean coal.
No. 2.	= Ash of group No. 1 + the distinct impurities derived from the seam.
No. 3.	= Ash of group No. 2 + dirt and rock.

Thus, if the coal is taken from the proper locality or seam, the requirements are automatically satisfied.

The size of the pieces in which the fuel is produced is a matter of great importance in certain coal districts. In others where only mine-run coal, owing to its friable nature, is produced, the consideration of size is entirely eliminated, as all of the fuel as hoisted out of the mine is loaded directly into railway cars. With the fuel, however, which is graded into various sizes, a more or less elaborate screening process is employed. Thus the producer has control over the sizes furnished.

The amount of ash content in the fuel is dependent largely upon the care exercised in mining, which consists in removing dirt and pieces of rock from the fuel mixture and in provision to prevent dirt becoming mixed with the coal. This is one of the important features of the preparation of fuel.

Other features which are often considered by coal consumers as something over which the producer has control, but which he really is unable to exercise any influence, are as follows:

Features over Which the Coal Producer Has No Control

(1) Moisture content, (2) heat value, (3) fixed carbon, (4) volatile matter, (5) sulphur, (6) evaporative perform-

ance secured in use of the fuel, (7) amount of smoke that may be produced, (8) suitability.

Referring to these features in detail, the moisture content, for example, is a constant of the coal seam and is the result of natural processes, extending over ages, during the time the coal was formed. The coal miner cannot afford to dry the coal by artificial means before shipment, neither would it be profitable as a general practice to add water to it, thus moisture is constant until changed by weather conditions, or time in transit. The heat value, fixed carbon, volatile matter and sulphur are likewise constants of the coal which cannot be changed. For illustration, it would be impracticable for a coal producer to make a change in the sulphur content. There is no method by which it may be reduced and it would not be profitable to add sulphur as an adulterant because it costs very much more than coal.

If a purchaser or consumer should demand coal from a prescribed locality, specifying heat value of the fuel mixture, and the heat value of the coal delivered did not meet the specifications, it would either be caused by excessive ash content, substitution from some other locality, or that the specification of heat value did not apply. It would not be because the producer did anything to alter the heat value and the same is true of any constituent of the pure coal.

The matter of the amount of water which may be evaporated when coal is burned under boilers is a matter around which more confusion, trouble and uncertainty has centered than probably anything else. This is because there are so many factors having influence that it is impossible usually to know whether the result was due to the fuel, the character of manipulation it received, or to the efficiency of the steam-generating apparatus in which it was employed.

Under the heading of what is designated as suitability a large variety of demands are made regarding the performance of fuel which have no reasonable application, as will be shown in the following six examples of cases which have actually occurred. These cases are quoted as illustrating troubles as they often appear when the causes are not well understood.

Coal of Too Large Size in Hand Firing

An important power producer had successfully operated a down-draft type of furnace for a number of years, but one day some new coal was received with which it seemed impossible to maintain the usual steam pressures. When the trouble was investigated, the engineer stated that the coal "appeared to be all right but that there was no heat in it." Screenings were the fuel which had been regularly employed, but owing to an emergency, it was necessary to accept anything obtainable, which happened to be some very high-quality lump coal; in fact a very much superior fuel to that which had before been satisfactorily employed.

The trouble was that a sufficiently deep fuel bed was not maintained. With the screenings, being of a small size, a comparatively thin bed was sufficient to exclude excessive air supply. But with the lump coal, the fireman followed previous practice as to thickness of fuel bed, with a result that so much air flowed between the pieces of the burning coal that the heat generated was almost entirely expended in heating this air and for this reason there was very little left to make steam in the boilers, or, in other words, nearly all of the heat went up the chimney. This fact, however, not being realized, it was thought the trouble was due to some mysterious characteristic of the coal.

Thin Fuel Bed

Complaint in a certain instance was made of a high quality of washed nut coal being used on a mechanical stoker. The report was that the coal would not burn. The coal company supplying the fuel sent its trouble man to investigate. He returned with the statement that the coal looked all right; it was clean, bright and accurate as to size, but that it would not burn. He had watched the performance himself. The only explanation offered was that, for some unknown reason, the particular lot of coal was of such peculiar chemical quality that it could not be ignited. The fact was that the fuel bed on the stoker grate was too thin, allowing such a great excess of air to flow through, that the temperature was not high enough to ignite the incoming coal.

Coal of Too Large Size with Stokers

A large coal company had a case of serious trouble with an important customer. The question was one of quality of screenings. Two mines were involved, which may be designated as *A* and *B*. Mine *A* was located upon what may be called the Central Railway, while *B* was upon this railway and also connected with what may be designated as the Western Railway, both of which roads terminated in the city where the coal was used. It appears that shipments had been from mine *A*, but owing to lack of orders for lump coal on the Central Railway, this screening order was transferred to mine *B*, because there were lump-coal orders which could be shipped over the rails of what is called the Western Line. When this transfer was made, the customer immediately complained, claiming that the coal from mine *B* was of an inferior character and not at all suited to the purpose, which was steam production in boilers served with a certain type of stoker. These two mines were located about ten miles apart and operated in the same coal seam. As far as chemical analysis and physical conditions are concerned, the seam at both places is exactly the same, and from this standpoint it would be difficult to find, in the quality of the coal itself, the reason for the trouble. But the screenings from mine *A* had been delivered in steel cars, bearing the imprint of the Central Railway, while the coal shipped from mine *B* came in wooden cars, bearing the imprint of the Western Railway. This in itself was an apparent evidence to the purchaser that the coal was different, which belief was confirmed when it was placed in the stoker and failed to produce as good a fire as had the former screenings. The facts, however, were that mine *A* was equipped with a perforated screen having 1¼-inch round openings, while mine *B* had a bar screen, set somewhat farther apart; the size of the openings, instead of being limited by the width, were the full length of the screen. The result was that the screenings produced by *B* were of a considerably larger size than those produced at mine *A*, because larger pieces passed through the bar screen. In fact, from the standpoint of the coal business, it was a superior fuel, because the size was larger; also from an analytical standpoint, because owing to the presence of a greater percentage of large pieces, the ash content was lower.

TABLE 10. SHOWING VALUES OF 1¼-INCH COAL SCREENINGS AS AFFECTED BY AVERAGE DIAMETER OF THE PIECES AND VARIATION IN ASH CONTENT

Per Cent. of Ash in Dry Coal.

Average Diameter of Coal in Inches	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	Values of 1¼-inch Coal Screenings													
0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.10	0.31	0.24	0.28	0.26	[illegible]	0.22	0.21	0.21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.15	0.50	0.49	0.48	0.47	[illegible]	0.45	0.44	0.44	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.20	0.75	0.73	0.72	0.71	0.69	0.67	0.67	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.25	0.91	0.89	0.88	0.87	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.30	0.98	0.94	0.92	0.91	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.35	0.80	0.79	0.77	0.76	0.74	0.72	0.70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.40	0.66	0.65	0.65	0.64	[illegible]	0.61	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.45	0.65	0.64	0.62	0.61	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.50	0.67	0.66	0.64	0.63	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.55	0.71	0.69	0.68	0.67	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.60	0.76	0.74	0.73	0.72	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.65	0.81	0.80	0.78	0.77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.70	0.89	0.87	0.86	0.85	[illegible]	[illegible]	[illegible]	0.75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.75	0.96	0.94	0.92	0.91	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

It was in fact this superiority that caused the trouble. The coal was too large to form a sufficiently compact fuel bed on the stoker, with the result that an excessive quantity of air flowed through it, producing unsatisfactory combustion. The customer did not understand this feature, however, and attributed the trouble to some inherent quality of the coal itself, and believed that it was a fuel of an entirely different nature, something on the order of an anthracite rather than bituminous coal.

At this stage of the matter the customer was satisfied by screenings shipped from another mine, which operated in an entirely different coal seam, although producing fuel through a 1¼-inch shaker screen with round perforations. Thus, it appears an actual change in the quality of the coal itself, although slight, when accompanied by suitability in size, gave satisfaction.

Exceptional Example of Benefit from High Ash Content

A large coal user, in an experimental way, invaded a new field for its fuel supply and a number of tests under boilers were made. The screenings from a certain mine gave an unusually high efficiency compared with those obtained from other points in the same general locality. This fuel, however, was extremely high in ash, but it was felt, at the time, that the coal was especially suited to requirements, although the high ash content was considered an objection and an investigation was made to ascertain if "similar" coal containing a reasonable ash content could be found. The investigation showed that, while the fuel in question contained a very large amount of ash, it was not of a seriously fusible character, therefore did not make trouble by clinkering, and that the amount of ash was sufficient to close the opening at the back end of the furnace between the bridgewall and end of the stoker grates, thereby excluding a very large excess of air which had found entrance when other coal of much lower ash content had been burned. An investigation at the mine showed that the roof was of such nature that a large amount of dirt became, at times, mixed with the screenings, but that as far as the coal itself was concerned, it was not different from adjacent mines, but which, however, had a much stronger roof and for this reason produced screenings which had much less dirt mixed with them. This is an illustration of an exceptional instance where high ash produced a desirable result.

Bad Stoker Action

A steam-boiler plant served by a particularly faulty mechanical stoker, was the cause of much trouble and indifferent service. On one particular occasion, however, performance was unusually satisfactory and the manager decided that it was due to his having some special coal which was superior to that usually burned. He thereupon called up the coal company and asked where the coal was produced. He was given the town and the mine from which it was shipped. He therefore decided that it would be desirable to obtain coal in the future from this mine. The dealer, however, was unable to regularly supply it, but shipped from an adjoining mine only a few miles distant, operating in the same seam and whose source of coal was exactly the same as the other mine. The performance of the plant when it was burned, however, was not satisfactory. This led the manager to call up the coal dealer and complain of the fuel. He was told that it was from the same locality and that it should in every way give the same result as that from the mine which he considered satisfactory. But in an effort to please the customer, special pains were taken to obtain additional coal from the desired mine and a report as to its performance asked for. The statement of the operator of the plant was that it was no better than the previous shipments. He was then told that it was fuel from the mine which he wanted and which he had stated had given satisfaction before. Notwithstanding the explanation, the manager could not realize that the fuel was from the same place as that which he had considered to be suited to his requirements and felt that if the coal dealer would deliver him "the right kind of coal" he would have no trouble.

Example of Confusing Report from Employees

Coal dealer No. 1 supplied a certain size of washed coal by wagon to a customer. When the time of expiration of the contract approached, coal dealer No. 2, who was an important patron of the customer, solicited the business for the coming year for his company, with the result that the contract was awarded to him. Dealer No. 2 purchased coal, which was of the same size, from the same producer who had furnished it to dealer No. 1. He sent his teams to the same team track, loaded it out of cars of the same railway, or, in other words, furnished exactly the same product that dealer No. 1 had supplied and it would be reasonable to expect that the results and service would be identical, but the report received from the boiler room was that the fuel supplied by the new dealer was decidedly inferior in quality to that which had been received from the previous dealer, that a much larger quantity was required to do the same work and that the cost of furnace repairs had been increased owing to its use. The purchaser, of course, who could understand none of these things himself but who must depend upon the statement of others, laid the case before dealer No. 2 and explained to him that while he was very anxious to reciprocate in a business way, he expected to receive equally good fuel as that which had been delivered under the previous contract. Of course, fuel furnished by the two dealers was of precisely the same grade, quality and prepared by the same washer, but how could the customer be expected to believe it in the face of statements of his own employees?

It is not the intention in the foregoing to intimate that the coal dealer or producer always furnishes satisfactory fuel, or that he delivers what he should, but it is the purpose to show to what extent and in what way it may be possible for him to fail to meet the consumer's demands.

B.t.u. in Coal

By J. M. Leunam

Manufacturers have for many years known that the value of coal depends upon the heat units in a pound, or, as we say, British thermal units per pound, which is usually abbreviated to B.t.u. They have been much handicapped in not having a ready method of determining such units, being unwilling to employ chemists for this purpose, or to go to the expense of a coal calorimeter and its operation.

A coal agent suggested to me a happy rule for determining this. It is such a valuable rule that all readers of Power should be informed of it. It involves no intricate analytics, trigonometry or calculus, but simply the multiplication and division of numbers. The rule is as follows:

Divide the pounds of coal in a car by the railroad number of the car, and multiply the quotient by the price per ton. The final result is the heat units or B.t.u. per pound.

In this connection, it may be interesting to know that a green salesman for coal approached an engineer of a large company recently, with a view of securing his year's business. The engineer asked him how much sulphur the coal contained. The salesman was ready with his answer and said, "As low as 1 per cent." The engineer next asked him how much ash was in the coal. Again he was ready with his reply and stated that it had 5 or 6 per cent. The engineer next asked him how much fixed carbon was in the coal. That was a new term to the salesman, but he was going to carry his bluff and said, "From 15 to 20 per cent." The engineer next asked him how many B.t.u. were in the coal. The salesman was again ready with his reply and said, "Do you know we have tried time after time to find those pesky B.t.u. but we have never succeeded in locating one in our coal."

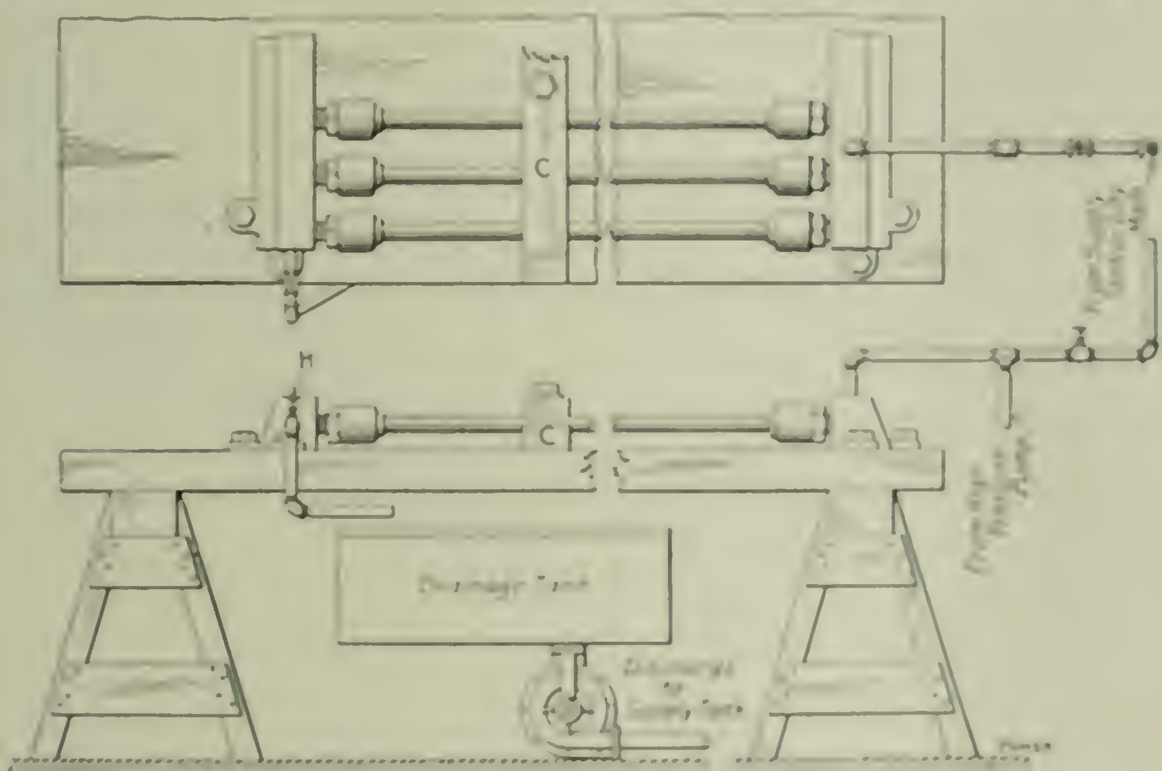
Reëxpanding Condenser Tubes

By Frank S. Bunker

Description of an apparatus designed to reëxpand old surface-condenser tubes and fit them for further use. Rigs for sawing the tubes and for hydrostatic testing.

In condenser tubes the most common defect is to have the ends crushed in by the packing. This not only causes a reduction in area of the tube, but also necessitates a large size of packing, which, as a rule, tends still further to crush the tube.

A rig which is used on the Pacific coast to roll the interior of the tube back to its original size is shown in Fig. 4. The rig was made by placing two small speed lathes tail to tail, with the headstocks in line. One lathe was bolted securely to the floor, and the other secured in slides which allowed the lathe to be moved to admit of longer or shorter tubes being handled.



Figs. 1 and 2. Top and Side Views of Apparatus for Testing Condenser Tubes

Block *A*, Fig. 4, is mounted on the shears of the lathe and securely held there on a proper fitting, in a central position. This block is of tool steel, hardened, and is hinged so that it will open and admit the tubes. The block is provided with a half-round groove in both top and bottom halves and, when the block is closed and locked, these grooves form a perfectly round hole the exact outside diameter of the tube when new.

A boilermaker's tube roller is used, only it is in miniature and made to roll the tubes to the proper inside diameter. With two boys, one at each lathe, the operation is simple.

Cutting Off

If the tubes are to be used in any but the original condenser from which they were removed, the length of tube required may be less, and the tubes must be shortened.

The rig shown in Fig. 5 is an excellent one for cutting them to the proper length. It is made with a column *A*, which is bolted to the table of a milling machine. The top of this column is cut out to receive the ends of the steel leaf spring on the end of which is a hinged clamp which is held open by a small steel-wire spring.

Fig. 3. Connection to Manifold

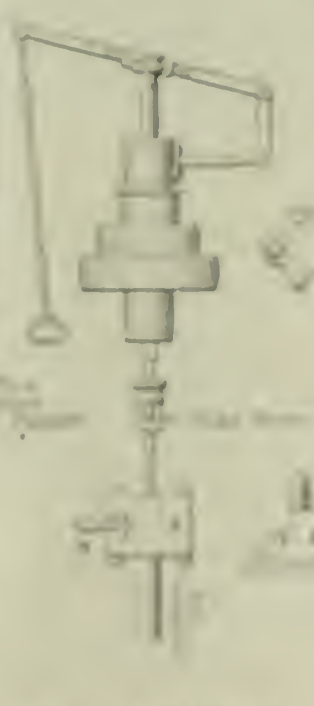


Fig. 4. Expanding Tube in Lathe

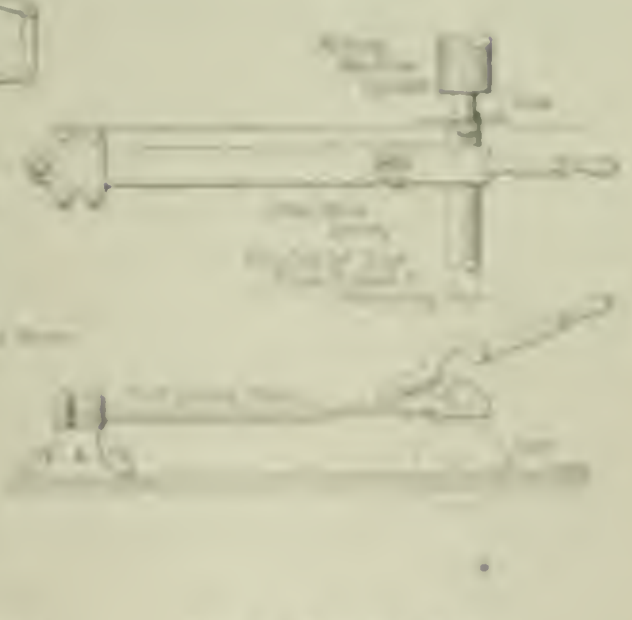


Fig. 5. Rig for Sawing Off Tubes

The tubes are backed against some conveniently arranged stop, and the end to be cut is rolled into the bottom half of the clamp. With a downward motion of the handle, the top of the clamp comes into contact with the tube, securely holding it and bringing it into contact with the saw. The burrs are removed with a cutter bar and small cutter mounted in an air drill which is held in a vise, the tubes being pushed against the cutter.

Testing

To make sure that the tubes are perfect the testing rig shown in Figs. 1, 2 and 3 is used. In the economical testing of small parts, such as tubes, etc., speed is the main object and it was with this in view that the rig was designed. It consists of two hollow manifolds of bronze, suitably designed to stand 1000 pounds per square inch hydrostatic pressure. One of the manifolds is mounted at the end of any suitable base, such as a long piece of boiler plate. The other manifold is mounted so as to be adjustable along the length of the base and thus permit the testing of various lengths. It must, however, be bolted securely to the base.

Fig. 3 shows the fitting which holds the tubes and forms a water-tight joint. This is made possible by the hydraulic cup leathers. The front end, or mouth of the fitting, is made bell shape to facilitate the adjusting of the tubes. One fitting is made like the sketch and the one which is to take the opposite end of the same tube is bored through on the dotted lines x y, x y.

To place a tube in the rig, simply shove it in through the bell mouth as far as it will go (see dotted lines showing extension of tube, Fig. 3). The other end of the tube should now be just clear of the bell-mouthed fitting in the manifold. Pull back and shove the tube into this fitting until it strikes the shoulder $x\,x$, and when tubes are in all of the fittings proceed with the test.

Owing to the tendency of the tubes to buckle, it is necessary to put on a restraining clamp, as shown at *C*, Figs. 1 and 2. This consists of a piece of timber grooved to let the tubes rest in it, and with another timber swiveling on a central bolt to swing over and clamp them down. For long tubes, two or more clamps of this nature may be necessary.

There is no restriction as to the number of bell-mouthed fittings to put in the manifold, as the more fittings the greater economy. By making the parts *A B*, Fig. 3, in one size for ¾-inch tubes, and another set for ⅝-inch tubes, the same manifolds will serve for the two sizes. When the apparatus is in use, be sure to leave valve *H*, Fig. 2, open until the tubes and manifolds are filled with water to the exclusion of all air; then close it.

An outfit of this kind is in use on the Pacific coast and is doing excellent work, saving a great deal of money. I hope someone else may find use for it, as it "delivers the goods."

The Patitz Steam Turbine

If the velocity of a body is doubled it will have four times the energy stored in it. If the velocity of a body is halved three quarters of its energy will be taken out. The inventor of this turbine, instead of getting up a low velocity and abstracting practically all of it in each stage gets up a high initial velocity, abstracts about one half of it, restores the initial high velocity by further expansion for the next stage, and gets out three times as much energy per stage as a turbine working on the lower half of the velocity range.

The energy required to get a weight W into motion at a velocity of V feet per second is $\frac{W V^2}{2g}$.

Taking g at 32.16 the energy in a pound weight would be approximately

$$E = 0.015\ V^2$$

The energy is thus seen to vary directly as the square of the velocity. A body one pound in weight having a velocity of 1000 feet per second has stored in it

$$0.015 \times 1000 \times 1000 = 15{,}000 \text{ foot-pounds}$$

of energy; but if it has a velocity of 2000 feet per second it has

$$0.015 \times 2000 \times 2000 = 60{,}000 \text{ foot-pounds}$$

To increase the velocity of a body 1000 feet per second starting from rest, then, takes some 15,000 foot-pounds; but to increase its velocity another 1000 feet starting from 1000 feet per second takes some 45,000 foot-pounds.

A turbine blade running at a certain speed will reduce the velocity of the jet passing through it a certain amount. Suppose this reduction to be 1000 feet per second. Then, if the jet enters the wheel at 2000 feet per second and leaves at 1000, the wheel will take out 45,000 foot-pounds of energy for each pound of steam passing, but if the reduction be from 1000 feet per second to rest, the same wheel at the same speed would take out only 15,000 foot-pounds.

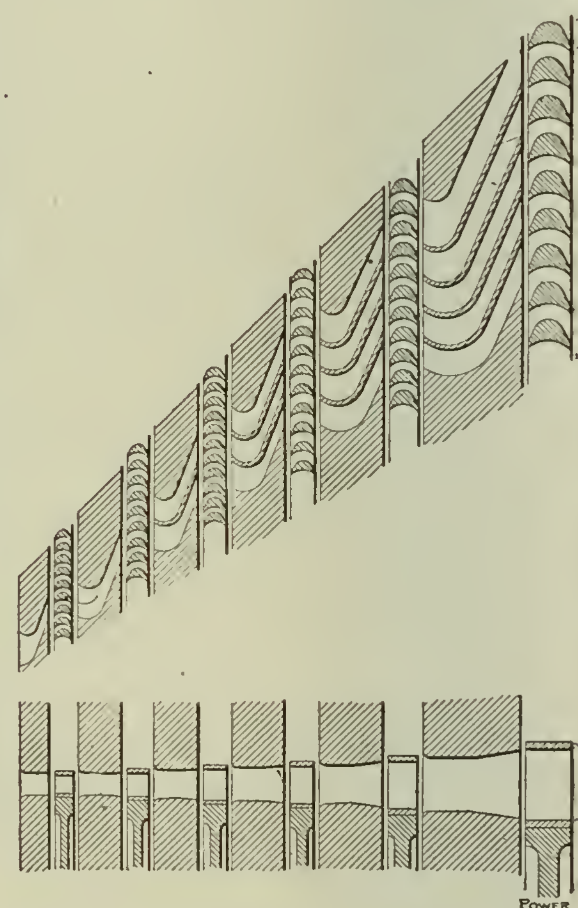


Fig. 2. Diagrammatic Sketch of Patitz Turbine

Based upon this fact, J. F. M. Patitz, of the Allis-Chalmers Company, has taken out a patent for a steam turbine in which the steam enters the first wheel at a comparatively high velocity. This velocity is only about one-half abstracted, however, by the runner, and the residual velocity is increased again to the maximum by further expansion before the steam acts upon the second wheel.

Fig. 1 represents diagrammatically an abstract case, the ordinates being velocities and the abscissas energy converted. Suppose the total energy derivable from a pound of steam flowing from the initial to the condenser pressure to be 240,000 foot-pounds, represented by the length of the line *O A*. Suppose that in a turbine of the multiple pressure-stage, single velocity-stage type, like the Rateau,

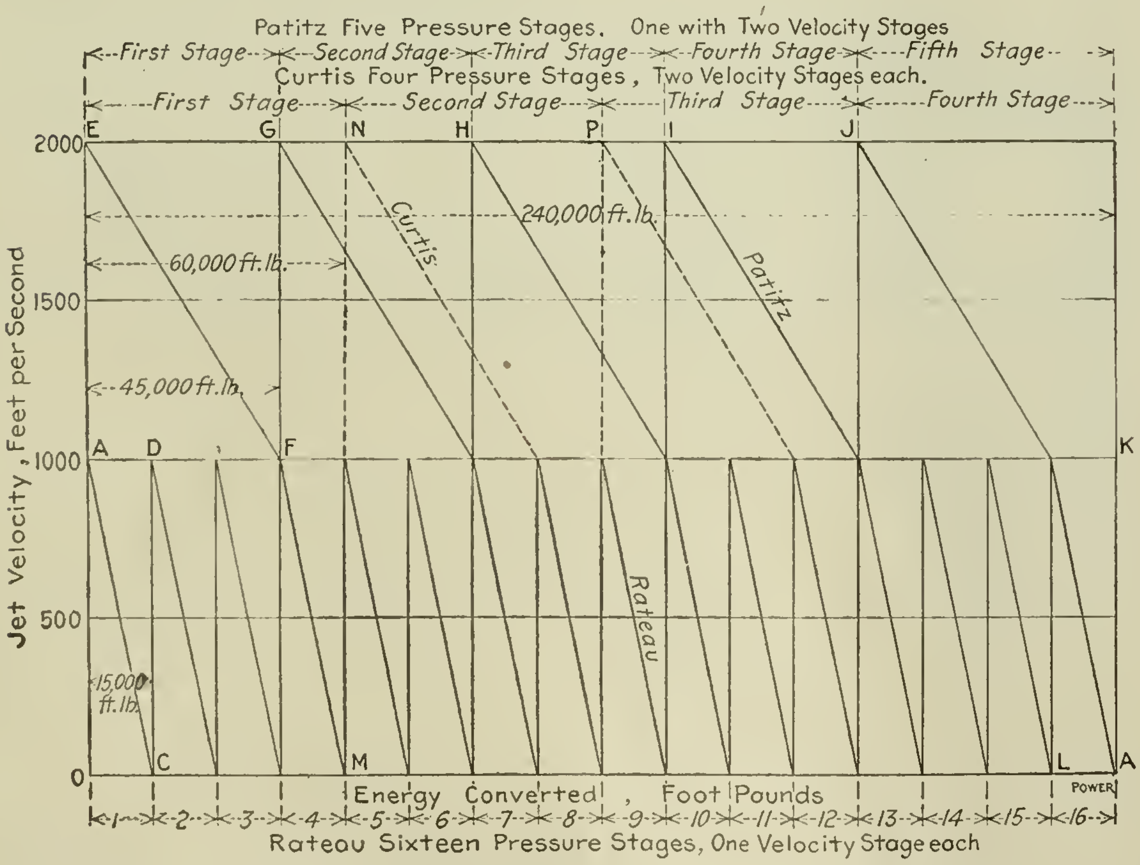


Fig. 1. Energy-Velocity Diagrams for Three Types of Turbines

the steam is expanded in the first stage sufficiently to give it a velocity of 1000 feet per second, represented by the line *O A*. Then a turbine wheel running at 500 feet per second (this takes no account of angle of entry, friction, etc.), would bring it to rest again, and convert into work the 15,000 foot-pounds of energy required to get up its velocity of 1000 feet per second. Its velocity would then be raised to 1000 feet per second again by expansion in the second set of nozzles, as represented by the line *C D*, and the process repeated until the 240,000 foot-pounds available had been all absorbed. This would, as the diagram shows, require 16 stages, absorbing 15,000 foot-pounds each, as

$$16 \times 15{,}000 = 240{,}000$$

If, however, the steam be sufficiently expanded in the first set of nozzles to give it a velocity of 2000 feet per second, represented by the line *O E*, a turbine running at 500 feet per second would reduce its velocity to 1000 feet per second and convert 45,000 (represented by the distance *A F*) of the 60,000 foot-pounds required to get up its initial velocity. If now its velocity is restored to 2000 feet by further expansion, as represented by *F G*, and the process is repeated it will be seen by the triangles whose apexes are at *E*, *G*, *H*, *I* and *J* that the process could be completed in five stages. Not completed exactly, for the steam would leave the last wheel with a velocity of 1000 feet, as shown at *K*, and it would be necessary to put in an additional low-velocity stage to reduce the velocity from *K* to *A* and rescue the last increment of energy *L A*; or to double blade the last wheel, as in the Curtis system, in which case the second blade upon the same wheel would take the steam at 1000 feet velocity, reversed in direction by a stationary blade between the two moving ones, and bring it to rest.

If the whole turbine were made in this way it would require but four stages, but with three times the amount of blading in each. In addition to the single blade of the Parsons wheel there would be the stationary reversing blade and the secondary running blade in each stage. A comparison of the three systems in this respect is shown in Fig. 3.

The course upon the diagram, Fig. 1, would be: generation of velocity to 2000 feet per second, *O E*; reduction of velocity to 1000 feet per second, *E F*; with the first running blade, reversal of direction by the stationary blade and reduction from 1000 feet per second to rest, *F M*, the absorption for the whole stage being 60,000 foot-pounds, *O M*. Expansion between the first and second stages would restore the velocity to 2000 feet per second, *M N*, and the process would be repeated, giving the four diagrams similar to *O E F M*, the apexes of which are at *E*, *N*, *P* and *T*.

This is, of course, simply an abstract discussion, the principal modification of which to make it apply in a comparison of the actual machines would result from the fact that some residual velocity is inevitable at all the wheels, which rather emphasizes the advantage of the new type. A disadvantage is that all the steam is used at high velocity, involving greater friction upon each blade, but there is a smaller number of blades subject to such friction.

The arrangement of the blades whereby the direction of flow is reversed and the residual velocity preserved and increased by further expansion is shown in Fig. 2, and a section of the turbine in Fig. 4, both reproduced from the patent drawings.

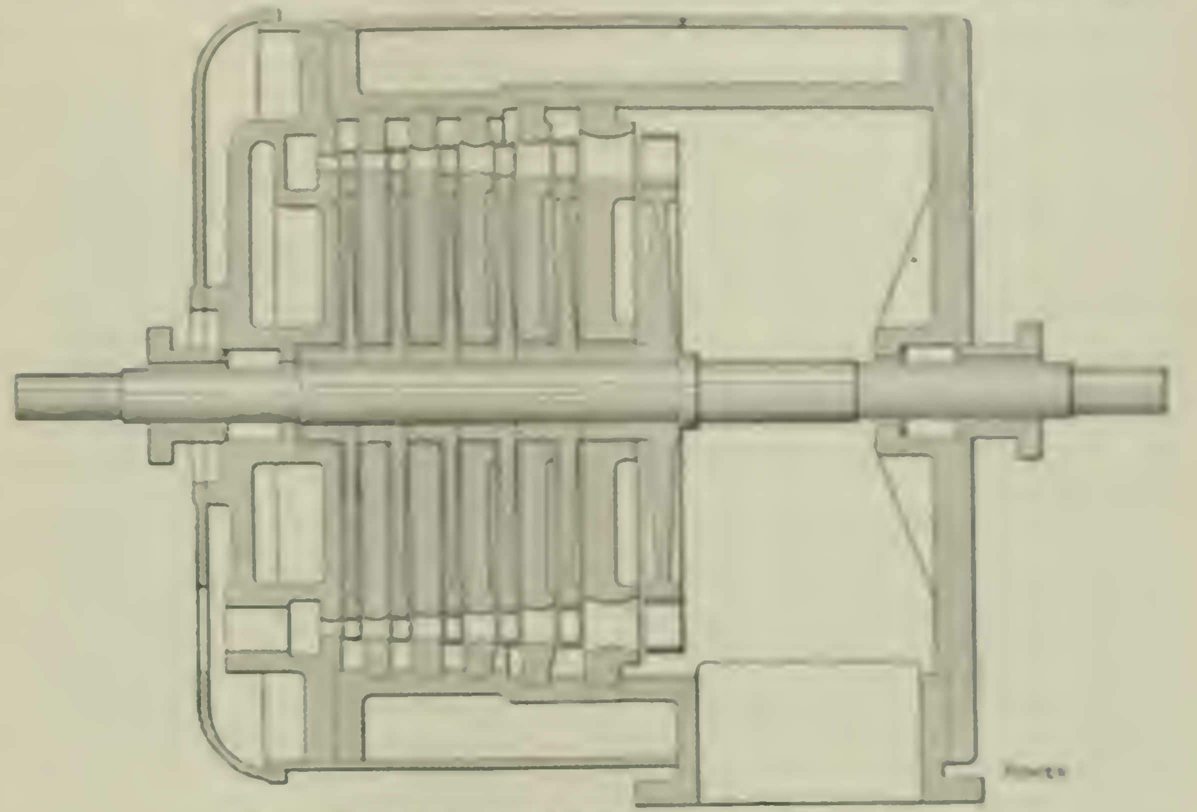


Fig. 4. Longitudinal Section through Turbine

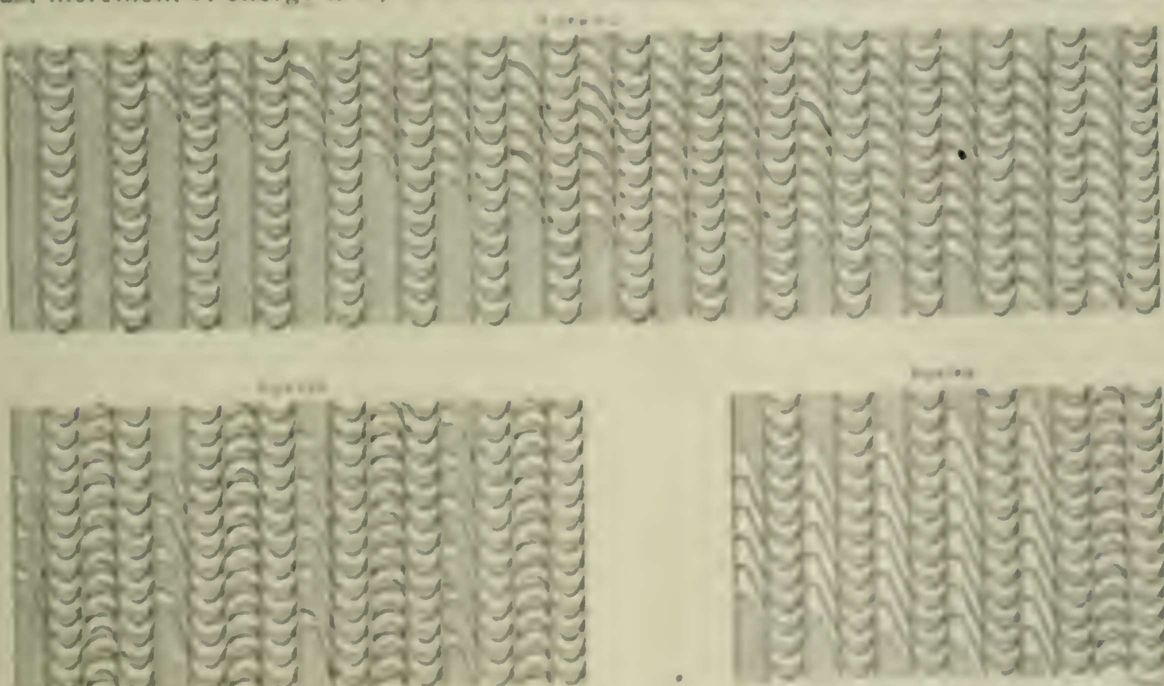


Fig. 3. A Comparison of the Three Types of Turbine

Why Smithy Didn't Get a Job

An erecting engineer was recently called upon to go to a steam plant in a city not many miles from Brooklyn, N. Y. Arriving at the plant he found that the running engineer had substituted a new throttle valve in place of the old one, but could not start the engine—why, he did not know.

The erecting engineer cast his eagle eye over the engine, and at once located the trouble, or rather troubles. The steam chest was cracked. The engine frame was broken and the crank rod was badly bent. Later he learned that the engine had received a dose of water the day before, and that the engineer, in his ignorance, blamed the throttle valve when the engine would not start, not knowing that the engine had sustained serious injury.

Some time later, as the erecting engineer was putting the finishing touches on a new installation, a voice addressed him saying, "What is the chance of a job governor?" When the erecting engineer turned to answer he beheld the engineer who had the throttle-valve trouble. Well, he did not get a job.

Uncle Pegleg on Force of Gravity

In which the old man tells, in his simple way, all about gravity and incidentally why Jim and the salt bag did not balance.

Fogchurn Hollow, Tenn., March 15, 1911.
Dear Uncle Pegleg:

I've bin readin' some of your talks with the kid in POWER (which hits the trail into this here lumber-chuck about as regular as the mail man) about ropes and pulleys and things. I want to ask you some questions about things in that line I can't understand.

'Bout three weeks ago I made a trip with anuther feller down the crick to town, to see the sights. Most of what we saw I don't remember very well, but early in the day we went around to the artifishul-ice plant to see how they made ice by machin'ry. and there we saw a sight I shan't forget so long's I live—though's I kum so pretty near dyin' o' laffin' right there I wuzn't so far from forgittin' that too.

They got a sizable engineer down to that plant, named Jim Taintor. My chum's father knowed him, and thet's how we kum to dare go round there and ask questions. Jim's got more fat to him th'n he has git-up-n-git. He don't ketch himself doin' 'n hour's labor thout he spends about half a day figgerin' out which is the easiest way to do it. Thet's how he come to do the vodeville act that near bust us up.

Ye see, they use a lot o' salt to thet plant, to make the ice—though Jim showed us as how they didn't use the salt to make the ice cold, 's they do in makin' ice cream, but only to make brine what wouldn't freeze. (Funny, I thought, to spend all thet money to make somp'n what wouldn't freeze, when the whole fact'ry was set up to make things freeze.) Howsmdever, they do use a lot o' salt, and it comes in big wagonloads o' sacks, and its Jim's job to get the sacks up into the storehouse loft above the "can room," as they call it.

Well, so Jim told us after he got cooled off some, them bags o' salt weigh about 180 pounds apiece. The only helper Jim's got, besides his fireman, who can't leave his fires, is a boy not big enough to do much pullin' on the rope. Besides, Jim needed him up in the loft, to untie the bags when they got up there. So he had to pull 'm up there himself, 'n they air heavy enough to most pull Jim off'n the ground—he weighs only about 200—at ev'ry heave.

So Jim got his thinker to work and figgered out 's how his legs were lots stronger 'n his arms—just 's sailors, he said, knows enough not to pull ropes down with their arms, but to jump up on it with their leg strength 'n then let their weight swing the rope down. So he'd first tie the rope to a sack o' salt on the ground, 'n then climb upstairs to the loft, ketch holt o' the rope out o' the door, 'n swing himself out on the rope. All he had to do was to hold on tight, 'n down he'd kum, just as easy, while the sack went up past him 'n stopped opp'sit the door when Jim stopped on the ground. Then the boy d' pull the sack in the door, untie the rop 'n Jim 'd be ready for another trip upstairs.

This went bully. But one day the salt man got a carload o' salt from a new place, 'n without sayin' anythin' to Jim about it he sent round a wagonload o' salt in sacks 'at weighed only about 120 pounds to the sack. Jim didn't notice no difference, 'n tied the first one on and clumb upstairs an' swung hisself out on the rope, expectin' ev'rything to work just 's it allus had. But it didn't work that way. Stead o' slidin' down easy to the ground he went away like a shot. The sack got such a yank thet it bumped Jim pretty hard on its way up, 'n bout time he wuz gettin' straight in his mind what had happened to him when the sack hit him, he found the ground had kum up 'n hit him hard from below—a good deal harder 'n ennybody 'd ever hit Jim that way sence he was a small boy; for it had all happened so quick Jim hadn't had time to get his feet down into shape fur landin', 'n he came down sittin' down.

But he didn't have much time for bein' dazed, cause when he landed he hit so hard, what with the whack the sack had given him on the way down, thet he let go his holt on the rope. Well, o' course, then the sack o' salt, which was up opposite the loft door, started back home agin; 'n as the boy had already caught holt of it, he a'most kum too. But he let go in time.

The sack didn't come down very fast, for it couldn't move along thout whippin' the rope, coil after coil, out from under Jim, 's he sat there wonderin' whether he'd been a big enuff fool to deserve treatment like that. The sack pulled powerful hard 'n jerky, 'n Jim couldn't help wonderin', he told me afterward, what sort of a horizontal buzz-saw it wuz he'd set down on, ennyhow.

Pretty soon he quit wonderin' 'n commenced to talk. I spose he'd made up his mind as to the buzz-saw, 'n was speakin' it freelike. Ennyhow, the langwidge was most enuff to make that sack o' salt ashamed o' intrudin' on his sassiety 'n turn round 'n go back to the loft agin. But it didn't do no sech thing. It kum right along down. 'N just about the time Jim had made up his mind that not even strong langwidge could appeal to thet buzz-saw, 'n he'd better stand up, the sack o' salt kum along 'n countermanded the order. It knocked Jim so flat there wuzn't no room left for langwidge at all.

He lay there so long I really thought he wuz hurt, though chum 'n me wuz so bad off for laffin' we couldn't do ennythin' to help. But he kum to bout 's soon ez we did—'n then we *had* to quit laffin' 'n ask him if he wuz hurt, 'n where.

It wuzn't until I got back up the crick on the job agin thet I've hed time to think about this thing. I haven't been able to figger out just how this thing happened, 'n why it wuz he went so much faster 'n usual. No, I don't mean thet. I can see *why* he went faster, but I can't figger out how ennyone wuz to know *how much* faster he wuz to go, under sech tryin' circumstances 's a 120-pound sack o' salt. Please help me, Uncle Pegleg.

Your lovin' nevvy,
DAVE.

The problem which is puzzling Dave is an important one, for it concerns all cases where force sets matter into motion.

Our most familiar instance of such a phenomenon is that of simple falling bodies, where there is no rope and counterweight attached to complicate the problem. We are accumstomed to say: "Oh, a body falls 16 feet the first second, 32 feet the next, and so on." But the schools do not commonly teach the broad significance of this fact.

We who live on the surface of the earth, where all bodies, except for air resistance, have this same rate of fall, naturally take this particular rate for granted, as an inherent property of matter. But, those who live elsewhere at times—and every mind which studies natural science must often wander above and below the surface of this earth—know that this is not so.

Every solid body presents to our senses at least two qualities. One is its *mass*. The other is its *weight*.

The mass of a body is the quantity of matter within it. This naturally is the same, wherever you may carry it. If Dave, for instance, should heave a chunk of coal at his chum, it would strike just as hard a blow wherever the act was performed, at sea level, on mountain top, on the surface of the moon or of Mars etc.

The *weight* of a body, on the other hand, is not an attribute of that body, but of its relationship with other, usually larger, bodies, such as the earth, moon, Mars, etc. Consequently it varies whenever you change either the other body or the relationship with it. This same chunk of coal, for instance, would weigh quite differently at the earth's surface accordingly as it were at the sea level, up in a balloon, down in a mine, at the North Pole, at the equator, etc. It would also weigh quite differently at the surface of the moon, Mars, etc., from what it does anywhere on earth.

Now *motion* is merely the result of the effect of this varying force *weight*, acting upon this constant *mass*. It is only a coincidence that at all the places inhabited by man the force of weight is so nearly constant that we say that the rate of fall is constant. Horizontally we may have any force acting on a given mass and any resultant rate of motion; and, in mechanical engineering, these laws of horizontal motion are all-important.

It was Sir Isaac Newton who first gave us the law of motion, or of acceleration, to speak exactly. He said that (a) the acceleration, or the gain in velocity each second, is proportional to the force and (b) told us what that proportion is.

We know, for instance, that when we drop a piece of iron which weighs one pound, the velocity at the end of the first second is about 32.16 feet per second. Therefore, this is called an acceleration of 32.16 feet per second.

According to Newton, this fact represents the broad law that

$$Force\ (=weight) = 32.16 \times mass$$

From this we get

$$Mass = \frac{weight}{32.16} = \frac{W}{g}$$

wherein g is the acceleration of gravity. Or, for other rates of acceleration,

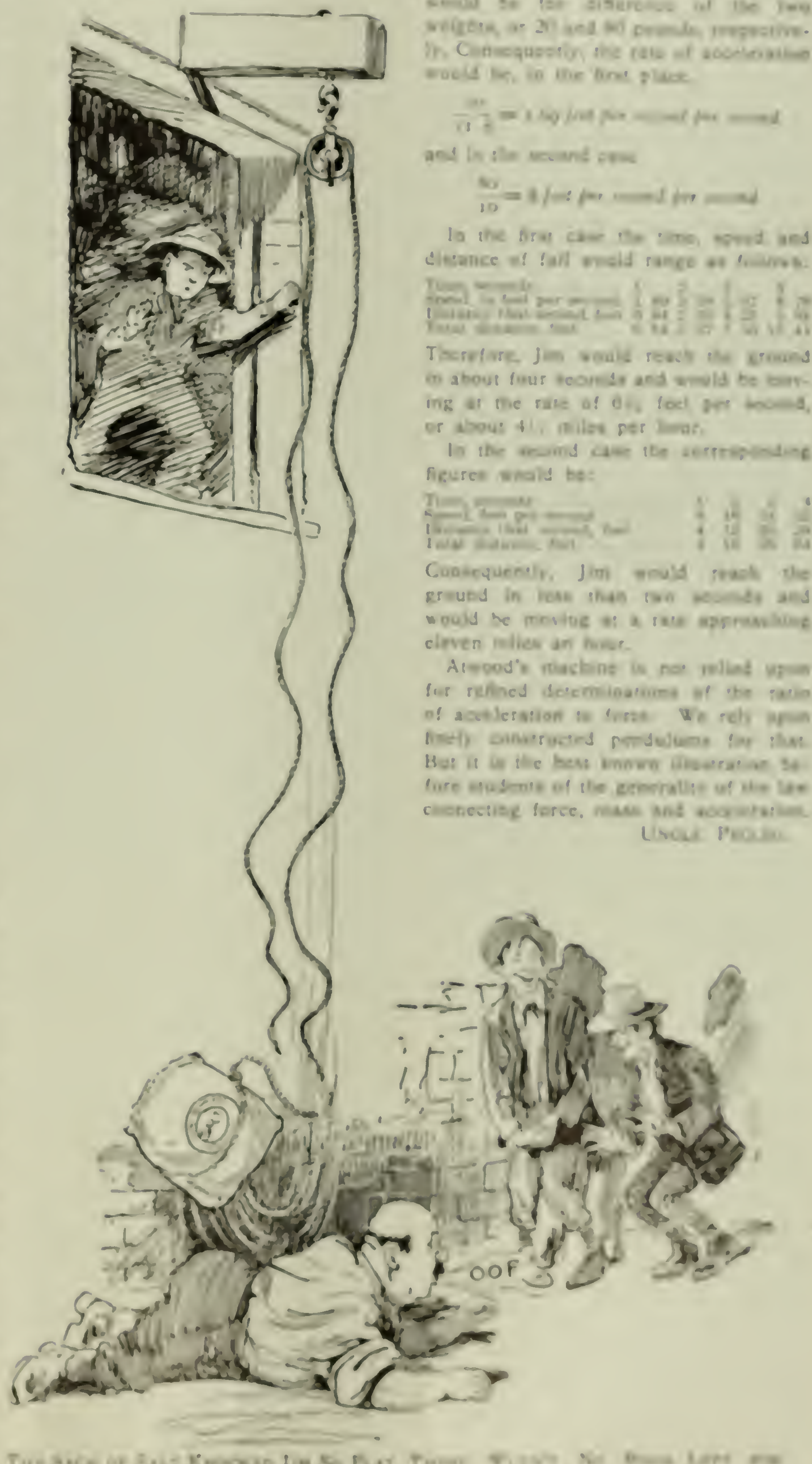
$$Acceleration = \frac{force}{mass} = \frac{force}{\frac{W}{g}} = g\,\frac{force}{weight}$$

In other words, the acceleration is proportional to 32.16, as the force is to the weight of the body subjected to it.

These facts are very hard to study on the earth's surface, because all vertical motions are tied down to the particular vertical force (gravity) which we cannot get rid of here, and all horizontal motions are afflicted with heavy friction due to the same. Newton studied the problem in the heavens, astronomically, because there we get rid of these earthly obstacles. But we ordinary mortals cannot do this.

To help this situation out a famous scientist, Atwood, built a machine modeled quite after Jim's salt-loft pulley and whip. By using *two* weights instead of one, attached to the two ends of a cord passing over a pulley above, and by making the pulley very carefully to be as frictionless as possible, vertical motions could be used and yet the effective weight of the mass being studied could be varied.

That is to say, in this machine the mass being set into motion is the sum of the two bodies. The force or weight which is promoting their motion is their *difference*. So, by making the two bodies fairly nearly the same weight, their sum becomes very large in comparison with their difference. Consequently, the motion will be very much slower than that of freely falling bodies and can be studied much more conveniently.



The Sack of Salt Knocked Jim So Flat There Wasn't No Room Left for Landscape at All

If we take Jim and his salt bag as an instance of such a machine, and disregard the friction of the pulley and rope, it appears that the sum of Jim's weight and that of the salt is, in the first case, 380 pounds and in the second 320 pounds. Consequently, the mass to be moved is about 11.8 and 10 units respectively.

The motive force, on the other hand, would be the difference of the two weights, or 20 and 80 pounds, respectively. Consequently, the rate of acceleration would be, in the first place,

$$\frac{20}{11.8} = 1.69\ feet\ per\ second\ per\ second$$

and in the second case

$$\frac{80}{10} = 8\ feet\ per\ second\ per\ second$$

In the first case the time, speed and distance of fall would range as follows:

Time, seconds	1	2	3	4
Speed, in feet per second	1.69	3.38	5.07	6.76
Distance that second, feet	0.84	2.53	4.22	5.91
Total distance, feet	0.84	3.37	7.59	13.48

Therefore, Jim would reach the ground in about four seconds and would be moving at the rate of 6¾ feet per second, or about 4½ miles per hour.

In the second case the corresponding figures would be:

Time, seconds	1	2	3	4
Speed, feet per second	8	16	24	32
Distance that second, feet	4	12	20	28
Total distance, feet	4	16	36	64

Consequently, Jim would reach the ground in less than two seconds and would be moving at a rate approaching eleven miles an hour.

Atwood's machine is not relied upon for refined determinations of the ratio of acceleration to force. We rely upon finely constructed pendulums for that. But it is the best known illustration before students of the generality of the law connecting force, mass and acceleration.

UNCLE PELEG.

Engines in British Rolling Mills

By Thomas B. Mackenzie

Abstract from a paper recently delivered at a meeting of the Institution of Engineers and Shipbuilders in Scotland. The relative merits of simple and compound engines for rolling-mill work are considered and also the application of low-pressure turbines.

Steam engines in use in the early days of the malleable-iron trade were mostly of the simple noncondensing type working with a late cutoff. As the puddling and reheating furnaces were able to supply enough steam for them, and as there was then no other known method of using the surplus heat, there was no inducement to install more economical types. With the advent of steel, however, this was changed; more power was required for rolling and less waste heat from the furnace was available for the generation of steam. Then when it became necessary to install new engines some attempts were made to improve their steam economy. The simplest of these was the introduction of feed-water heaters and by this means a saving of from 10 to 12 per cent. was obtained.

In the case of mills the rolls of which run continuously in one direction, compound-condensing engines of the most modern type with automatic expansion gear have been, and still are being, used with excellent results. In the case of reversing rolls the case is different. Early attempts at compounding such engines in England ended in failure and prejudiced those in charge against them; and it is only since they have been introduced successfully on the Continent that they are again beginning to be taken up by English steel makers.

The conditions which a reversing rolling-mill engine must fulfil are briefly these: It must be simple and free from all unnecessary complications, in order that it may be able to work day and night with the minimum risk of breakdown; it must be able to start with the cranks in any position, and with the load on; and it must be easily handled; the handles requiring to be continuously used should never be more than two, one for the steam and one for the reversing gear. The first of these conditions is met by making all the motions as direct-acting as possible and giving all parts ample strength. The second condition means that with two-crank engines the cutoff cannot be earlier than 75 per cent., and with the three-crank engines 55 per cent. of the stroke. The third condition almost prohibits the use of expansion gears, and leaves the control of the engine to be effected by throttling the steam supply, which operation is as follows: The engine is turning slowly round in the proper direction when a hot ingot is brought forward and caused to enter between the rolls; the driver at this instant opens the throttle and the ingot is pulled through, the throttle being closed just as the steel is about to leave the rolls. There is still steam in the connecting pipes and valve chests, which, together with the kinetic energy stored in the rotating parts, causes the engine to race until the reversing gear has been brought into use, when the engine begins to rotate in the opposite direction. The steel again enters the rolls and the operation is repeated until it has been rolled down to the required dimensions.

The early compound engines made in England were constructed in the way usual in land and marine practice, with a throttle on the high-pressure cylinders only; consequently, the racing was very much accentuated. In addition to the steam in the high-pressure pipes and valve chests, there was the steam in the connecting pipes, intermediate receiver and low-pressure valve chests. Furthermore, when the engine had been reversed the receiver pressure had fallen to that in the exhaust pipes of the low-pressure cylinders, and only the high-pressure cylinders were available for starting the mill. The drivers had, therefore, to use their own expression, "to take a race at it," that is, the engine was allowed to get up to speed before the piece was entered, causing severe shocks and often leading to breakdowns; hence the compound engine was condemned as unsuitable for rolling-mill purposes.

As is commonly the case, the cure is almost ludicrous in its simplicity, consisting as it does in merely placing a valve between the intermediate receiver and the low-pressure valve chests, connected to, and acting along with, the high-pressure throttle valve. Therefore, when the driver closes the throttle valves, he bottles up the steam in the receiver, and the steam in high-pressure pipes and valve chests, together with the kinetic energy stored in the rotating parts, compresses this steam and raises the receiver pressure, at the same time bringing the engine quickly to rest. On reversal the receiver supplies the low-pressure cylinders, so that all are available for starting under load, and the engine starts easily.

The question: "How much steam does a reversing rolling-mill engine use per horsepower-hour?" is perplexing, and one to which it is difficult to obtain a direct answer. Last year a paper was read at the London meeting of the Iron and Steel Institute by Messrs. Sehmer and Drawe on "Economy and Design of Modern Reversing Rolling Mill Engines," in which it was stated that on a forty-five hours' test of a compound rolling-mill engine the average steam consumption was 350.77 pounds per ton of material rolled to 9.222 times its original length. This is equivalent to about 22 pounds per horsepower-hour. The steam pressure was 103 pounds gage, and the absolute back pressure in the low-pressure cylinders 3.25 pounds per square inch. It was also stated that formerly, with a noncondensing engine, under the same conditions, the steam consumption was 880 to 1100 pounds. In the case of the compound engines the steam consumption named is said to have included that required for the condenser pumps and auxiliaries. There can be no question as to this being an exceptionally good performance, and one which could not be maintained under ordinary working conditions. For everyday practice 24.2 pounds per horsepower-hour will be nearer the figure.

Until within the last few years the only use to which the heat in the exhaust steam from noncondensing engines could be applied was for heating feed water, etc. Since the advent of the steam turbine, however, it has become possible to collect this steam in a closed system of pipes and use it in exhaust-steam turbines. Such an installation, when used with intermittent running engines, consists of three essential parts: first, a thermal storage tank, called by Professor Rateau the heat accumulator; second, the turbine proper, and, third, the condenser and its pumps. The pressure in the thermal storage tank supplying these turbines is usually 17 to 17½ pounds per square inch absolute. It is dangerous to let the pressure fall to that of the atmosphere, and fatal to let it get below that point. To prevent such an occurrence it is customary either to fit a reducing valve which will allow live steam to pass at the lowest permissible pressure in the storage tank, or, as in more recent practice, to use a mixed-pressure turbine. There can be no question as to the latter being by far the better method, as the live steam can then be used with maximum efficiency.

In considering the adoption of an exhaust turbine, it must be kept in mind that the result of its introduction will, by raising the back pressure, increase the steam consumption of the engines exhausting into the thermal storage tanks.

In the case of the noncondensing engine cited, it would increase the steam consumption about 20 per cent. The increase of back pressure will not be less than three pounds per square inch. The loss by condensation, leakage, etc., between the reciprocating engines and the turbines will generally be about 15 per cent. For every 100 pounds of steam which a noncondensing engine uses when exhausting freely into the air, it will, when connected to thermal storage tanks, use 120 pounds. Of this 102 pounds will be available in the turbine. The author recently had occasion to witness a careful test of a mixed-pressure turbine, and the result showed that with dry saturated steam at a pressure of 17 pounds per square inch absolute and a vacuum of 27 inches of mercury the steam consumption was 26.6 pounds per horsepower-hour, the thermal efficiency of the turbine being 0.626. From this performance 102 pounds of steam would be capable of developing 3.83 horsepower. As a live-steam turbine, working with the same initial pressure and degree of superheat as the reciprocating engine, would use 54.7 pounds of steam to develop the same power, the noncondensing engine should be credited with this amount, making its equivalent net consumption

$$120 - 54.7 = 65.3 \text{ pounds}$$

in the same time that it formerly used 100 pounds when exhausting freely to the atmosphere.

A compound engine uses 58.7 pounds of steam for every 100 pounds used by a noncondensing engine doing the same work. Also, it has just been shown that a live-steam turbine will use 54.7 pounds of steam to develop the same amount of power which could be gotten from an exhaust turbine placed beyond and in series with the reciprocating engine, which the compound replaced, per 120 pounds of steam used. The sum of these is

$$58.7 + 54.7 = 113.4 \text{ pounds}$$

instead of 120 pounds required by the noncondensing engine with the increased back pressure due to its exhausting into the thermal storage tanks. The same amount of work can therefore be done with 6.6 pounds less steam, an apparent saving of 5½ per cent. The real saving, however, is greater because it is impossible to so arrange matters that the load on the turbine will always be proportional to that on the engines exhausting into it. There are therefore times when the supply of exhaust steam is in excess of the turbine's requirements when it blows off at the safety valves on the storage tanks and is wasted. Conversely, there are times when there is a deficiency of exhaust steam, and the turbine's demands have to be made up with live steam. With compound engines and live-steam turbines, on the other hand, each takes from the boilers just what it requires and no steam is wasted.

Gas Explosions in Boiler Flues

Before the Oldham Engineers' Association, of England, William Ingham recently delivered an interesting lecture on the above subject. *The Engineer*, of London, abstracted the lecture and we are thus enabled to present briefly the gist of his remarks. In the course of his lecture, Mr. Ingham referred to the Distington boiler explosion which occurred on December 18, 1889, when eight Lancashire boilers were simultaneously destroyed, four exploding violently and completely destroying the other four. The boilers were fired by blast-furnace gas and beneath each gas burner at the front of the boiler a small coal fire was kept constantly burning to ignite the gas flame should this become extinguished.

At the time, there was a certain amount of mystery surrounding the explosion, and it was suggested that, as there was considerable fluctuation in the gas pressure and variation of the quality and constituents of the gas, if, after the flame were extinguished and the gas and air were discharged in considerable quantities in the flues before ignition, an explosive mixture might accumulate, and the ignition of a large volume of such mixture by the flame from the coal fire or by the flame from an adjacent boiler might cause the explosion, which would lift the boiler and cause it to explode from internal pressure in dropping down again.

Careful investigation and calculation showed, however, that the maximum pressure which could be produced by such an explosive mixture would not exceed 10 pounds per square inch if confined in a closed vessel. Immediately a boiler was lifted, however, or the brick envelop forming the flues gave way, the force of the explosion would have spent itself and the gas pressure would fall, and probably the boiler would drop on its seat again or roll over. Certainly the boilers would not be blown into fragments, many of which were hurled to great distances by this explosion.

The conclusion arrived at by the underinsurance company's engineers and the engineer surveyors of the Board of Trade was that this multiple explosion was caused by an excessive accumulation of pressure in one boiler due to the blocking up of the orifice leading to the safety valve in some manner not clearly ascertained.

It was Mr. Ingham's opinion that no really disastrous boiler explosion or economizer explosion had ever been due to sudden and violent combustion of an explosive mixture of gas and air. In a dozen or so of cases investigated by the lecturer, the effects all bore a marked similarity to each other. They occurred in most cases after the fires had been banked for some time. In one case the flue covers were blown away and about two-thirds of the brickwork from the top of the boiler. Another occurred in the overtop flue of a Galloway boiler. In one case the chamber of a Green economizer was blown down and the upper portion of the back end of the economizer was blown away. In all these cases it will be noticed that the results of gas explosions in boiler flues were almost invariably of a mild character, seldom doing more than finding vents for the gases by blowing down the brickwork forming the flues, or lifting up the iron plates or other coverings.

The Central Station Could Not Meet His Figures

At the March meeting of the National Isolated Plant Association, held at the Engineering Societies building, several members related their experiences with the central-station solicitor. Among the most interesting of these was the story told by the chief engineer of a large association building. The plant is of approximately 300 boiler horsepower and has a fairly high load factor, owing to the elevator service. Complete records are kept of all fuel, supplies, meter readings, etc., and all labor is charged to the proper items. As a result power is produced here for less than two cents per kilowatt-hour, including all fixed charges. Some time ago the management was approached by the central-station solicitor who wanted a chance to submit figures for central-station service. He was accordingly given access to all the plant records and allowed to take such instrument readings as he wished, with these data he departed and promised to return within a few days with an attractive offer. A month elapsed, however, and he did not return, whereupon the engineer called up the central-station office in regard to the matter. He was informed that they were figuring upon the proposition and would be prepared to submit figures in a few days. After another prolonged wait, followed by another telephone message, the solicitor finally put in appearance and rather sheepishly informed the engineer that the central station was not prepared to offer a proposition which would better the figures of the present plant and ended by congratulating him upon the good showing.

Among the various committees appointed at the meeting was one upon "standardization," one of the duties of this committee being to draw up a standard form of records which will enable the engineer to tell at any time just what it is costing him to produce power.

Sulphur is one of the best things for hot bearings and is often used on the engine guides and crank pins. It is best used in a powdered form mixed thoroughly with oil.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

A New Engine Type Alternator

The accompanying engravings illustrate the construction of a line of low-speed alternators built by the Westing-

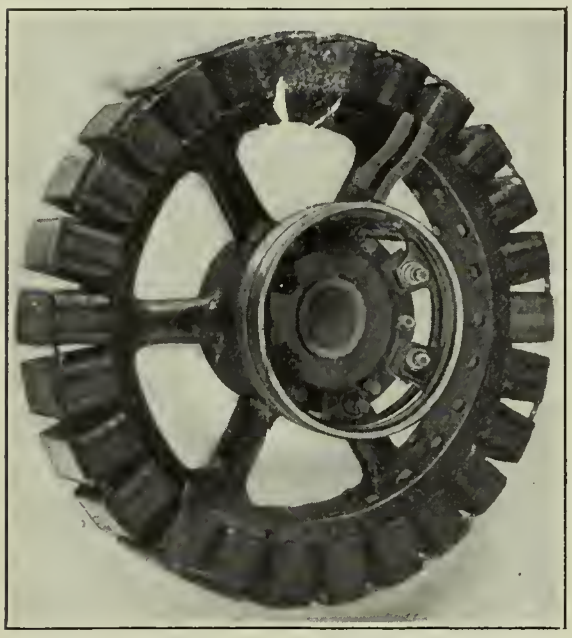


Fig. 1. Complete Field Magnet

house Electric and Manufacturing Company for mounting the revolving field magnet directly on the shaft of its driving engine or waterwheel. The field magnet (Fig. 1) consists of a steel wheel, exactly like a flywheel, the rim of which forms the yoke of the magnet, with laminated poles bolted to the face of the rim and exciting coils surrounding the cores. The magnet poles are of the usual type, having extended poletips at the faces, as indicated in Fig. 2. The poles are held on the rim by simple hrough bolts, no dovetails or other means than the bolts being employed. The magnet coils are composed of copper ribbon or strap wound edgewise with fireproof insulation between the convolutions.

The collector rings are of cast iron with radial lugs projecting inwardly. These lugs are bolted to a supporting cast-iron ring which, in turn, is bolted to the hub of the field-magnet spider, as shown in Fig. 2; the lugs are insulated, of course, from the bolts and the supporting ring. This construction obviously leaves the collector rings entirely open on the interior, permitting heat to be dis-

Fig. 2. A Field-magnet Pole

sipated from the inner as well as the outer surfaces.

The armature core is built up of segmental stampings of the form shown in the upper part of Fig. 5. The dovetail projections stamped on the backs of the

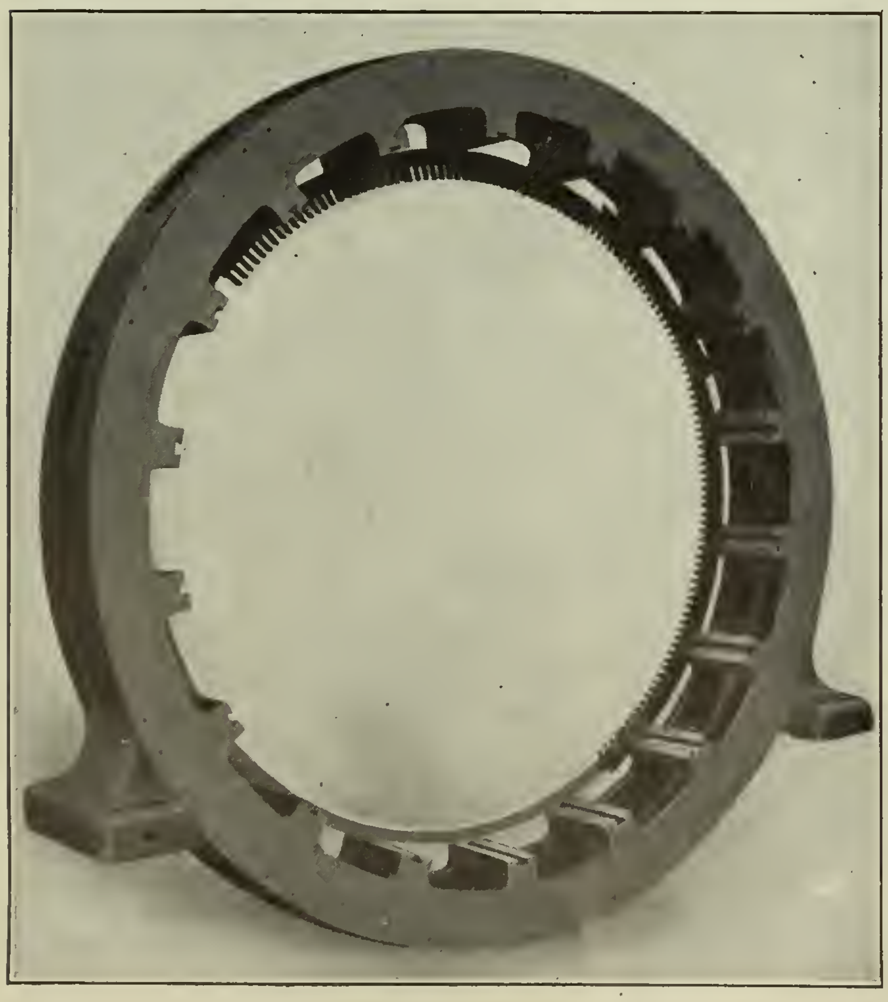


Fig. 3. Armature-housing Ring

Fig. 4. The Complete Armature

segments fit snugly in slots milled in ribs which extend axially across the face of the housing ring, as shown in Fig. 3. The joints between the ends of the segments are staggered in successive layers so that each joint is flanked by solid sheet on each side of its own plane. The housing or main frame is of cast iron of skeleton cross-section and ventilated by large slots cored in the center of the housing face or "rim." Fig. 3 gives a very clear view of the construction of this piece, which combines lightness, strength and ability to get rid of heat to a remarkable degree. The segmental laminations are assembled in the housing ring under pressure and held in place by malleable-iron finger plates of the shape shown at the center of Fig. 5, backed up by cast-iron end rings which are keyed to the housing. The segment shown at the bottom of Fig. 5 is a ventilating spacer. A ring of these is inserted between the core laminations at intervals, during the building up of the core, to form ventilating ducts in the completed core.

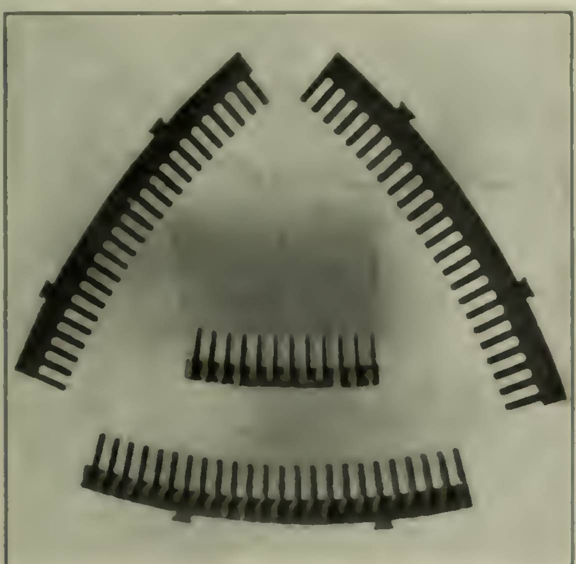


Fig. 5. Core Laminations, a Finger Plate and a Ventilating Spacer

Very close inspection of Fig. 5 will show that the core teeth are notched on each side near the free ends; these notches are to receive hard fiber strips which close the slots after the winding is in place. The armature coils are form-wound and individually insulated before being put in the slots, as is now the standard practice in the construction of machines for moderate and high voltages. After each coil is wound and shaped, it is dried in a vacuum and impregnated with a moisture-proof compound under pressure; then the wrapping is applied and finally the insulated coil is coated with an insulating varnish.

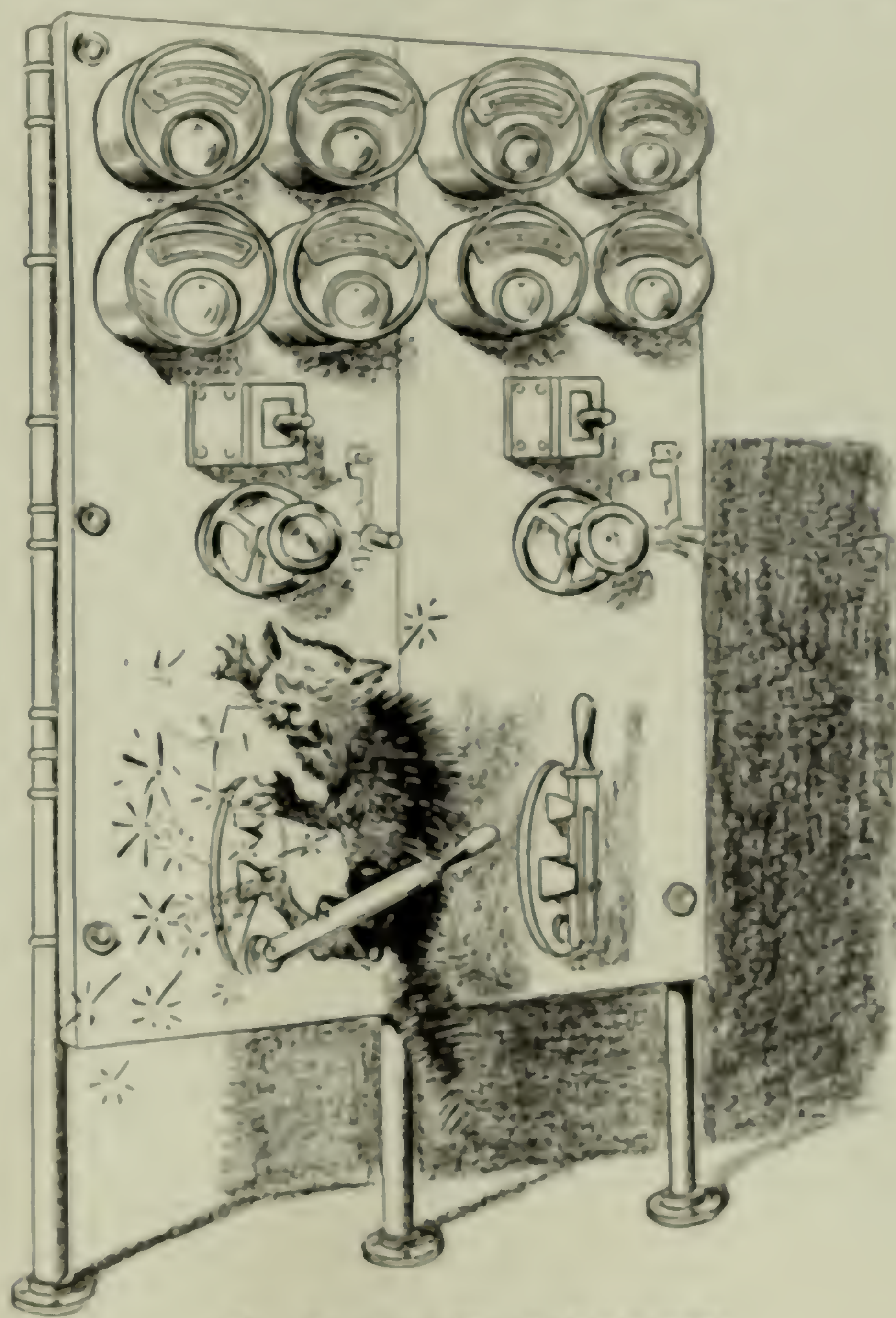
The armature or stator winding is protected from mechanical injury by steel cages or "bells" bolted to the housing ring, as shown in Fig. 4. These cages are built up of bent strips and circular segments of sheet steel riveted together.

These machines are built in sizes ranging from 50 to 1100 kilovolt-amperes and potentials of 240 to 2400 volts. They are wound for either two-phase or three-phase delivery at the standard frequency of 60 cycles.

Reddy Causes a Catastrophe in the Power House

By S. Kirlin

Reddy's official position in the power house was that of fourth assistant to the second engineer's oiler and he was supposed to make himself generally useful in any department in which he was needed. He was about ten years old, had a freckled face and a shock of brilliant red hair which had given him his nickname of "Reddy." His wearing apparel consisted of a shirt, overalls, one suspender and an impish smile which had never been known to come off before the occurrence of the event herein related.



The Result of Reddy's Experiment

His duties were supposed to begin at 7 a.m., but he usually got around earlier and put in the spare time tying knots in the legs of the overalls belonging to the day shift. Then he sat in a convenient place out of their reach and offered sundry bits of advice as they struggled to untie the knots. His activities in this line finally led to agitation among the men to be supplied with lockers, and after this was done Reddy had to find other means of entertainment. The men claimed that these lockers were the only good that had ever resulted from Reddy's connection with the company; yet, if he had been discharged for any of his tricks every man in the station would have joined in a petition to have him reinstated, for life around the plant would have been very dull without him.

One of his first capers after coming into the plant was to set fire to a small piece of oily waste, tie it on the [illegible] rim of one of the engines, and then enjoy the frantic efforts of the second engineer and the oilers as they ran around trying to find a hot box. After this had happened a few times they caught him at it and the chief convinced him of the inadvisability of doing it again. He occasionally varied his tactics by abstracting fruit from the cook's lunch basket, inserting a liberal amount of red pepper in it and returning it to the basket; the facial and lingual expressions of the victims at lunch time were his reward.

This trick usually exhausted everybody's patience and the men would catch him, carry him out to the boiler room, hold his feet up and pour coal dust down the legs of his overalls. After he had accumulated all the dust that would stick they would take him out in the yard to the overflow tank in which the condensers discharged and throw him in. Reddy enjoyed the latter part of the treatment as much as any of them, but did not like the amount of work that was necessary to get the coal dust out of his pants.

He met his match one day when he tried to play a joke on Hans, the station repair man. Business had been poor in Reddy's line all the morning and he was looking for trouble. He had not been able to find an opportunity to start anything worth while until he happened to spy Hans down on his knees scraping the end of a belt which was to be spliced, the glue pot being near at hand. When he discovered Hans in this position the possibilities for breaking the monotony appealed to him at once and he began to plan the most effective way to break it. The belt driving one of the exciters was close to where Hans was working and was charged heavily with static electricity, and an overpowering curiosity induced Reddy to find out if Hans' overalls were thick enough to insulate the electricity. Going into the stock room he found a piece of heavily insulated wire, one end of which he laid on the floor, bending it up so as to come near the belt; the other end he wrapped around a stick and touched it to the seat of Hans' overalls.

Ordinarily Hans was very slow in both speech and action and had never before been known to make a sudden move, but the effect of the shock was surprising. "Gott in Himmel," he yelled, and making a violent effort to straighten up, pitched forward on the floor and upset the glue pot. Scrambling to his feet he looked around and, seeing Reddy, knew instantly the cause of his trouble. Reddy had been so surprised by Hans' sudden move that he delayed making his exit, and as he turned to run he tripped over the belt. Before he could get on his feet, Hans had him and was calling to the other men to come and see what was going to happen to Reddy. The entire station force turned out to see the show, many willing hands helping to drag Reddy back to where the glue had been spilled, and while they held him, Hans wiped up the glue, using Reddy's hair for a mop. After getting it thoroughly saturated they carried him out to the boiler room and rubbed his head in the coal pile. Reddy spent the next two hours in the overflow tank trying to wash the coal and glue out of his hair, but with poor success. Coming into the engine room he tried to complete the job with a bunch of waste soaked in gasolene while the men stood around and gave him all kinds of advice about the danger of premature ignition from getting the gasolene so near his hair.

After this strenuous experience, Reddy remained fairly quiet for a few days, but such a condition could not last long and everybody around the station was wondering where he would break out next. His success in applying electrical treatment to Hans prompted him to try it, a few days later, on old Tom, the station cat. He had often tried the experiment of rubbing Tom's fur in the dark, and knew that as a generator Tom was a success; but he was curious to know if the process were reversible and how Tom would perform as a motor in case the current should be applied to him from an outside source. As a motor old Tom proved to be a "howling" success.

Reddy found him curled up asleep on the operator's desk, which stood just in front of the switchboard panel containing the circuit-breaker and instruments controlling one of the main units that was in operation at the time. He made the connection with Tom in somewhat the same manner that he had with Hans, but the result was rather different. Old Tom let loose a blood-curling yowl and went up in the air several feet. As he came down "all spraddled out," his feet landed on the handle of the main switch; his struggles pushed the switch open and there were fireworks all along the line.

Here was where Reddy's smile faded. After the men had got things straightened out and the service had been restored, the superintendent came in and investigated. Upon learning of Reddy's experiment on the cat he took that youthful genius "on the carpet" so effectively that he didn't smile for the next hour and a half. Then the superintendent went out into the boiler room where he could laugh without Reddy seeing him.

A Big Hydroelectric Development in India

A hydroelectric undertaking has been promoted by a Mr. Tata, of Bombay, which will require a capital of about twenty million rupees (more than six million dollars). The site for the generating plant is at Lanowli, about 40 miles from Bombay, the chief commercial city of India. The waterfall has a head of about 1734 feet, which is one of the highest in the world, being ten times as great as that of Niagara and four times as great as that of Kauveri. The average rainfall in this locality is 175 inches.

The power is to be carried over a transmission line only 43 miles long at a pressure of 80,000 volts. The plant, as at present laid out, will suffice to supply Bombay in the season of least rainfall with 30,000 electrical horsepower, on a basis of 3600 working hours a year, but provision is made for enlarging the plant by developing another valley, which will bring the total power to 50,000 electrical horsepower. The company expects to be able to bring the cost of the power down to 0.55 anna (about 1 cent) per kilowatt-hour. The development is being financed entirely by local (Indian) capital.

CORRESPONDENCE

Effect of Field Adjustment on a Rotary Converter

I once installed some compound-wound rotary converters for supplying current to 550-volt direct-current power circuits. One Sunday I received a hasty message from the power house that the transformers furnishing current to the rotaries were burning up. I found the transformers smoking hot but no permanent injury had been done.

As the power load was very light on Sunday, the operator had decided that high voltage was unnecessary and therefore proceeded to weaken the field of the converter in service, causing the current to lag and increase in value until the transformers were seriously overloaded. When the shunt field rheostat was set back to the point marked for maximum power factor the transformers soon cooled down.

To those who have had no experience with rotary converters a few words explaining their characteristics which bear on this trouble may be of interest. The direct-current voltage delivered by a rotary converter bears a certain fixed ratio to the alternating-current voltage supplied to it. Hence, in order to change the direct-current voltage the alternating-current voltage must be varied; altering the field strength merely alters the power factor of the alternating current. There is one field strength of a rotary converter that is called "minimum-input" field. At this point the alternating current delivered to it is minimum because the power factor is 100 per cent. To decrease the field current below this point will cause the current taken by the rotary to lag; to increase it will cause the current to lead. In either case the current is increased because the power factor is decreased. Therefore, when the operator weakened the field strength of the converter he caused the alternating current to increase sufficiently to overheat the transformer windings.

Anniston, Ala. G. J. Reynolds.

A feller frum over t' Jayville kum inter my ingin room tother day an' after he'd gawped at th' ingin fer awhile he ast me what th' thing wuz thet wuz whirlin' 'round so fast. I told him it wuz th' flywheel; he sed he didn't see how th' gol darnd flies cud stick to it with it goin' so fast.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

The Gas Power Boat "Holzapfel I"

There was launched recently from an English shipbuilding yard a producer-gas power boat for the Holzapfel Marine Gas Power Syndicate, Ltd. She is the first gas-power sea-going vessel to be built, and measures 120 feet in length between perpendiculars, 22 feet in breadth and 11 feet 6 inches in molded depth. She will carry a little over 300 tons on a draft of 10 feet. The vessel will be fitted with a set of high-speed six-cylinder vertical engines, developing 180 brake horsepower at 450 revolutions per minute. The plant will be in duplicate, each division being of 100 horsepower. The generators are square in section and will stand side by side on the port side of the vessel, with their "faces" to the engine room. The scrubbers, which will stand forward of the generators, are about 13 feet high, the lower portion being the wet cooler and the upper portion the dry scrubber. Both generators and scrubbers will be inclosed in a gas-tight compartment separated from the engine room, and provided with adequate ventilating arrangements.

The power of the engine will be transmitted to the propeller shaft by means of the Fottinger transformer, which reduces the revolutions of the latter to any desired number, within certain limits, while the engine is running at full speed. It can also stop or reverse the propeller while the engine is running at full speed ahead. The loss of power entailed by its use varies from 3 per cent. to 20 per cent., according to size, and to the gear or ratios of the number of revolutions of the prime mover to the number of those of the propeller shaft. A favorable ratio is from 300 revolutions of the prime mover to about 100 revolutions of the propeller shaft. In the vessel just launched the transformer is geared from 450 revolutions of the gas engine to 120 revolutions per minute of the propeller. The transformer, together with the thrust block, is coupled directly to the engine, and the total length of the two is about 20 feet.

It is expected that the consumption of anthracite coal will be from 2800 to 3400 pounds daily, as against 3½ tons of steam coal for compound steam engines of equal power. An air compressor and air cylinders will be provided for starting the gas engines. The blowing up of the gas producers while they are being fired up will be effected by air injectors supplied from the compressed-air cylinders. The vessel's average speed will be 7½ knots.—*The Mechanical Engineer.*

A Bituminous Producer Gas Power Plant

There has recently been installed at the works of S. F. Bowser & Co., Fort Wayne, Ind., a mechanically poked producer using Pennsylvania run-of-mine bituminous coal, the gas being used for operating a number of Riverside gas engines for lighting and power purposes. This producer installation, which was put in by the Holbeck Gas Power Company, of Cleveland, O., is one of the first of its type to be used for power, although this type has been in successful operation in furnace work several years.

Fig. 1 is a cross-section of the type of generator, cooler, rotary washer and dry scrubber used at this plant. It will be noted that the generator is of the up-draft type and the gas passes directly from it to the cooler by a short connection lined with firebrick and provided with a manhole cover at M. Bituminous crushed, nut or slack coal is fed automatically through the revolving drum D, which regulates the fuel according to the load.

The gas generator, which is 10 feet in diameter and rated at 750 horsepower, revolves on steel trunnions, making about one complete revolution every twenty minutes; it is driven through a gear train by an electric motor. The cast-steel poker P is oscillated by the gear mechanism, stirring the fire as the generator revolves. As the top remains stationary a water seal is provided at the top to prevent the escape of gas. Peep holes are provided through which to inspect the condition of the fuel bed at different points.

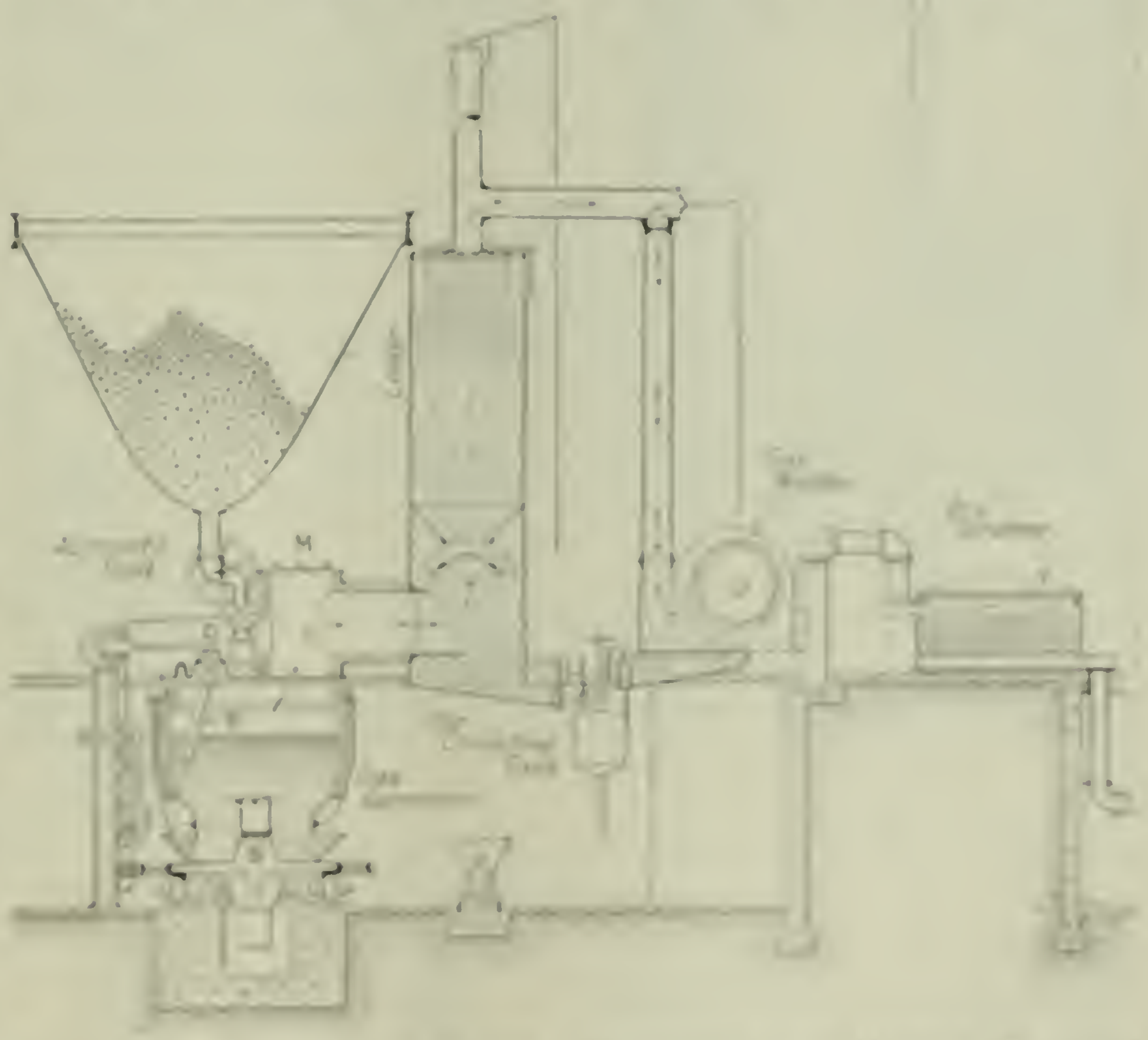


FIG. 1. SECTIONAL ELEVATION OF THE ELEMENTS OF THE HOLBECK EQUIPMENT

Ash is taken out through the lower water seal, this operation being necessary only once in 24 hours. Air and low-pressure steam are delivered to the fuel bed by the induction blower *B*, through the central tuyere immediately above it. The relation of grate area to the horsepower developed is such that at no time is a combustion rate greater than 16 pounds of coal per square foot of grate surface per hour required. No attempt is made to work at the high temperatures sometimes attained in producers. It was thought better by the designers to run at a lower temperature and make no attempt to fix the tar.

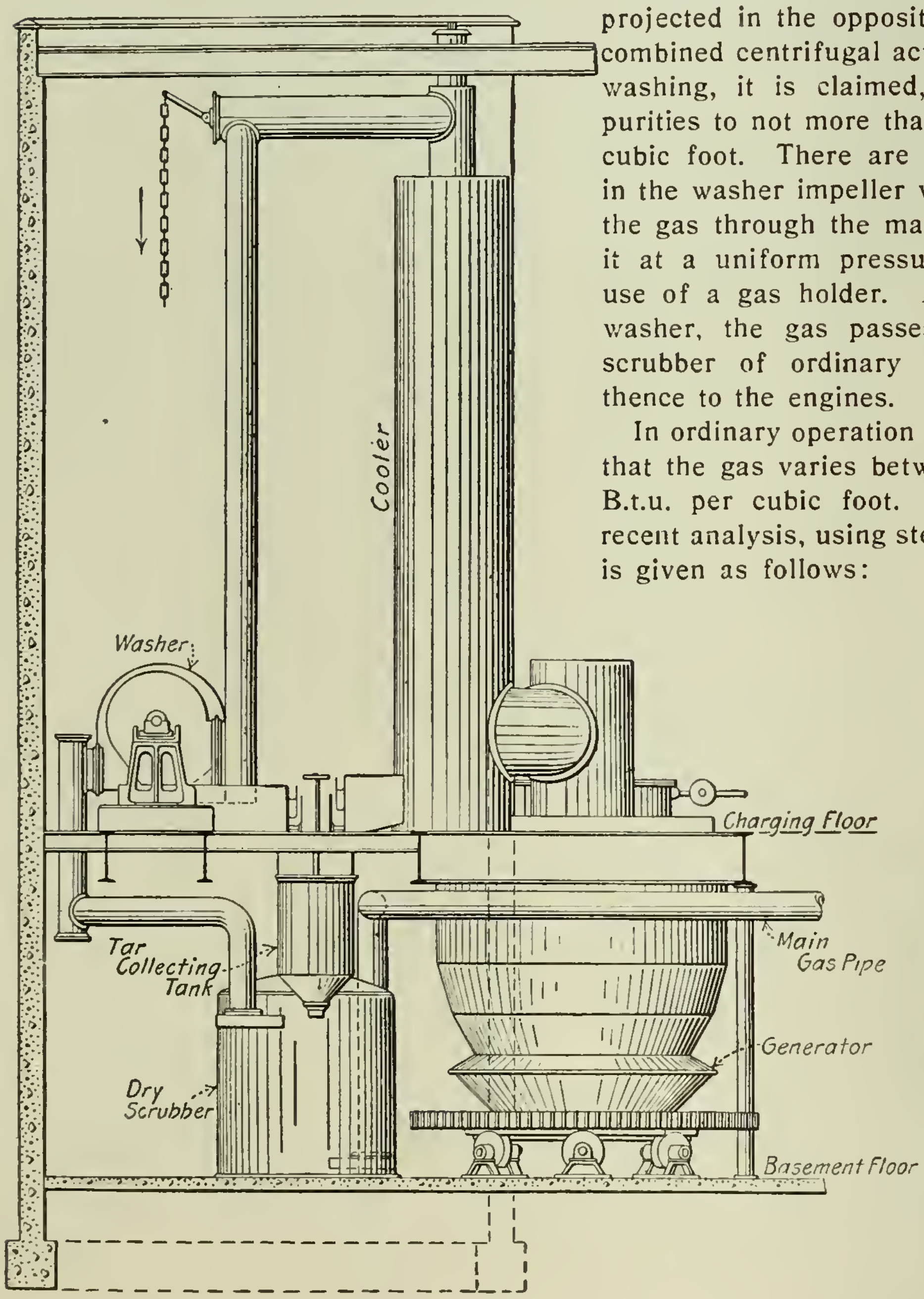
The cooler shell is a tall steel tank of simple riveted construction. In this tank the gas meets a fine spray of water discharged downward and filling the entire shell. The hot raw gas enters at the bottom and passes upward, being intimately mixed with the spray, cooled and partially purified. The tar which accompanies the gas in vaporous form is condensed and forms into tar bubbles, most of which pass off with the gas to the washer. A part of the tar, however, falls to the water seal at the bottom of the tower and sinks to the bottom, whence it is periodically drained into a tar-collecting tank.

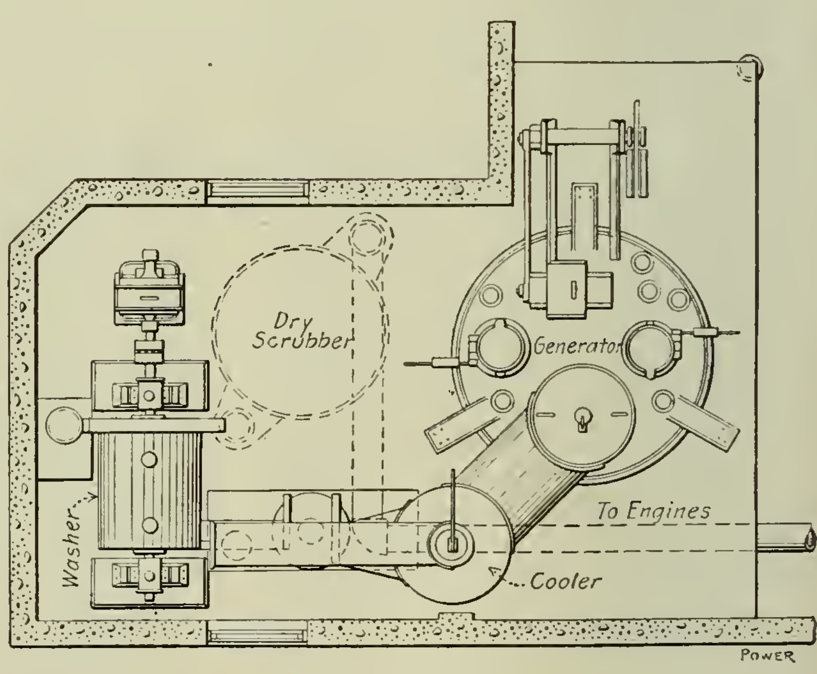
One of the vital parts of the system is the rotary washer, which mechanically separates the tar from the gas. This is of the Saaler type; its operation depends upon centrifugal force and the fact that the gas is lighter than the tar. The gas is caught by the rapidly revolving drum and whirled at high speed; the tar bubbles, being of greater density than the gas, are thrown outward by centrifugal action into a film of water covering the inner wall of the casing. Furthermore, the vanes on the revolving drum of the washer are so placed that the gas passing through the machine comes intimately into contact with a water spray projected in the opposite direction. The combined centrifugal action and thorough washing, it is claimed, reduce the impurities to not more than 0.015 grain per cubic foot. There are also incorporated in the washer impeller vanes which draw the gas through the machine and deliver it at a uniform pressure, obviating the use of a gas holder. After leaving the washer, the gas passes through a dry scrubber of ordinary construction and thence to the engines.

In ordinary operation it has been found that the gas varies between 175 and 180 B.t.u. per cubic foot. The result of a recent analysis, using steam at 20 pounds, is given as follows:

CO	20
H	18.9
CH_4	5.6
O	0.2
CO_2	8.4

The heat value was 184.4 B.t.u. per cubic foot. This high value, it is claimed, is largely due to the low temperature at which the producer is run, which evaporates the tar and enriches the gas with some of the higher volatiles of the coal which are ordinarily burned to carbon dioxide when higher temperatures are maintained.





Figs. 2 and 3. Elevation and Plan of the Producer as Actually Installed

Engineers for Gas Engines

By Charles O. Hamilton

For years salesmen—and builders, too, I am afraid—have preached the "no engineer" gospel in regard to the operation of gas and gasolene engines and there is no doubt that they and the misguided user have, in consequence, been reaping a big crop of trouble. What is the real truth about the gas-engine engineer question anyway? Why not thresh it out and settle it, now and for all time?

The "no-engineer" fallacy originated, I believe, in the early days when the gasolene engine was being introduced. The engines then offered to the public were of small power and low compression and had hot-tube igniters. They were sold largely to replace small steam plants, and once started—a mysterious operation understood about as well by a greenhorn as by a professional—they would keep on running as long as the fuel supply held out. If anything happened, the engine simply stopped. There was very little danger in its operation as compared with the known necessary care of a steam boiler and engine.

Nobody seemed to know much about the engines, not even the men who sold them. Therefore, why not make the claim that no engineer was needed? "No ashes"; "no dirty fuel"; "no cost except when running"; "no engineer." These looked like reasonable claims for the new power and were generally accepted by intending buyers as facts.

Gradually great progress has been made in gas power. Larger engines have been developed; new fuels found and used; higher compression, electric ignition, more exacting service conditions, all have followed. Now, the man familiar with steam engineering knows that the better-grade engine, with the accessories necessary for high efficiency, calls for more ability in the operator. This is equally true with gas engines. The better they are, the more efficient and reliable, the more attachments and appliances are required and the more skill needed to operate them.

The advancement in gas-engine practice was seemingly slow but it has, in reality, been very rapid. Ten years have produced a revolution in the way of sizes, types and fuels used. Yet many of the old-school salesmen are still active and cannot seem to get over using the arguments "No engineer" and the others which are so foolish in the light of present-day conditions.

This "no-engineer" talk has made an enemy of thousands of steam engineers. Even if they knew the truth about the silly claim, their antagonism was aroused and they naturally fought back in self-defense. Many have been so blinded by prejudice that they have not even recognized the advantages that the new prime movers possessed.

Many of us gas-engine men stopped talking this "no-engineer" nonsense long ago but we are still reaping the crop of trouble sown in former days and other crops are still being sown to some extent. We are, right now, at a most trying period in the industry. It is still hard to do business and do it right. For example, if a conscientious builder tells a prospective buyer that an engineer is necessary and another builder assures him to the contrary, what show has the man who tells the truth? The prospective buyer will naturally conclude that the conscientious man's engine is too complex and difficult to run and it will be extremely difficult, if not impossible, to get him to consider it at all.

Anybody with experience with both steam and gas power knows that a good gas-power plant requires less time from the operator than a corresponding steam plant. He also knows that it requires as good or even a better quality of man to get equally satisfactory results from the gas plant. Do not overlook this distinction. Less time, but as good or better men, are needed in gas-power plants.

It may interest the reader to know that a careful canvass of over two hundred plants put in by one company, ranging from 25 to 200 horsepower, shows that the average time required daily in plants running on natural or city gas or gasolene, where other work is at hand for engineer to do, is not over two hours. About 30 to 40 minutes of the time is spent stopping and starting at morning, noon and night, and the balance in occasional trips to engine room to look over the engine, and in overhauling, taking up bearings, repairing igniters and other incidental work at convenient times. Where a suction-gas producer is used it requires about another hour for handling the producer in the morning.

The experiences in these plants show conclusively that the better the operator, the less time he takes to take care of his engine. Where the operator is a good man, the engine is a good engine always.

The necessity for an engineer in a gas-power plant certainly does exist and always will. The sooner buyers realize it, the better for all concerned. Does the present steam engineer realize what an important voice he can have in saying who the gas engineer shall be?

LETTERS

Mr. Benefiel's Generator Lining

On page 494 of the March 28 issue there is a misprint in my letter on gas-generator linings. Instead of reading: "We set the firebrick in 8 inches from the shell," it should read "3 inches from the shell."

J. O. Benefiel.

Anderson, Ind.

Cracked Piston Faces

In the issue of March 28, John G. Kohnsberg asks for advice about cracked piston faces. I have handled a good many pistons from small gas engines, but I have never seen one cracked in the way shown by his sketch.

If all his cracked pistons are from the same make of engine, it would look as though it was due to the design of the pistons. An examination of the crack might help one to form an opinion.

I have seen a good many pistons from engines with the valves in the top of the cylinder which have had a piece knocked right out because of the valve stem breaking; lately, some of them have been completely and permanently welded with the oxyacetylene welding torch. I am very dubious about results with brazing, Smooth-on, or soft patches.

John Bailey.

Milwaukee, Wis.

I have been having a little of the trouble that Mr. Kohnsberg asks about and I believe the best way to repair a cracked piston face is to drill holes along the crack, plugging each one as soon as drilled and drilling the next so as to cut partly into the plug just inserted.

I cannot recommend this from experience, but will soon be able to report on the merits of the plan as I have charge of three 12-inch two-cylinder engines in which every piston developed a crack after about three years of service. Only one of them has ever leaked. This one I first calked with copper, which soon came out; I then used soft steel instead of copper, making small wedges which would drive tight in the crack. This has been holding tight for several months but the first time I have occasion to take the piston out I shall drill and plug it, unless someone suggests a better way.

Floyd L. Fearing.

Kane, Penn.

Mr. Hall's Inconsistent Engine

In the issue for March 28, Mr. Hall wants to know why opening the pet cock on the third cylinder of his engine makes the engine run faster. It seems to me that the mixture is too rich in that cylinder, perhaps due to the piping to the intake valves not being such as to feed the same mixture to all four cylinders, and when the pet cock is opened the third cylinder gets about the proper amount of extra air to make the proper mixture. The intake piping should be arranged as shown by the accompanying sketch.

Symmetrical Intake Manifold

B. M. Howe.

Rural Retreat, Va.

I think if Mr. Hall will examine his engine he will find that there is a pocket in the intake pipe leading from the carbureter to cylinder No. 3, which collects some liquid gasolene. Surface evaporation from this makes the mixture too rich until it is diluted by the fresh air drawn in through the pet cock.

Another possible cause is a leak in the induction pipe which may admit air in such a way as to dilute the mixture going to the other three cylinders. Mr. Hall may have enriched the mixture to suit these cylinders and made it too rich for No. 3, which does not happen to be affected by the leakage of air. Opening the pet cock would tend to correct this.

I would suggest also that he examine the action of the exhaust valve on the third cylinder. It is quite possible that this valve opens too late or does not have sufficient lift to allow the exhaust to entirely escape and thus maintains some compression at all times unless it is relieved by opening the pet cock. I have repaired and adjusted several engines that had this trouble. If this is the trouble, it can be quickly proved by placing a thin piece of wood or iron under the end of the valve stem so as to increase the lift of the valve. If the trouble is due to insufficient lift, the engine will immediately speed up.

H. K. Wilson.

New Bedford, Mass.

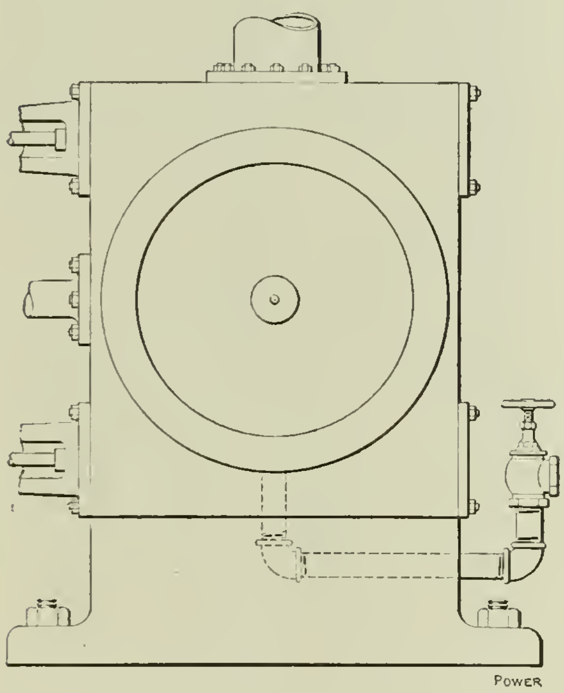
Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Unnecessary Clearance Loss

Builders of reciprocating engines recognize that clearance is a source of considerable steam loss, and design their engines so as to reduce this loss to the lowest possible amount. The erecting engineer, however, frequently makes mistakes in erecting the engine which offset much of the builder's effort toward economy.

I recently saw an illustration of this in a municipal electric-light plant, in which one of the main generating units consisted of a 350-horsepower four-valve engine. Each end of the cylinder was equipped with a 1½-inch relief valve, the openings for which were on the bottom of the cylinder. There was plenty of room to have placed these valves in an inverted position directly underneath each end of the cylinder, by simply using nipples long enough to reach through the lagging. Instead of doing this, however, the erecting engineer had connected them as shown in the illustration, putting in a trifle over three feet of 1½-inch pipe between the valves and the cylinder.



A Case of Unnecessary Piping

The total volume of this six feet of pipe amounts to something over 125 cubic inches and as this volume was added to the total clearance of the cylinder it is easily seen that it did not add anything to the engine's economy; in fact, the engine gave such poor results in this respect that it was only used when the peak load made it necessary.

S. Kirlin.

New York City.

Leaving Things Right for the Man Coming On

The duties of the men in the power plant are made imperative by the demand for satisfactory service and the assignments by the chief. Nevertheless, a man can make the duties of the man coming on the next shift difficult, although apparently leaving everything in a satisfactory condition. When leaving his shift the operating engineer should make a tour of the plant to determine the pressure on the boilers, the water level in the boilers, and to see if all engines and pumps are in proper working condition.

If an engine is running condensing, the degree of vacuum maintained should be noted, making sure that all apparatus is working satisfactorily and, if not, it should be reported to the man coming on duty so that an investigation can be made and the trouble remedied without delay.

The oiler should, as a final duty, take a trip around the engines, feeling of all bearings and running parts to see that they are not running unusually warm. If anything should be found not running right, the oiler should report it to his successor, so that he can keep a special watch of it. In feeling for hot bearing or pins, always use the back of the hand, because it is more sensitive than the front of the hand. The oiler should leave all oil and grease cups, reservoirs and lubricators full or nearly so and make sure that they are feeding. He should also leave all oil cans full and see that all drip pans are empty and wiped out. He should also pick up any waste that may have accumulated during his shift and leave everything as clean and orderly as circumstances will permit.

One of the most important duties of the fireman in this connection is to leave good fires for the next man. Sometimes in a plant where the fuel on each man's shift is weighed and kept on record, there is a temptation to leave light fires for the next man to build up. Of course, this low coal consumption looks good to the "powers that be," so the mean fireman gets the credit of being a more economical fireman than the other.

If the man coming on duty is to clean fires at the beginning of his shift, the man relieved should leave them in the right condition. He should have a heavy bed of incandescent coke in one-half of the furnace, and the other half burned almost down to the ashes. He should also have the water level as high as practicable. These conditions enable the man coming on duty to clean the fires with comparative ease and without the necessity of feeding water to the boilers during the period of cleaning.

The night fireman in a manufacturing plant should leave the fires thoroughly clean and as well coked as possible, because there is no demand for steam while the fires are coming up in the morning; the pressure quickly rises to that required for the day's run before the fires and furnaces have become thoroughly hot, consequently the day man has to get a morning's start under adverse circumstances. The morning's start is the hardest part of the day, assuming the boilers are worked at or above their rated capacity.

The night man can also help matters by having the water well up in the boilers, so that the day man will not have to feed water to the boilers until everything is in running condition. He should also leave the ashpits clean and partly filled with water, the floor swept and the lubricator or the feed pump full of oil.

J. A. Levy.

Greenfield, Mass.

Reduced Compression and Lead Saves Coal

At one time I worked in a plant in which there was a 24 and 48 by 48-inch cross-compound Corliss engine, rated at 1500 horsepower.

The economy of the plant was not bad, but the engine did not carry the peak loads at all satisfactorily. I applied the indicator and reduced the lead and compression until the engine began to run noisily. After adjusting for quiet running, the engine was let alone.

Another engine that was rated at 800 horsepower was indicated and the valves set about the same as in the first instance. The load varied considerably each day and at different times in the day. The load the next two days after the engine had been adjusted happened to be heavy, but when I went into the fire room the firemen were taking it easy and remarked that the load was lighter than it had been. The recording instruments, however, showed that the load was being carried much more easily and the voltage held up better than formerly. Last, but not least by any means, not as much coal was being burned per kilowatt-hour as formerly by an average of 3000 pounds less of coal per day out of a total of from 70,000 to 80,000 pounds.

The engine had double eccentrics and the governor controlled the cutoff of both cylinders. The high-pressure cylinder was steam jacketed on the heads only. Saturated steam was used which, by calorimeter tests at the throttle valve under similar conditions, showed from 98 to 99% dry.

C. B. Smith

South Framingham, Mass.

Vacuum Increased by Reducing Pump Speed

In the power plant where I am employed there is a condenser that is supplied with water by a rotary pump. This pump was run at a speed of 72 revolutions per minute and a vacuum of 26½ inches maintained.

Recently, a shortage in the supply water was experienced. The speed of the rotary pump was reduced to 44 revolutions per minute, and paradoxical as it may seem the vacuum is now maintained at 28½ inches.

C. D. Eldredge

Fairport Harbor, O.

Adjustable Indicator Cord Hook

The object of this device is to provide a means whereby the indicator cord can be adjusted to run parallel with the center line of the engine. The accompanying drawing shows that it is adjustable both horizontally and vertically. The pointed screw *A* passes through the flange of the plug *B* and is intended to prevent the plug from unscrewing from the crosshead in case the hook should get caught in any way, as the block *C* would turn on the long arm instead.

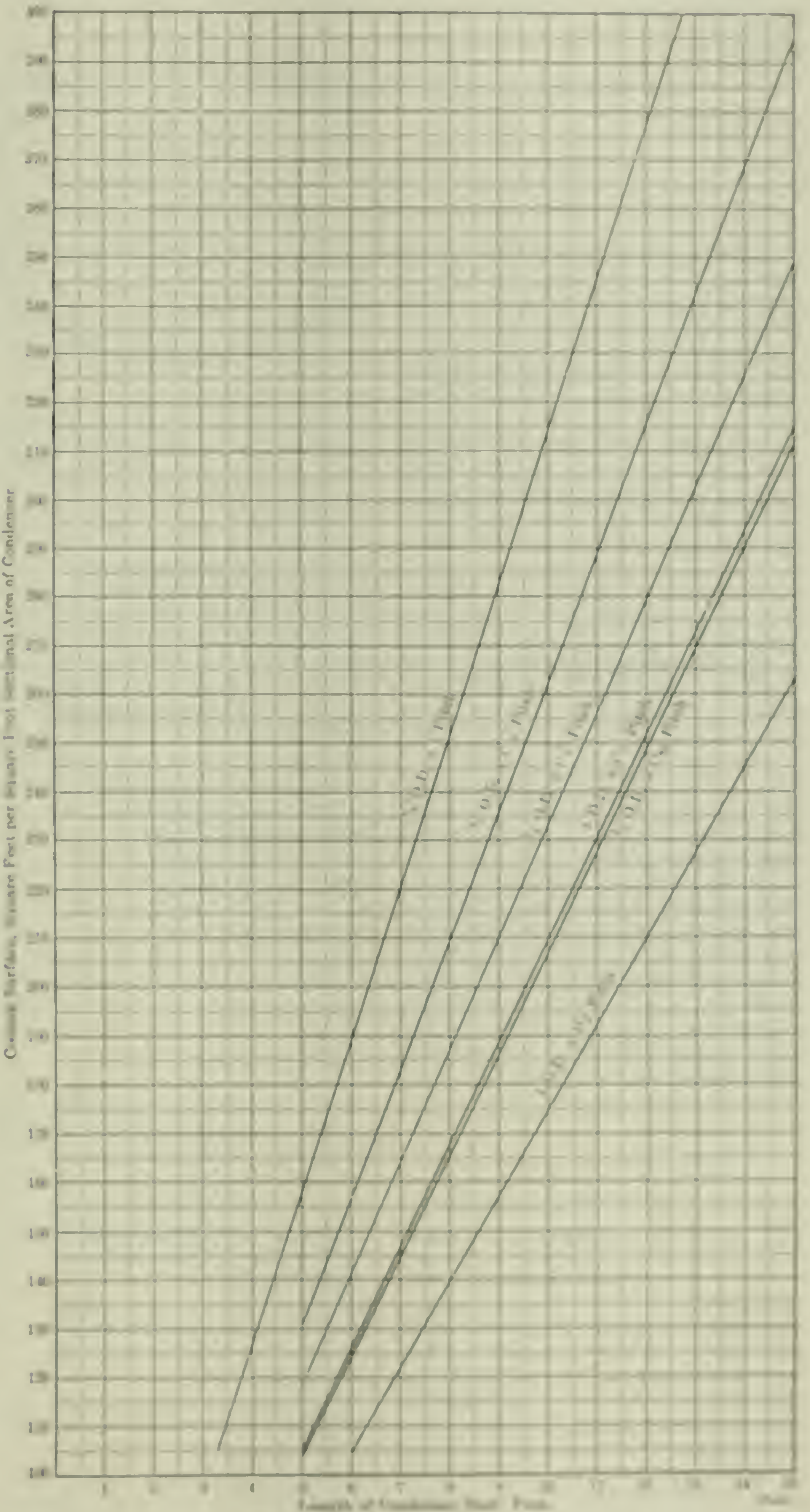
Adjustable Indicator-cord Hook

George J. Little.

Passaic, N. J.

Condenser Diagram

The accompanying diagram gives curves which enable one to approximate the dimensions of surface condensers to be estimated, having been given the surface in square feet and the length of condenser shell in feet.



Condenser Diagram Chart

The tubes have a 5/8-, 3/4- and 1-inch external diameter, 18 Stubs wire gage thickness and a 60-degree pitch. The tubes are arranged for two passes of circulating water, but with a four-pass condenser deduct approximately 30 per cent. of the surface shown. If the ...

dome is dispensed with, necessitating provision of steam paths between the tubes, suitable connections should be made.

This has proved of considerable value to me and doubtless will be to many engaged in the design of condensing plants.

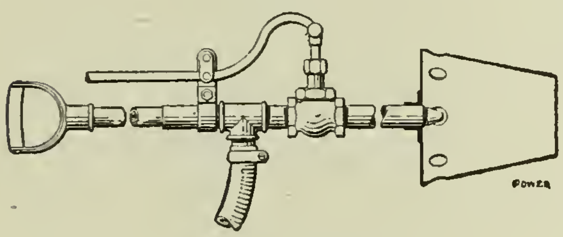
W. VINCENT TREEBY.

Goodmayes, Eng.

Homemade Tube Blower

Following is a description of a tube blower that I made from a few old fittings. The accompanying diagram shows the completed blower.

I took an old tee and screwed a short piece of pipe into it and plugged the inner end. Then a wooden handle was fitted into the other end of the pipe, an old shovel handle being used to furnish a grip. The controlling valve was made out of an old ¾-inch globe valve, with the threads removed from the stem, so it would work freely in the gland nut.



TUBE BLOWER

The valve is set so the pressure will come on top of the disk.

The blower head was made of No. 18 gage iron; the nozzle projecting about one inch into the head, which is 6 inches long. The end that enters the tube is 3½ inches, and the other end is 6 inches in diameter. It is used on 4-inch tubes.

I can blow out seventy 4-inch tubes in four minutes. A hand scraper is used once a week, the blower being used the rest of the time.

W. H. MATTHEWS.

Tecumseh, Neb.

Head End Cinders for Fuel

This is a description of the apparatus used and the results obtained in a steam-power plant using head-end cinders under the boilers. Head-end cinders are the half-burned particles of coal which are drawn out of the firebox, through the flues, and lodge behind a screen in the smoke chamber of a locomotive engine. An analysis of these cinders shows them to be a form of coke with most of the volatile matter and moisture liberated, but still very rich in fixed carbon.

The boiler under which a test was made was an ordinary return-tubular boiler of 100 horsepower capacity, set exactly as it would be set for coal burning. The grates were of the very fine sawdust type and were placed 30 inches below the boiler to provide space for the very thick fire required. The grates had 10 per cent. greater area than would have been required for coal burning.

All ashpit doors were entirely removed and the openings bricked up, leaving four 4-inch tiles protruding through and extended to about the center of the firebox. In the center of each of these tiles was placed a ½-inch pipe for a steam jet, the four small pipes being fed by a 1½-inch pipe from the boiler. These steam jets serve the double purpose of assisting combustion in the furnace by the mixing of steam with the gases, and also creating a forced draft by drawing air through the tiles in the firebox. About 10 per cent. of the steam capacity of the boiler was required for the jets.

An extra door was placed in the side of the ashpit for the removal of ashes and it was found necessary to clean the pit about once in two weeks.

To appreciate fully the results obtained in this plant it is necessary to first consider the cost and supply of cinders. This plant is located at a railroad division point where engines are cleaned out and where cinders accumulate, more than enough to supply this plant. Cinders are sold at $5 per car, regardless of the weight of the car, but the average car probably contains about five tons.

This plant has a 50-horsepower engine and a 35-kilowatt generator running from dusk to midnight and from 5 a.m. until daylight, making a total run of about 12 hours per day at the time this test was made. During the remaining 12 hours per day there was just sufficient fire under the boiler to heat the building in which it was located. The daily consumption of cinders was 3000 pounds, of which 2500 pounds were used on the lighting load and the remaining 500 pounds to keep the building warm.

The low fuel cost of this plant is apparent. The total average load was 240 kilowatt-hours per 12-hour run, which means 10.4 pounds of fuel per kilowatt-hour, not a very low fuel consumption when compared with some coal-burning plants, but an extremely economical plant when taking into consideration the low cost of the fuel. The cost of fuel averaged $0.0052 per kilowatt-hour, which compares very favorably with the fuel cost of internal-combustion engines in plants of this size.

Aside from the economy of this fuel, another great advantage was found in that it was practically smokeless, due to the fact that the volatile matter was entirely removed while in the locomotive firebox. Another advantage was the almost total absence of ash and the attendant bother and expense of the removal of same.

There are, however, some objections to this fuel, some of which are rather serious. Chief among them is the care of the fire, as the cinders are very light and quick burning and the fire requires frequent replenishing to maintain the necessary thickness; the fire must be thoroughly cleaned at least once every hour or the clinkers will get so large that the fire will have to be practically killed to take the clinkers out. Another objection is the fact that 10 per cent. of the steam output of the boiler is used to blow up the fire and, consequently, the full capacity of the boiler could not be depended upon. The life of a boiler is materially shortened by the use of this fuel, just how much I am unable to say, but I know of one boiler that was so badly crystallized after ten years' use that it had to be condemned, but this was at least partly due to lack of care of the boiler.

Taking all things into consideration there is no good reason why these cinders should not be used more in plants which are located at points where they are obtainable, provided the plant is not sufficiently large to make the necessary investment to get the highest efficiency out of a coal-burning plant a drawback.

P. E. MATTESON.

Fort Dodge, Ia.

Catalog Misstatements

Manufacturers, for a reason best known to themselves, put in at the back of their catalogs a section entitled, "Useful Information." While the body of the catalog is written by their best engineers and carefully revised and checked, this information section is a haphazard miscellaneous collection of supposed facts which I hope were not compiled by anyone higher up than the office boy.

I have often noticed rather serious errors in this section of catalogs and have now at hand three catalogs all containing the same mistake. Evidently the error was made in one of the catalogs and copied by the other manufacturers. This shows the necessity of avoiding any misstatement of facts, for, if the men getting up a catalog and who are on the lookout for errors are led into copying such a serious blunder from another catalog, how much more likely are engineers reading the catalog apt to use the incorrect figures and be led into serious mistakes.

Any one error in itself may not seem of much consequence, but the principle at stake is large, and the consequences arising from the use of such misstatements may be great. For most engineers take the statements in the catalog of a reputable concern as facts and unless they can be correctly presented, it would be much better not to present them at all.

W. L. DURAND.

Washington, D. C.

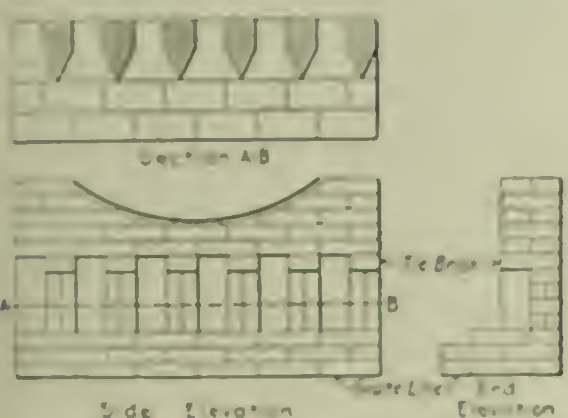
Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Furnace for Bituminous Coal

It was a pleasure to read F. B. DeMotte's letter in the March 21 issue. His thought for the welfare of the men under him is very creditable, and I feel sure that he will have their full support and coöperation.

In regard to changing from bituminous to anthracite coal, it appears to me that the price of the latter makes this impossible. Suppose anthracite containing 14,000 B.t.u. were procurable at the price mentioned in his letter. The increase in the cost of the coal would be 100 per cent. and the increase in the available heat would be only 16.7 per cent. Then, the cost of installing a fan to increase the draft and the cost of furnace alterations, together with the loss due to steam used to run the fan would



Design of Bridgewall for Aiding Combustion

probably eat up the gain due to the extra heat available from the anthracite coal.

I suggest the arrangement of a system of firebrick arches and baffles to secure smokeless combustion with the bituminous coal. The accompanying figure shows a bridgewall design of which I have a high opinion. The hot gases leaving the grate strike against the wedge-shaped bricks that are placed vertically on the bridgewall; the gases are spread out by the wedges. This results in a much better mixing of the combustible gases and more nearly complete combustion.

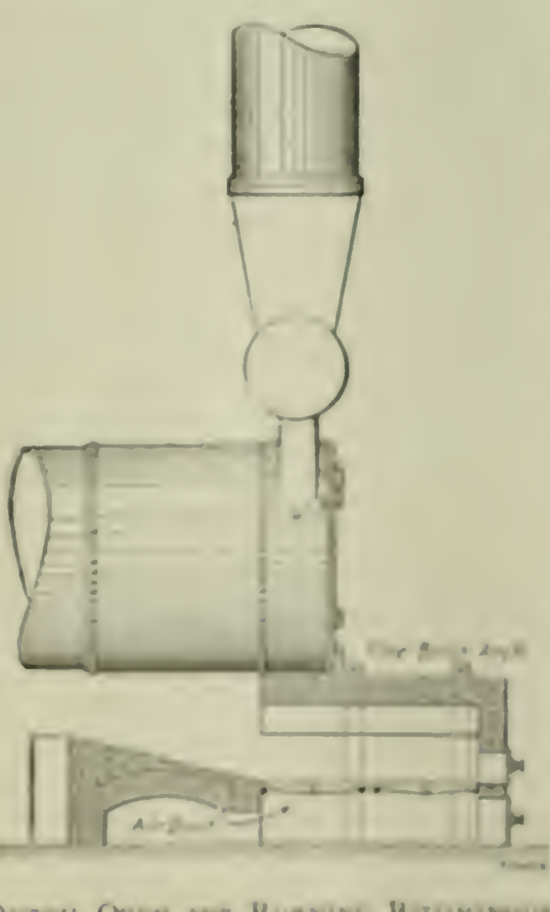
Care should be taken when installing the bridgewall to have the area of the openings at least equal to that of the tubes. The reversed arch rising around the boiler shell should be about [illegible] inch clear of the shell to allow for expansion. The soot found in the combustion chamber will be of a gray color and more like a fine ash, proving that combustion is quite complete.

The only way I know in which to keep the boiler house clean is to keep at it. A steam nozzle used in the chimney while the tube blower is working would certainly keep much of the dirt out of the room.

H. Prew.

Montreal, Que.

The question of F. B. DeMotte in the issue of March 21 in regard to the smoke and dust nuisance in his boiler plant is a creditable one. Wanting to improve the plant and the conditions of the fireman, he asks for the opinions of Power readers.



Dutch Oven for Burning Bituminous Coal

If he does not have to crowd the boilers while using run-of-mine bituminous coal having a heat value of 12,000 B.t.u., a steam jet is not necessary to secure smokeless combustion. A jet should never be used for continuous operation but only applied for temporary use in cases where there are extreme demands on the boilers during short periods.

As Mr. DeMotte has ample boiler capacity, I would suggest the installation of a dutch oven, as shown in the accompanying figure. This arrangement of furnace has proved very successful in just such cases and is not expensive. The room it occupies is generally not of urgent need as there is generally at least 20 feet of space in front of the boilers as clearance for the tubes. The dutch oven takes about 5 feet; this would leave 15 feet for the firemen to work in, which is ample.

The principle of operation of the furnace is easily explained. Under ordinary circumstances the air by passing through the air duct is preheated and comes hot under the grates. In the meantime it has cooled the firebrick arch forming the roof of the duct and in that manner it lengthens the life of the arch.

The fire fed by preheated air will be a good deal hotter than under present conditions and the flame will be about 5 feet longer, giving the smoke an opportunity to burn thoroughly before striking the cold boiler shell. Under the present conditions the flames strike the cold boiler shell before the smoke formed has an opportunity to burn.

Furnaces as proposed have been very successful in preventing the smoke nuisance when the boilers were not overcrowded. They also greatly abate the dust nuisance of which Mr. DeMotte complains.

As to the use of anthracite pea coal, this does not seem advisable. It is twice as expensive as the run-of-mine now used and requires a little over twice as much draft.

Rulof Klein.

New York City.

Effect of Discharge Pipe Size on Motor Load

Referring to Mr. Lee's letter in the March 14 issue, it is my opinion that Mr. Lee is mistaken about the size of the discharge pipe of the triplex pump under discussion. I was assistant engineer when the pump was purchased and I helped to install it. Unless my memory does not serve me well, the discharge outlet was 3 inches in diameter and not 4 inches as he stated.

During the years that I had charge of the plant the pump motor took 5.1 kilowatts per hour.

Francis J. Doyle.

Watertown, S. D.

Water Gages

Various writers have expressed their opinions as to the different kinds of valves and their location on water-column connections.

Where the water is nearly free from scale or sediment the globe valve should give satisfaction, but if there is a great amount of scale to contend with I prefer the gate valve and would use a cross in the water connection. Instead of connecting the drain to the bottom of the cross as Mr. McGahey showed in the December 13 issue, I would connect it directly opposite the boiler connection by using a short nipple and plugged tee as an elbow and carry the drain down according to circumstances. With this arrangement there would be much less danger of scale lodging in the cross and the tee would be handy as a means of cleaning out the pipe in case of an emergency.

I see no reason for using a cross in the steam connection as very little, if any, solid matter would rise to that hight. In exceptional cases where the boiler foams a great deal a cross might come in handy in the steam connection.

William E. Piper.

Farmington, Utah.

The Cost of Power

I was much interested in the editorial in the March 21 issue on the cost of power and with the writer thereof regret that at the recent meeting of the American Society of Mechanical Engineers there apparently was no determined effort made on the part of the isolated-plant engineers to refute the arguments of the central-station people.

It has been my experience that the central-station salesman or sales engineer has not been overburdened with conscience when competing with the isolated plant. He has invariably used high figures for cost of installation, high coal bills, discrediting the matter of the use of exhaust steam, and has done everything possible to make the figures for the cost of power with the isolated plant appear as high as possible, bringing in many items which are rather questionable in their actual application to the situation.

There is no real reason why the generating outfit of an isolated plant should not be quite as economical in its operation as a fair-sized unit in the central station, if bought for the express purpose of low cost in power production. Frequently, however, this point is not of prime importance. The value of the exhaust steam as a means of heating water or for serving some other purpose and for heating the buildings, is of greater importance than is good steam economy of the engine. The mechanical efficiency, however, is no lower for engines for this service than any other, nor should the efficiency of the generator be any different.

When a fair-sized central station can produce a kilowatt-hour at the switchboard with 4 to 5 pounds of coal and often even less, there is no reason for assuming that a fair-sized unit in an industrial plant should not do the same. This, however, does not seem to enter into the calculations of the central-station agent, as is seen in the article by Mr. Parker, where he takes 6½ pounds of coal per kilowatt-hour as the consumption for a plant of 150 kilowatts capacity. Further, I note that Mr. Parker makes a charge of $936 against the industrial plant for emergency service, whereas in the electrically driven plant with power purchased, there is no such allowance; is the practice of central-station companies such that they can guarantee continuous service? The records of the past few years would hardly warrant any such assumption. On the other hand, the records of many individual plants are better than those of the central station, so we could reasonably wipe out the emergency-service charge or put a corresponding charge against purchased power.

I also note that the manager's time and the clerical expense are charged against the isolated plant at $1150, whereas the manager's time and clerical expense under the head of purchased power are but $25. It may be Mr. Parker's experience that no attempt is made to check the bills or to follow up the meters or to pay any attention to the cost of power as purchased. My experience, however, is different, and I believe that the proportion of manager's time and clerical expense chargeable against power in a plant with purchased power is very nearly as much, if not quite, as in an isolated plant.

I further note that the fixed charges against the isolated plant are pretty heavy, so heavy as to cause some question as to their actual fairness; I am led to question whether the central-station company makes any such charges against its own plant when it is supplying power at the low rate quoted. The central-station business is, of course, that of producing and selling power and if it invests any money in apparatus for the production and sale of power, it does it with the expectation of getting a fair return on the money, just the same as does an industrial enterprise of any character. If there is to be a charge termed profit ratio against the money invested in an industrial enterprise for production of power, in order that it may produce its goods, it would seem equally true that there should be a similar charge against the money invested in the apparatus of the central station. I decidedly question whether this is done.

It seems to me that the amortization figures would be somewhat larger for the central station than for the average industrial plant, owing to the fact that the machines are harder worked and scrapped earlier in their life to make place for new and more efficient apparatus. The taxes and interest might be somewhat smaller. My figures, comparing the central plant with the industrial plant, are as follows:

Marginal interest	5 per cent.
Amortization, so called	5 per cent.
Taxes and insurance	2 per cent.
Fair profit ratio	11 per cent.
Making total fixed charges	23 per cent.

Taking this as a basis of the fixed charges, I examined into the report of one or two of the big electric companies as given in the State report, and have taken their own figures as regards cost of plant, electric lines, transformers, meters, arc lamps, etc., and have taken their operating expenses, including operation of station, distribution of power and management. I have also taken the income as given in this report, which, according to the report, includes income from sale of current and other sources. In addition, I have taken into account the total kilowatt-hours generated and the total kilowatt-hours sold, also in accordance with the report. Against the total cost, I have made a charge of 23 per cent., leaving out, however, in this particular case, one-half of the real-estate cost, as the company owns considerable land which is not built upon and I wish to give all a fair show. From these figures I find that the average remuneration for the total kilowatt-hours generated is 4.7 cents per kilowatt-hour, and for the total kilowatt-hours sold, 6.6 cents per kilowatt-hour. Its expenses have been:

Operating, including distribution and management, 2.5 cents; per kilowatt-hour sold, 3.5 cents.

On the fixed charges, the cost per kilowatt-hour generated is 4.7 cents; per kilowatt-hour sold, 6.5 cents, making a total cost per kilowatt-hour generated of 7.3 cents, and for a kilowatt-hour sold, 10 cents.

These reports are average, but they show conclusively that there is something lacking in the method of charging if the total cost of producing power is 3.3 cents greater than the price for which it is sold. This would show, then, that according to Mr. Parker's figures and method of figuring that this company is operating at a loss. The company, however, is paying exceedingly good dividends and the stock is selling at considerably over par.

Apparently, then, the central station does not figure its costs on the same basis as it would have the individual plant figured. The average purchaser of power has not the remotest idea what his power bill is going to be. He leans entirely upon the sales agent of the central station, and in many cases goes so far as to allow the engineer of the central station to lay out his plant, in some cases relying upon him to such an extent as to wipe out his original plant, in the firm belief that the figures given to him by the central-station sales agent will be realized. The only safe way for the purchaser of power to make a contract with the central station is on the guarantee basis of the cost of power; and if the central station will not give a contract on the guarantee basis, the sales agent is either a fool or a knave and the chances favor the latter, for the fact that he will not make a guarantee is pretty good evidence that he is certain that his figures are not correct.

The purchaser has one recourse, that is to put the matter into the hands of a disinterested party for thorough investigation, in order that he may have a careful and concise estimate of the cost of the power used throughout his plant, what it will cost him to make the changes necessary to install the electric drive, and an estimate of the cost of power as operated by electric drive with the increased fixed charges due to the added installation and the loss of the apparatus which may have to be discarded. Every item entering into the operation of the plant should be gone into, for in the northern latitudes especially the question of heat is of much importance. There often is also the item of steam for industrial purposes, for heating water for toilet and other purposes, all of which should enter the calculation. The value of the electric drive as regards its cleanliness, convenience, economy of space, uniformity of speed and the possible increase in production due to the constant speed must also be considered.

The owner should be very careful that the man he employs to examine into these details goes into them so completely as to preclude any possibility of error, and that he, the owner, thoroughly understands what the engineer has done and what his figures mean. The engineer should explain the weaknesses and possible dangers of power as supplied from the central station. It is usually claimed that central-station power is more reliable than the power generated by isolated plants. This is questionable. The engines in an isolated plant are no more liable to break down than are those of the central station, nor are the boilers. There are no long-distance transmission lines to take into account, little or no danger of electrolytic troubles, practically no danger from operating troubles in the operating station, lighting is not a factor, and on the whole there is more reason to believe that the isolated plant is less liable to interruption than the central station. The isolated plant has against it the charges in common with the central station, except the added clerical expense of solicitors for business, meters and the meter readings, the clerical expense of rendering the bills and keeping track of the accounts and the very heavy expense of distributing lines and the losses over these lines, so that in isolated plants of fair size it ought actually to cost less at the isolated plant for power than at the central station. It would have to be a plant of pretty small size that could not produce power as cheaply as the central station could deliver it to this plant, not taking into account the value of steam for heating purposes, but figuring on using the best possible type of prime mover. Then, however, taking into account the value of steam for various uses, the cost of power might be considerably reduced; first, by a reduction in the first cost of the engine owing to using a less expensive type of engine, and, second, taking into account the value of the exhaust steam which would have to be supplied anyway.

HENRY D. JACKSON.

Boston, Mass.

Valve Leakage

At various times articles have appeared in POWER on the subject of leakage through slide valves. Some of these have tended to show the advantage of the single-valve type of engine over the four-valve type using flat balanced valves.

Perhaps my experience with a pair of engines of the latter type might be of interest in that it does not agree with some of the statements made in the articles referred to above, in which it was claimed that these valves were hard to keep steam tight due to excessive wear and the large amount of clearance required between the valves and pressure plates.

In the engines of which I am writing the clearance amounts to 0.003 of an inch on the steam side and 0.0025 of an inch on the exhaust side. During ten years' time the wear on these valves was about 0.01 of an inch, which was taken up at intervals of about two years, about 0.002 at a time. The method used to determine the clearance is to shut the engine down after a run and while all of the parts are as near the working temperature as possible insert the blades of a thickness gage at different points of the valve travel.

At one time the steam valve of one engine became leaky while the exhaust remained tight and the result was the engine would run off when no load was on the generator. A few hours' work with the scraping tools stopped this trouble. This goes to prove that leakage from the steam chest to the cylinder is not entirely lost as it is when the single valve leaks steam into the exhaust passage. The amount of clearance is largely a matter of design and temperature and the wear a matter of good metal and lubrication.

The advantage of independent release and compression is well worth the extra complication, and the large ports and small clearances possible with this design more than make up for the friction of the extra parts.

P. L. [illegible].

McKeesport, Penn.

Writers among Engineers

The question has been asked why more engineers do not write of their experience.

Those that do write should at least be given credit for their intention of letting others profit by their experience, and when their letters are castigated as "hot air" and "rot," I say it is wrong and uncalled for.

In the March 21 issue, under the heading "Specialists," Mr. Scotch tells us the class of an engineer that he is and he evidently thinks that the same class of engineer writes the practical letters in POWER.

I would like to tell Mr. Scotch that the writers of practical letters do not get their inspiration from furnaces or gas houses and that the erector or experts sent out by the manufacturer today are human and as liable to make mistakes as any other men. But, their mistakes, as a rule, do not come under the observation of the dinky one-horse engineer. The practical progressive engineer that has work going on, either repair or new installation, is onto his job and when things are not going right, whether it is the fault of the mason, carpenter, erecting engineer or laborer, he does not stop to consider how many years' experience he has had; he corrects the trouble, for that is what he is there for.

M. [illegible].

Burlington, Vt.

In the issue of March 21, Mr. Beck[illegible]with makes a good point. He asks for information in regard to getting up an article and the best subjects to write upon or rather the most acceptable ones. Here is the rub with most people, the failure to realize that many of the little, everyday happenings, the commonplace incidents of their own experience are not commonplace to many others, even to the editors, who have opportunity to see the work of many. The trouble is to get started on an article. The first word, the first paragraph is the hardest to get, the rest will come of itself. As for the subject it is hard to assign one offhand, but here is a suggestion for a number of subjects. Just use your eyes and your ears. Look around your own "diggings" and observe how you or the other fellow does something, then find out the reason and get busy. Just listen to the questions others ask you, the experiences they tell you; it is easy to find a story, for something which will interest you while one hears it will interest others when they read it.

The shape in which you present your material to the editor is not so very important if your subject is a good, strong one, but there are a few conventions that should be observed. The following are the most important:

Write on one side of the paper only. Do not try to crowd too much on a sheet. Start a couple of inches from the top of the sheet. Leave a fair margin at the sides. Leave some room between the lines. This will permit you to make corrections without rewriting. It will also permit the editor to make corrections and will save time. Paper is the cheapest thing about an article, so it is not worth while to economize in it. Do not waste your time in rewriting; simply make all the corrections in the first draft in such a way that they can be read. If you have to make a long insertion where you have left out something, write it on another sheet of paper and mark it and the place where it is to be inserted.

Write your name and address at the top of the first sheet. Number all sheets in consecutive order. It is a good plan to give your article a title and to place that title with your name upon each sheet of the article. Then if you happen to dump the bunch of literature on the floor you can sort it out and rearrange it without much waste of time.

Remember the one-page article, one page of your manuscript, may be more useful to the editor than the forty-page manuscript. It is easy to find a place for the short article; for the long one, it is sometimes a difficulty.

Finally, do not be afraid of your spelling or the way in which you write a thing down. Remember that the compositor, aye, even the editor, is not infallible. If you have a message, get it out of your system in some way or other, and then forget it. The most important thing is to get it out.

A. D. Williams.

Cleveland, O.

Overload Boiler Test

In looking through the issue of March 21 I noticed an article entitled, "A Remarkable Overload Boiler Test." There are several things in the report of these tests that strike me as peculiar and I question some of the results given. For instance, the heat units given, upon which all efficiencies are based, are not, apparently, the result of a calorimetric test. Also, it seems to me something more than a coincidence that the grate efficiency of 97.12 per cent. should be identical to the last decimal place for both tests. I think you will find on investigation that the ashes in these tests were not analyzed and that the grate efficiency given is the result of a theoretical correction applied to the weight of the refuse based upon the coal analysis. It would indeed be remarkable if we could run a stoker of this type, or in fact any other, at the ratings given, with a grate efficiency of 97 per cent. It very likely would be closer to 95 per cent.

There is nothing very remarkable in the capacities developed, as with this type of stoker it should be entirely possible to operate the present-day boilers at 200 per cent. of rating continuously and I should think it would be well not to call this overload capacity as it seems to me that we are just learning how to burn coal and get some results out of the heating surface of the boiler.

I have in mind several recent contracts made for stokers of this type, which call for as high as 240 per cent. of builders' rating to be developed for a period of several hours.

C. W. E. Clarke.

Boston, Mass.

Improvement Turned Down

All business men do not seem willing to take advantage of a saving in dollars and cents when it is put plainly before them. According to R. O. Warren in a recent issue they do. But, how about this:

The coal bill of the plant in which I am employed averages $82 per week. After due investigation and consideration I made the proposal to reduce the weekly bill $17 by the outlay of $500. About 80 per cent. of our work is supplying steam for drying rooms and for cylinders over which goods pass to be dried. In order to obtain proper drying it is necessary to carry a pressure of 80 to 95 pounds. After a test I found that 60 pounds pressure was enough for the power requirements but not enough for the drying. On inquiry I found that a separately fired superheater large enough for our needs could be purchased for $450 and $50 would pay for the necessary piping and fittings. This arrangement would give us 75 degrees of superheat with 60 pounds boiler pressure or about 380 degrees in the coils of the drying rooms, which is about 50 degrees higher than the temperature due to saturated steam at 90 pounds pressure. The expert from the superheater manufacturers went over the whole thing with me and agreed that the saving could be made. The saving would have been made by burning a cheaper grade of coal with which 60 pounds pressure could be maintained. In order to keep an average pressure of 85 pounds, I must burn coal costing 85 cents per ton more.

Perhaps it is not good engineering to reduce the pressure and then superheat to obtain the same results, but the saving in dollars and cents would be made and that is the main point. My proposition was considered by the firm and turned down. The reason why it was not accepted was because first cost only was considered.

Harold James.

New York City.

Pressure and Pump Plunger

It seems to me that the reason for the breaking of the pump described by Mr. Potter in the March 28 number is very apparent if the cycle of operations be considered.

Consider the pump to be ready for operation with all of the cylinders empty and with the proper connections made to the well and to the discharge main. As soon as the pump is started the cylinders fill with water below the pistons on the up stroke. Then, on the down stroke this water is discharged and a partial vacuum is created in the cylinders above the pistons. These spaces are connected each to the other and to the well. As the supply pipe to the upper chambers was not of sufficient capacity to admit of filling them at a single stroke, the pumping had to continue a little before the upper space was filled. This finally occurred, however, and then there was a solid body of water filling the entire volume including the supply pipe back to the well. This water was in a state of constant vibration or oscillation due to the motion of the piston and the total quantity remained constant.

Suppose, now, that the supply pipe or, in fact, any portion of the system were suddenly restricted to a greater or less extent. Pressure would instantly develop which in Mr. Potter's case only found relief in rupturing the pump.

The pump which Mr. Potter described is apparently neither a single-acting plunger pump nor a double-acting piston machine but rather a hybrid affair.

T. D. Hayes.

Cambridge, Mass.

Engineers and Boiler Inspectors

I have been taking a great deal of interest in the editorials and articles on boilers and boiler inspection which have appeared in Power from time to time.

I think that engineers should have nothing but the most kindly feeling toward inspectors. Unfortunately, there are engineers who seem to hate inspectors, who hide defects and in every possible way make it difficult for the inspectors to do their full duty.

When I am notified that an inspector will call on me at a certain time, I try to have things ready and convenient for him and I am careful to have things so that the inspector may see the boilers in the same condition as that in which they are operated—I do not touch a thing inside.

S. P. Eaton.

Great Bend, Kan.

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Technical Education

The Technology Congress recently held in Boston to commemorate the fiftieth anniversary of the founding of the Massachusetts Institute of Technology also marks an epoch of engineering development unequaled during any like period in history, a development in which the technically trained engineer has played a very important part.

Fifty years ago steam engineering was in its infancy; the steam engine in small units had been applied to mill work, but the power house, as we now understand it, had not yet made its appearance. Electricity had not been applied to commercial utilities, such as lighting and the transmission of power, but instead was still a product of the laboratory. The telephone was still in an experimental stage, tunnels were yet to be successfully constructed under rivers, the railroads were undeveloped and sanitary engineering, which has been such a large factor in improving health in our large cities, was then unknown.

The engineer of that day received his training through an apprenticeship course, which, although usually thorough, was more or less narrow. However, as the engineering problems were limited in extent, this preparation answered the purpose very well. Moreover, due to the limited size and character of these projects, they could usually be planned and carried out by one man. With the enormous increase in the magnitude and the diversity in the character of engineering projects during recent years, the methods of handling them have changed, and their successful completion has been made possible only through organization. Likewise, the qualifications of the engineer have changed; his training along engineering lines must be broader and he must possess executive ability.

Previous to 1860, the colleges had offered only courses in history, literature, languages, pure science and a few of the older professions, such as medicine and law. About this time, however, a number of far-sighted men, individually, conceived the possibilities of some of the rather crude mechanical appliances then in vogue and recognized that there was much in the realms of pure science which could profitably be applied in extending the industrial development of the country. In other words they did not coincide with the prevailing belief that theory and practice were incompatible, but instead were convinced that the two should be made to serve the ends hand in hand. To accomplish this they recognized the necessity of systematic study and training in applied science. Consequently, through the efforts of these individuals, several of our large technical schools were founded almost simultaneously.

There is a mistaken impression in many circles that the technical schools attempt to turn out finished engineers. Such is not the case, and no reputable school will attempt to make such claims. The most they can do is to give the students a thorough grounding in the fundamentals of engineering and to train them in systematic methods of attacking engineering problems. This, combined with the experience gained in actual practice, goes to make up the successful engineer and has been instrumental in placing engineering upon an equal footing with the so-called learned professions.

Chicago Smoke

In a report of the work of the Department of Smoke Inspection from the time of its organization in October, 1907, to December 31, 1910, Paul P. Bird, chief smoke inspector, calls attention to the fact that Chicago is essentially a manufacturing and commercial rather than a residential city, and that in attempting to eliminate smoke it is not possible nor practicable to pursue any policy which will injure the interests of the railroads, shops, factories, mills, packing houses, etc., that are spread over the one hundred and ninety-three square miles of the city's area and have made Chicago what it is today.

The power and heating for this large city are practically all produced from soft coal, only about five per cent. of the total coal being anthracite and about ten per cent. semi-bituminous from the West Virginia district. The remaining eighty-five per cent. is from the local coalfields of Illinois and Indiana.

At the close of 1909 there were, according to the department, about seven thousand high pressure boilers in Chicago exclusive of locomotive and marine boilers. Low pressure boilers which are also a factor in the smoke question number about twelve thousand two hundred and fifty.

Further investigation has shown that among the high-pressure plants there are on an average of two boilers to each stack, so there doubtless are in the city limits about three thousand five hundred smokestacks connected to high-pressure boilers. Similarly there are about 1.16 low-pressure boilers to each stack, or about ten thousand five hundred smokestacks in Chicago connected to low-pressure boilers, making a total number of smokestacks for stationary purposes of fourteen thousand.

During the last few months of the year 1910, the department made a careful investigation of the subject and, as a result, estimates that there are burned annually in the city limits of Chicago, ten million tons of bituminous coal, divided as follows:

Class	Consumer	Annual Consumption	Per Cent.
1	Central district....	1,500,000	15.0
2	Miscellaneous power plants...........	4,500,000	45.0
3	Flats..............	750,000	7.5
4	Domestic...........	650,000	6.5
5	Special furnaces....	600,000	6.0
6	Railroads..........	1,850,000	18.5
7	Boats..............	150,000	1.5
		10,000,000	100.0

To burn this enormous amount of fuel fifteen to twenty thousand men are constantly employed, and as long as the smokelessness of the city depends upon the carefulness of this great number of individuals, the work of keeping them at the highest degree of efficiency will be stupendous.

As an ultimate solution of the smoke question the department recommends the centralization of plants. In every block in the central district there are from two to twenty steam plants and in the manufacturing districts each factory, no matter how large or small, has its own power-generating outfit. If, in place of this multitude of small plants, a relatively few large power houses could be installed, the result, according to the report, would be most beneficial from a smoke-prevention standpoint, as the large plants would be equipped with automatic stokers, would operate under fairly uniform load conditions and it would be an easy matter to prevent smoke.

This recommendation is made, of course, without regard to financial or commercial considerations, which might, when analyzed, prove the scheme impracticable. As a matter of fact it is generally conceded that smoke from stationary power plants will give less and less trouble as time goes on and proper supervision by the city authorities is exercised. In the stationary plant there is generally ample room to install furnaces of proper design, with large combustion areas and mixing chambers, so that it is reasonable to hope for practical elimination of the smoke nuisance from this class of plant. It is from the railroads that the greatest trouble is encountered. Railroads are credited by the department with making forty-three per cent. of the total smoke of Chicago and over fifty per cent. of the total dirt, due to cinders, ashes, etc. Electrification is advanced as the only means whereby this may be absolutely eliminated.

During the present smoke administration there has been a great improvement in the atmospheric condition of Chicago. In the "loop" district this is especially marked. When it is considered that the fourteen men whose duty it is to observe the stacks of the city, have approximately twelve hundred stacks in each of their territories, covering fourteen square miles apiece, it is truly remarkable what has been accomplished along this line.

If the amount of smoke that was being made in 1907 at the beginning of the present administration be represented by one hundred, it is stated that the smoke now made, at the end of the administration, may be represented by sixty-six.

If all of the railroads coming into Chicago should be electrified, with other conditions remaining as they are, the amount of smoke that would then be made is estimated at thirty-eight.

With all the railroads electrified, all boats in the river burning hard coal, all flats heated by gas or coke and central-station power and heating plants covering the city, the amount of smoke is placed at five; while under the best theoretical conditions, with all power electrical, and all heat electrical, or obtained from gas or coke, the smoke conditions are placed at zero.

It will be a great many years before these ideal conditions are even approximated. In the meantime the smoke administration just coming to a close, has organized and placed on a solid engineering basis, a city department, the value of which, to the citizens of Chicago, cannot be overestimated.

Electricity and the Engineer

Although electricity has now found application in most fields of industry it is still regarded by the layman with a sense of mystery. This is probably due to the fact that scientists have thus far failed to furnish a simple definition of electricity; they know how it is produced and that it follows certain well defined laws; but all attempts at telling exactly what it is have resulted in elaborate theories which only they themselves can comprehend.

Electricity, however, is not alone in this position; there are numerous other phenomena which are known only by their effects, but which are of such common occurrence as to excite no curiosity. Perhaps the most common of these is gravitation. Everyone knows that a body left entirely unsupported will fall toward the earth with a certain force, depending upon its mass. The measure of this force is called weight, a term with which everyone is so familiar that it carries with it a certain assurance of its identity; yet if one were called upon to explain exactly what gravitation is, he would probably find himself in a position similar to that of a man trying to give a definition of electricity.

Engineering, however, is not concerned with what electricity is but rather with what it will do, and this is now pretty definitely known. It is not a source of energy but is a medium for the transmission of energy, in many ways fulfilling the same uses as shafting, belts and gears; it possesses, however, much greater flexibility of application than any mechanical means. If the operating engineer would regard electricity in this sense and then become familiar with the established laws which it follows, he would find little trouble in understanding the operation of the electrical part of the plant equipment. Such knowledge is essential to the engineer of today if he is to keep pace with the increased responsibilities of his position.

Many engineers will go down without a struggle before a formula which has a logarithm, entropy, or a sine, cosine or tangent in it. It is just as simple to look up one of these quantities and to substitute the value given in the table for the letters of the formula as it is to hunt up the steam temperature corresponding to a given pressure or the area corresponding to a given diameter, and the same book which contains the tables of the properties of steam and of circumferences and areas will usually have the other things too.

The correspondents of *The Engineer*, of London, are having an animated discussion regarding the live-steam feed-water heater. Will a boiler actually deliver more steam per pound of fuel burned, if a part of the steam which it makes is used to heat the feed water to the boiling point? And, if so, why?

Investigation will show that water powers are not "gold mines" and that it costs something for their development. In fact, in many cases they cannot successfully compete with steam or gas.

Have you ever talked things over with the owner and found him a gentleman and willing to help carry out your suggestions?

There seems to be a great variety of opinion regarding the proper control of water powers. At present the Government has no definite policy except to maintain the existing status of confusion.

Have you noticed in small plants that some men leave the door between the engine and boiler rooms open when coal is being delivered and ashes removed?

"It is not so bad to be ignorant as it is to know so many things which are not true."

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Area of Pump Valves

How is the proper area for the discharge valves of a pump determined?

J. C. K.

The area should be such that at a piston speed of 100 feet per minute the velocity of the water through the valves shall not exceed 200 feet per minute, that is, the effective discharge area of all the valves should, at least, be equal to one-half the area of the piston. Some builders, however, make the valve area two-fifths that of the piston.

Ratio of Air Pump to Steam Cylinder

What should be the ratio between steam- and air-pump volume for a simple condensing engine?

J. A. L.

For an equal number of strokes in the case of a single-acting pump and jet condenser the ratio of cylinder volumes should be from 5 to 1 to 10 to 1. For a double-acting pump the ratio may be from 8 to 1 to 16 to 1, depending on temperature of injection water, hotwell temperature, terminal pressure in the cylinder, etc. For a surface condenser a double-acting air pump may have a piston displacement 1/25 of the steam piston.

Compound Engine Cylinder Ratios

What would be the comparative diameter of the low-pressure cylinder of a compound engine to develop the same horsepower as a simple engine at the same speed and steam pressure?

C. L. R.

If the work done is to be the same in both cases the number of expansions must be the same, consequently, with the same initial and terminal pressures the diameter of the low-pressure cylinder of the compound engine must be equal to the diameter of the single cylinder of the simple engine.

Energy in One Pound of Coal

If all of the energy in a pound of coal could be utilized, how much power would it develop?

E. P. C.

Coals vary in heat value, but if a pound could give up 14,000 heat units it would be the equivalent of

14,000 × 778 = 10,892,000 *foot-pounds*

or energy enough if it could all be used to project itself over 2000 miles upward.

Dynamo and Motor Speeds

Why does a machine run at a slower speed when operating as a motor than when being driven as a dynamo, the terminal voltage being the same in both cases?

C. F. J.

Because the resistance of the armature circuit cuts down the net voltage to be balanced by the motor's counter electromotive force and adds to the electromotive force that the dynamo must generate. Suppose the armature winding and field strength to be such that the armature will generate one-tenth of a volt for each revolution per minute and the drop in the armature circuit is 5 volts at full-load current. Running as a dynamo delivering 110 volts, the armature must generate 115 volts total, to overcome the internal drop; the speed then will be 1150 revolutions per minute. Running as a motor on a 110-volt circuit, the armature drop of 5 volts leaves 105 volts to be balanced by counter electromotive force; to generate 105 volts, the speed needs to be only 1050 revolutions per minute, or 100 revolutions per minute less than the dynamo speed.

Shunt Strip of a Compound-wound Dynamo

What is the purpose of the shunt strip across the series field winding of a compound-wound dynamo?

T. B.

To adjust the proportion of the armature current that passes through the series winding and, thereby, the compounding effect of the winding. Read the "Primer of Electricity" in the February 21 number.

Proportions of a Gasolene Motor

In a gasolene motor for a small load, what relation of bore to stroke would you advise and what compression pressure and piston speed?

J. T. W.

Make the stroke one-fourth to one-third greater than the diameter of the cylinder bore, according to how your power and speed work out. The compression pressure should not be over 70 pounds gage; the piston speed may be anywhere from 400 to 800 feet per minute, according to your power and rotary speed requirements. The reciprocating parts must be designed in view of the speed selected as well as the pressures involved.

Ignition Current from Lighting Circuit

Can a jump-spark ignition system, using the ordinary induction coil and vibrator, be supplied from a 110-volt incandescent-lighting circuit?

J. R. L.

Not satisfactorily, unless special provision be made for reducing the voltage at the primary terminals of the coil. Simply putting resistance in series with the primary winding is not satisfactory because the vibrator has to open a 110-volt circuit instead of a 6-volt circuit. The nearest approach to a satisfactory arrangement of this sort is a resistance coil connected directly across the 110-volt circuit, the primary circuit of the ignition system being connected to the resistance coil at such points as to get 6 volts potential for the system (see accompanying diagram). This is wasteful, because current flows through the resistance coil all the time and at the full circuit voltage.

Advantages of Condensing Engine

What two advantages has a condensing engine over one which is noncondensing?

C. F. K.

Two advantages of a condensing engine over a noncondensing engine are that more power can be obtained out of a given sized cylinder and it can be obtained more cheaply; that is, for less steam per indicated horsepower-hour.

Reversing a Compound-wound Motor

What is the best way to change the connections of a compound-wound motor for reversing its direction of rotation?

S. G. R.

Exchange the connections of the cables leading to the brushholders so that the current will go through the armature in the opposite direction. Do not make any change in the connections of the field windings.

Government Control of Water Powers

A continuation of the report presented in last week's number on the water-power conference held by the National Electric Light Association.

J. R. McKee: The public domain of the Government of the United States, including all the cessions from the thirteen States that made cessions and, including Alaska, amount in all to about 1,800,000,000 acres. Of this there is left as purely Government property, outside of Alaska, something like 700,000,000 acres. Of this the National Forest Reserves in the United States proper embrace 144,000,000 acres; the rest is largely arid or mountain country, offering some opportunity for agriculture by dry farming and by reclamation and containing metals as well as coal, phosphates, oils and natural gas. To the above 144,000,000 acres of forest belonging to the Government should be added 26,000,000 additional acres withdrawn in two forests in Alaska. Omitting Alaska, the 144,000,000 acres of forestry land withdrawn is equivalent to more than 27 States the size of Massachusetts.

In giving the extraordinary figure as to the amount of land in the forestry bureau, I do not understand that these figures include the 92,000,000 acres additional of land covered by document 10,860—lands withdrawn from settlement under provision of an act of June 25, 1910. Adding these 92,000,000 acres it means an additional area equivalent to an excess of 17 States the size of Massachusetts; for the two combined an area equivalent to an excess of 44 States the size of Massachusetts.

Appropriations for the support of the forestry bureau beginning with the year 1900, when they were $48,500, increased until in the year 1911 the appropriations for the support of that bureau are $5,051,000, making the total appropriations for the support of the bureau to date approximately $23,000,000. According to Congressman Edward T. Taylor from Colorado, who quoted the former head of the forest service, this forest system when it reaches its real development will require the services of 118,000 to 120,000 men.

I have taken the list of appropriations made by the last Congress and, including all of the salaries from the secretary of the forest service down to the office boy, the average salary is in excess of $1200 per year each. Assuming these same figures it means when the forest service comes to its own the salary list alone will be $144,000,000 per year. The question naturally arises in the minds of some people as to whether this is not pretty nearly a case of the Government owning its own forests and buying them over again from itself.

For the benefit of those who are not familiar with the subject, I would state that the forest reserves are established not only for the cutting of timber but are let out for pasturing. For instance, during the last year, there have been pastured on the forest reserves nearly 1½ million cattle, in excess of 85,000 horses and over 7½ million of sheep and for this the Government has received over $986,000 which, however, was less than they received the previous year from this source. From the timber sold they received just a little over $1,000,000. Taking last year's (1910) appropriations for the support of the forest bureau, which were $4,682,000, the total cost for that year's upkeep amounted to a total of $6,711,428. We all know what compound interest means and if one will take these appropriations as a start and compound the interest on them and charge them against the forest reserves and add to that the additional appropriations as they come along, it is hardly necessary to say how startling the figures will become.

I have dwelt upon these figures and this situation because I am wondering if this has not a great deal to do with the attitude of the Government officials. It is only human that those who undertake enterprises want to see them work out successfully, whether they be individuals in the Government employ or otherwise.

The 92,000,000 acres mentioned as withdrawn under the special act included those upon which it was thought there might be found coal, oil, gas or sites available for water power. Now, in regard to the latter these lands as they now stand are so tied up that it is impossible for anyone, no matter how sincere or desirous they may be of locating upon them, to get located. In other words, there is no law under which the Government can allow him to acquire possession. Suppose you found a site or parcel you would like to take up and develop and you notified the department. The President might give orders to restore this land to the public domain and let you locate upon it. What right has the President to give you preference? In other words, would he not find himself in a position similar to the one, for instance, where the Indian or other reservations are thrown open to entry and where a date is fixed and an order is given and the proposed settlers line up at the border and at the sound of a gun make a rush and the first one to arrive at the location gets it.

Mr. McKee then presented a situation not only possible but not at all improbable, showing the difficulties that might be expected in building on a navigable stream and in erecting a pole line. A brief abstract follows:

Suppose that you own by outright purchase the shore lines along a stream whereby the erection of a dam, a head suitable for the development of power can be secured. It happens that the stream in question at some point below the proposed dam, not necessarily near it, is navigable, but at the particular point where you wish to put your dam, it is impassable. In other words, there is not sufficient water for navigation and the stream is not of sufficient size to be navigated above there, although presenting the possibility that by the aid of the Rivers and Harbors Committee in the way of an appropriation, it might be made so, but whether commercially is a question. You, however, own this property and want to develop it. You must go before Congress for the privilege because it is called a navigable stream. You get an act passed granting this right and there is attached to it the stipulations that you must at the time or thereafter, if the Government so orders, construct at your own expense and on your own land, locks and operate them without expense to the Government, giving preference to whatever water there may be available without regard to what effect this may have on your power-generating plant, which, by the way, may be a serious situation during low-water periods. You have now dealt with Congress and your stipulation is that you must thereafter deal with the Secretary of War and also the Chief of Engineers.

For your transmission line it happens that adjacent to your site is a farming land where the homesteader has filed and is living in process of acquiring title. Of course, the homesteader has not yet secured his title and therefore cannot give you any right to cross his land. The Government also cannot give you any right because the land has been filed upon by the homesteader and to that extent it is beyond the privilege of the Government. So if you go across this land with your pole line it must be illegally. Adjoining the homesteader's land and also to be crossed by your transmission line is land still in the public domain. If you wish to cross this you must deal with the Secretary of the Interior, who will impose upon you such restrictions as he deems essential, such as police regulations, stipulations as to charges and limit as to time. The next land your pole line has to cross is a forest reserve. You much now take up your negotiations with the Secretary of Agriculture who will suggest to you a use agreement with time limits and stipulations as to charges, etc., and these charges have been suggested on a basis as though your entire plant was on the public domain. Finally you reach your destination for delivery of power and it is a city where you own the electric-lighting company and you will probably come under a public-service commission who will also stipulate charges and other regulations. You now have a property to get together with which you have dealt with Congress, the Secretary of War, Chief of Engineers, a homesteader, Secretary of the Interior, Secretary of Agriculture and a public-service commission.

What is to be the solution of such a complex situation as this and is it not absolutely imperative that there shall be some solution before it is possible to persuade financial interests to undertake any such enterprises?

Personally I think that water-power sites ought to be made readily available and it should be possible for them to be taken up and developed the same as a railroad can locate on public lands, and presuming they will be developed as a public utility, which most of them certainly are, I do not see why it should not be a sufficient safeguard if they be brought under the regulations of the local authorities, the same as other public utilities. The true regulation of water powers is that which will prevail and pertain to the respective localities where they may be located. Public-service commissions are handling these questions broadly and I think that their experience demonstrates that this is the most satisfactory and the ultimate outcome of the entire situation.

Ralph D. Mershon: A discussion of this important question resolves itself into the following questions:

1. Shall the control of these hydraulic development sites lie with the Federal government, or with the respective State governments?

2. If the present Federal control be ceded to the respective State governments, shall such action be absolute or with restriction?

3. Whether the control rests with the Federal Government or with the respective State governments, shall absolute title in these sites be ultimately passed to the individual or corporation; or, shall the ultimate title remain with the people?

4. If the ultimate title be passed from the people, how shall it pass? By mere location and exploitation, or by some form of competitive purchase?

5. If the ultimate title is not passed from the people, how shall such title, as is passed, be limited as to the length of tenure and the privileges it conveys? Furthermore, what method shall be employed for determining who shall be the recipient of such title as conveyed.

My views in regard to questions 1 and 2 are that the control should be vested in the respective State governments, but that the Federal control should be ceded with such restrictions as will result in uniformity in these matters among the States. Regarding questions 3 and 4, I believe that in no case should absolute title to the water-power sites, which are at present on the public domain, be passed to individuals or corporations; that the ultimate title to these sites and all rights in connection therewith should remain with the people.

Item 5 cannot be so simply disposed of as the preceding items as individual cases will differ. It must be borne in mind that these enterprises should be attractive to capital, and ample time should be allowed in which to accumulate the necessary physical data, and in which to make financial arrangements under such conditions as will be manifestly fair toward those acting in good faith, while endeavoring to insure against mere monopolistic or speculative control.

It is held by some that the idea of a limited tenure is economically unsound and financially impracticable. I do not agree with either of these statements. Certainly at the present time no one, for either financial or economic reasons, would refuse to invest in a public-utility enterprise simply because the contract had a limited time to run. If such a limitation of tenure is unobjectionable in the case of a public utility, I can see no reason why it should be objectionable in the case of hydraulic development sites.

I believe it possible to satisfactorily and equitably handle these matters from the point of view that the rights conferred upon the individual or corporation making the developments are in the nature of a franchise, and are neither absolute nor perpetual.

As I understand it, Mr. Doherty's claim is that a limited tenure of water-power rights must necessarily result in greater cost of power and otherwise to the detriment of the consumer; that this is uneconomical and that the only course broadly economical is that of perpetual tenure in one form or another. The elements of this argument are as follows:

1. That limited tenure will make it difficult to finance and enterprise a development, which will mean a higher rate of interest and this, in turn, must be borne by the consumer.

2. That under unlimited tenure, bonds can be refunded as they fall due, thus obviating the necessity of a sinking fund, but that limited tenure will require amortization of the bonds; hence the sinking fund or its equivalent.

3. That as the end of the tenure approaches, it will be increasingly difficult to provide money for any needed extensions or improvements, with the result that either the service will be less effective or that the price of power will be higher.

The foregoing propositions are predicted upon the assumption that the physical property will at the end of the term of years pass in fee simple to the State. On such assumptions they are undoubtedly true, though the degree to which they are true will depend upon the length of tenure. I believe, however, that this assumption is not necessarily true. So far as limited tenure is concerned, objections 2 and 3 will evidently be done away with if the bonds representing the money expended in creating and extending the property carry with them the assurance that at the end of their term the principal will be paid or the property will again be available for bond issue.

The only apparent reason why limited tenure should, in itself, be productive of objection 1 is that if the enterprise were unsuccessful and they were unable to amortize the bond, they would find themselves at the end of the bond series with neither principal nor property on which to foreclose. But such contingency also will be obviated by the clause suggested for meeting objections 2 and 3.

It seems to me the conditions indicated will be fulfilled and therefore the objections met by the following clause:

This was to build and extend the plant under the State's supervision and operate it for a term of years under the State's supervision as to maintenance. Let the time be extended at its expiry or, if not extended, let the State redeem or guarantee the bond issue for the creation and the extension of the property.

I believe the majority of the people in this country are unalterably opposed to passing absolute title to these water powers to individuals or groups of individuals. It seems to me, therefore, that these gentlemen who are now opposing the policy of limited tenure had much better bow to the inevitable and cheerfully assist in devising effective plans for the carrying out of this policy. By so doing, they will be encouraged in that rapid development of water powers which they advocate, whereas their present attitude will merely serve to retard development.

Calvert Townley: I am strongly opposed to Governmental meddling with hydroelectric properties by control, regulation, by special taxes, or any other way whatsoever, except by the exercise of the ordinary police power to maintain and uphold the law where necessary, and by the collection of the usual and ordinary taxes the same as would be collected on all other real property.

A tax on water powers can evidently be imposed only for one or both of two reasons: First, to restrict or control the development; second, to produce revenue.

for the Government. It would be wrong in both counts. If a tax is to be imposed to produce revenue for the Government, it will fail in its purpose. If the rate be made so small as to have an insignificant effect upon the power company's expenses, can it have other than an insignificant effect upon the Government's revenue? And if the rate be made high enough to afford a substantial revenue it must act to deter many developments, which under the most favorable conditions might be made, and thus both keep the Government from getting any revenue and the neighborhood from any advantages which cheap power might offer toward improving that section of the country.

Public-service corporations of all kinds are now in process of being regulated and controlled. No one can say where the process will stop. Occasionally a corporation official is found who says he thinks this control will benefit his company. The very great majority, however, feel that such control will either limit their earnings or increase their expenses, or both, and thereby make their securities less attractive to investors.

It is impossible to convince the promoter who wants to invest other people's money that a water power is not a splendid investment, and it is useless to argue with the man who knows all about the subject but has not yet tried it. However, a list of hydraulic developments—real ones, those that actually have been and are now doing business—showing the amount of money put in and the amount taken out, would make interesting reading. The small percentage of earnings and the number of plants that have gone to the bad financially might astonish some of our able-bodied legislators who are afraid that somebody may make money while they are not looking.

Percy Thomas: The thing that is to be avoided is monopolistic control which will permit an original owner from reaping a tremendous profit, say, after fifty or one hundred years, when the property may have become extremely valuable.

Suppose we are going to give a fifty-year franchise for the development of a water power. The public, in addition to having fair service, etc., expects to get some rental from that. Suppose the Government is arbitrary and says—if you develop 50,000 horsepower, that shall be so much per horsepower, from the beginning to the end, each year. That would be very difficult for the capitalist. Suppose, on the other hand, the public is ready to take low rates at first, before the public demand is quite up to the full installation, and a higher rate toward the end of the term, when the consumption is fuller, and the load factor is satisfactory? That makes very little difference to the public. We will assume that the public gets the same total amount out of it, but it makes an enormous difference to the investor—he knows that he will not have to pay the taxes until he has something to pay them with.

Take the point about amortization—we have the same fifty-year term of the franchise—the public can be assured, nineteen chances out of twenty, that at the end of the fifty-year term in some form or other they will get back the money invested in the plant. At the end of the fifty years they will either agree, as a matter of reason, to extend the franchise, or make someone else pay the value of it, or force the Government to pay for it, if the Government will take it over. There is every chance that the Government will get something for it, and they might as well agree that they will take it over, as they have in the case of the New York subway. It makes little difference to the public whether or not it is arranged for in the beginning, but it makes an enormous difference to the man who has to raise the money.

If that point of view is taken by those who have the final arrangements to make, namely, that the rights of the public should be secured in such way as to be most favorable to the capitalist, and the capitalist is willing to take his security and profit in the way that will be of greatest advantage to the public, I think we will get along more satisfactorily than if each side is arbitrary and thinks its arrangement is best, and insists on something which appears to be theoretically correct.

Regulation must be arranged in such a way that the rivers which are interstate shall be protected. Take the case where a river flows from one State to another, and the development may have been made in the State in which the river flows somewhere near the border, and a profitable business built up. Now, the State which grants the franchise and the water rights to this plant has no control in the next State, and we will say, later, in the next State another water power is developed near the point at which this river leaves the second State. Now, in view of the fact that there may be pondage in the upper plant, they may store water by night for use in the day time, but if the two plants happen to be the right distance apart, the period during which no water is passed at the upper plant becomes the day period, when the maximum flow of water is necessary at the lower plant, and also the free flow of water occurring during the day in the upper plant will occur perhaps at night when in the lower plant it is of little use. Thus, if we are to have State regulation and State control of water powers, they must be secured in such a manner that one State will respect the rights and privileges already granted by another State.

Francis E. Frothingham: The public-service corporation, while it serves the needs of a great many people, serves the needs of a minority of the people, and it is right and proper, it seems to me, that many of the taxes borne should be directly levied against the public service and stood by those benefited from it, but there are other kinds of taxes which should not be so borne, such as the building of a lock in the Mississippi river development, for instance, and the giving of it to the Government, and a lot of things of that same kind, and these taxes should be distributed among all the beneficiaries. If we create a reservoir on the head waters of a stream, the beneficiaries therefrom are every power user below, and they should stand some of its cost. Every other abutting property owner, and every farmer who has land that is irrigated at high water, also benefits, as well as the navigable interests in the river, by such improvements. Therefore, these taxes should be distributed among all the beneficiaries. If the problem is gone at fairly and reasonably, I think the Government will meet us at every point, sooner or later, and all that we need is to be the source of the latest technical information and advise the Government, which, after all, wants to work to the best interests of all the people.

James H. Cutler: What we all want is the decision of this thing based on intelligence rather than ignorance, based on a spirit of fairness rather than that of self-interest, and I believe that the day is not far distant when that will be done.

It has been assumed, and I think correctly, that 3,000,000 horsepower are in the mountains of western North Carolina, and in that section, which, if the bill which has now passed Congress and has the President's signature, had not been passed and become a law of the land, the day would not be far distant when this 3,000,000 horsepower of water would be gone—and when such a power is gone, it is almost impossible to get it back again, except, certainly, at very great expense. They have been through that in France and know what it is to reforest the mountains, to get the land in condition so that the trees may grow. Now, that 3,000,000 horsepower we have saved. The difference of cost between water and steam is at least $15 per horsepower per year—3,000,000 horsepower at $15 per year means $45,000,000 per year, which would have been added to the cost of manufacture of cotton goods and other industries in the South. That might mean the difference between holding and losing a foreign market of cotton goods. That is only one section of the country. Without doubt, it is more than 3,000,000 horsepower that was in jeopardy in the West.

P. V. Stephens: There are in the Southern States over 9,000,000 horsepower which may be developed at a reasonable cost. There is a possibility of something like 25,000,000 horsepower which may be developed, with suitable reservoirs. Only one-tenth of this has been developed at the present time. The water powers of the Southern States are their most valuable resource, and yet the least developed resource, and I think that this statement, so far as development is concerned, applies also to the West as well as to the Central States. It means that for the salvation of our resources, especially in the Southern States, we need immediate and thorough legislation which will put aside the barriers to the water-power development.

Economy in Burning Oil on Revenue Cutter Vessels

Capt. C. A. McAllister, engineer-in-chief of the United States revenue-cutter service recently presented some interesting data in the *New York Herald* on using fuel oil as a motive power. It was first tried out by Captain McAllister on the revenue cutter "Golden Gate" at San Francisco. So economical were the results obtained that it has now been decided to gradually spread the system to all the revenue-cutter vessels. The three boarding vessels in New York harbor—the "Hudson," the "Calumet" and the "Manhattan"—will soon be equipped with oil-burning apparatus.

The revenue cutter "Golden Gate" is a vessel of the ordinary harbor-tug type, and is engaged in boarding duty in San Francisco harbor. This is an intermittent duty involving daily a number of short trips around the harbor, a state of readiness to go at a moment's notice, and consequent lying at a wharf with steam up for the greater portion of the time. The tug is 110 feet long and up to six months ago was provided with a water-tube boiler of the Ward type and a triple-expansion engine capable of producing 515 maximum indicated horsepower. Last year a new Babcock & Wilcox water-tube boiler was installed and fitted for oil burning. Grates were put in place so that coal could be burned whenever necessary. A small cylindrical tank with a capacity of approximately 23 barrels of oil was installed in the fire room well up under the deck beams so as not to interfere with the removal of the boiler tubes when necessary. The burners are spaced about 2 feet apart, project 12 inches beyond the door-frame liners and slant slightly downward to within a distance of about 6 inches from the grate. The entire installation for burning oil, including the tank and its supports and all incidental expenses necessary to make the apparatus ready for use, cost $2500.

The oil supply is sufficient for four or five days' steaming under ordinary circumstances. It is obtained from a pipe line on the wharf where the "Golden Gate" is moored, and the tank can be filled in ten minutes.

The relative costs of coal and oil as fuel may be deduced from the performances of November, 1909, and November, 1910, which are given in Table 1:

TABLE 1. COMPARATIVE COSTS OF COAL AND OIL FUEL

	Nov. 1909 (with coal)	Nov. 1910 (with oil)
Hours under way a day, average	4	3
Knots an hour	8.5	8.5
Total miles steamed a day	34	[illegible]
Banked fires, hours	620.5	461.2
Fuel used a day, average, pounds	4,728	1,265
Fuel used a day while under way	3,600	675
Fuel used a day with banked fires	1,128	[illegible]
Cost of fuel a day for steaming	$5.40	$1.73
Cost a mile	0.21	0.069
Miles steamed a ton of coal at 8.5 knots		21.2
Miles steamed a ton of oil at 8.5 knots		48.5

From these tabulations, it would appear that the cost of oil fuel under conditions found on a revenue cutter is only slightly in excess of one-fourth the cost of coal. A further reduction in the cost of operation of the machinery due to the use of oil fuel comes from the fact that the personnel has been reduced from four to three men by dispensing with the services of one coal passer who cost the Government $674 for a year's service.

Judging by the saving indicated by the returns from the operation of the oil plant for the first quarter, there will be an annual saving in fuel alone of $2160. This, with the reduction of $674 for labor, will make a total annual saving of $2834 due almost entirely to the installation of apparatus, the first cost of which was $2500.

The following notes from the report of the engineer officer in charge of the steam machinery may prove of interest in connection with the operation of this plant.

With oil, the steam pressure can be kept stationary, as the machinery responds to unusual or varying demands. A great economy is effected through the careful use of the damper. The firebrick in the furnace act as accumulators of heat and about 20 gallons of oil will maintain steam at about 100 pounds pressure for 24 hours, so that steam may be easily held at night. From water at 50 degrees Fahrenheit, steam is raised in one hour, with the middle burner turned down as low as possible and using an inappreciable amount of oil.

The proper adjustment of the firebrick over the grate bars is important. They are laid flat and lengthwise across the grate. The first five rows back are laid close together and three extra rows are added for ordinary steaming. The remainder are laid in the same manner with a space of 3 or 4 inches between each row, depending on the amount of air required. If too much air is admitted, oil is wasted and if too little the burners give out a dark flame and sputter.

The temperature of the oil in the tank is kept at about 80 degrees Fahrenheit. It is delivered to the burners at about 180 degrees Fahrenheit under a pressure of 40 to 60 pounds, depending upon the work required. It is a California product known as Richmond Hill oil, and its physical properties and chemical analysis are given in Table 2.

TABLE 2. RICHMOND HILL OIL

Ultimate Analysis	Per Cent	Physical Properties	
Carbon	[illegible]	Specific gravity	[illegible]
Hydrogen	[illegible]	Flash point	[illegible]
Sulphur	0.75	Fire point	[illegible]
Nitrogen	[illegible]	Calorific val.,	
Oxygen	[illegible]	B.t.u.	[illegible]
Moisture	[illegible]		

The efficiency of the entire system is dependent on the regularity of the oil supplied. If through any cause the pump is not operated uniformly, no amount of attention will avail at the burners.

Spring Meeting of Mechanical Engineers

Preparations are actively under way for the spring meeting of the American Society of Mechanical Engineers, to be held in Pittsburg, Penn., May 30 to June 2. The headquarters during the meeting will be at Hotel Schenley and the professional sessions at the Carnegie Institute which is in close proximity to the hotel.

The first session for the presentation of papers will be on Wednesday morning on the subject of "The Mechanical Engineering of Cement Manufacture," following which there will be an opportunity to visit the plant of the Universal Portland Cement Company through invitation of its president, E. M. Hagar. The special train to this plant will stop at East Pittsburg, giving members an opportunity to visit the Westinghouse works. On Wednesday evening there will be a session on "Machine Shop Practice" at which the subjects of assembling small machine parts and the development of milling cutters will be discussed.

On Thursday morning the session will be very short with miscellaneous papers, after which an excursion on the river is planned. In the evening will be the reception and dance.

On Friday morning there will be papers relating to steel-works machinery with especial reference to blowing engines and forging presses. Friday afternoon will close the convention with excursions provided for that afternoon.

A session is also planned for the gas-power section.

Previous to this meeting the American Foundrymen's Association is to convene in Pittsburg and the exhibit of foundry appliances, under the auspices of the association, will be held over during two days of the meeting of the American Society of Mechanical Engineers.

New Power House Equipment

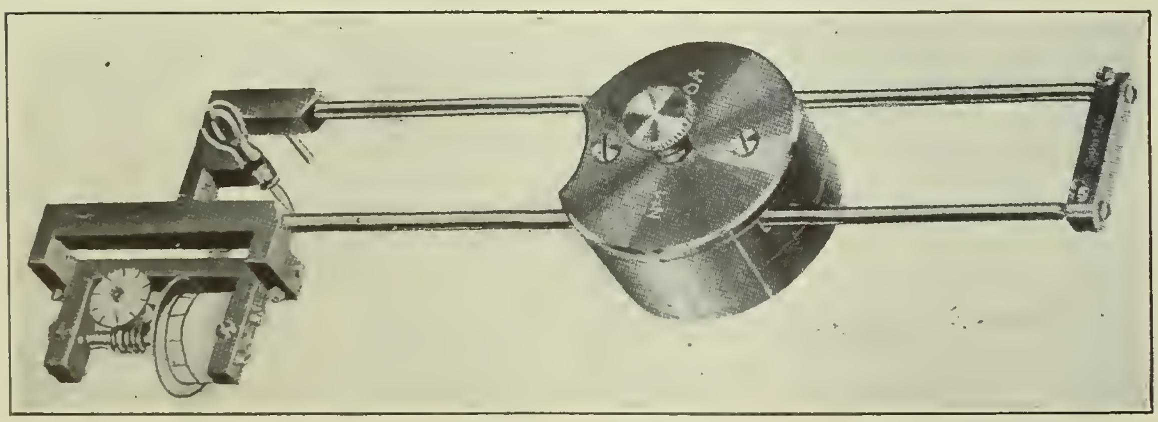
What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Durand Radial Planimeter

The illustration herewith shows a form of radial planimeter developed to meet a demand for a type of instrument which will give a mean value of the ordinates of a circular diagram or dial instrument in measuring and recording engineering quantities such as pressure, temperature, electric voltage, current, electric power, flow of water, etc., in the same manner as does the ordinary planimeter for a diagram in rectangular coördinates.

It contains the following geometrical elements: (1) A base which is to be centered with the diagram or chart to be averaged, and carrying a pair of parallel guide slots. (2) A pair of rods working in the slots of (1) and carrying at their end a frame to which is attached a tracing point and a pivoted carriage for the integrating wheel. (3) The integrating wheel for measuring the record.

The line joining the tracing point with the center of the base determines the radius vector at any one instant. The axis of the integrating wheel is parallel with this line. Under these conditions it is easy to show mathematically that the record counted on the integrating wheel will be proportional to the product of the average radius vector multiplied by the angle through which the radius vector is carried. Hence by dividing the reading by the angle the mean radius vector is obtained. The instrument is graduated to give mean ordinate in linear inches, so that by applying the appropriate scale factor it may be used for all diagrams no matter what may be the character of the engineering quantity recorded. The limits for the movement of the tracing point are from a circle of 1.5 inches diameter as a minimum to a circle of 10.5 inches diameter as a maximum. This form of instrument is made in Switzerland by Amsler, Laffon & Co., and its American introduction is in the hands of W. L. Durand, 929 K street N. W., Washington, D. C.



Durand Radial Planimeter

Randall Graphite Sheet Lubricant

This graphite sheet lubricant is a mechanical device the purpose of which is to eliminate friction in engine journals or other babbitted boxes. The lubricating element is composed of graphite that is held in bond in the form of tapered cones which are attached by hydraulic pressure to a fine copper-wire screen, as shown in Fig. 1.

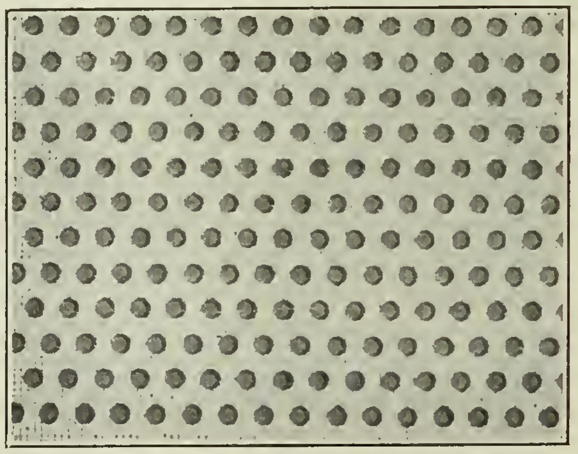


Fig. 1. Wire Screen Containing Graphite Cones

Anyone who is capable of pouring babbitt into a box can install this lubricant, as it is only necessary to use sufficient soft-copper wire to bind the sheet so that the surface of the graphite cones will be held tight against the shaft, as shown in Fig. 2. The babbitt metal is then poured as with the ordinary bearing.

When a bearing has been finished ready for use it has the appearance as shown in Fig. 3, the black places indicating the graphite cones.

The idea of this arrangement is to get the graphite in the right place and keep it there. This combination of graphite and babbitt metal is suitable for long or short bearings, and especially for high-speed machinery where the bearings have a tendency to heat.

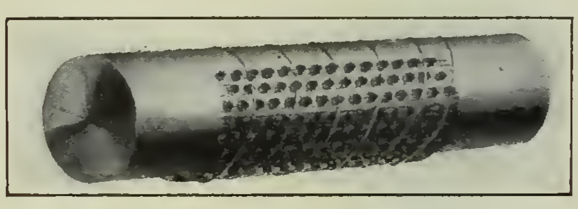


Fig. 2. Wire and Graphite Cones Against Shaft Ready for Babbitt

In order to show how simple it is to babbitt a box with the graphite sheet lubricant the following directions are given: A strip of the lubricant is cut wide enough to reach not quite half around the journal so that it will not reach quite to the top of the box, as shown in Fig. 2. It is then shaped by hand to a half circle a little smaller than the journal to be babbitted and placed on the journal so that the straight rows of graphite cones will run lengthwise of the box, and secured as already explained. The small ends of the cones should always be placed next to the journal so that the wire cloth will be embedded in the babbitt near the bottom of the box. This also produces a greater lubricating surface to the journal as the babbitt wears away.

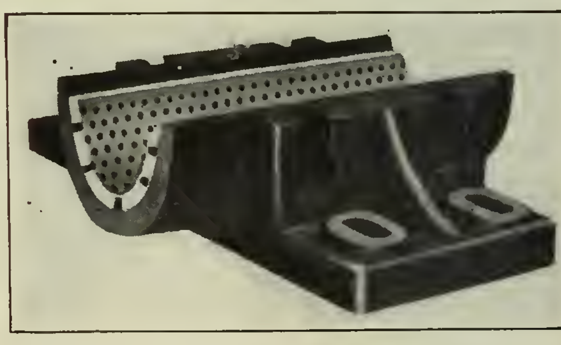


Fig. 3. Babbitted Bearing. Black Places Indicate Graphite Cones

The Randall Graphite sheet lubricant is manufactured by the Strong, Carlisle & Hammond Company, 326 to 339 Frankfort avenue, Cleveland, O.

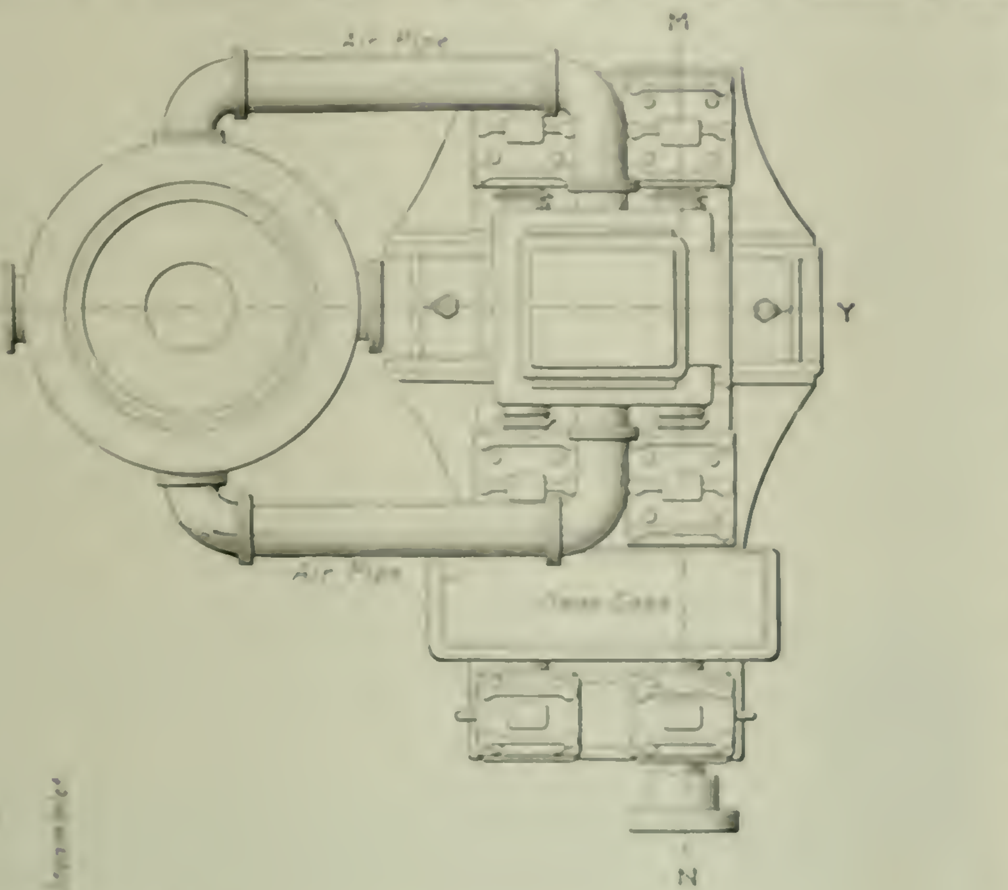
The Connersville Condenser

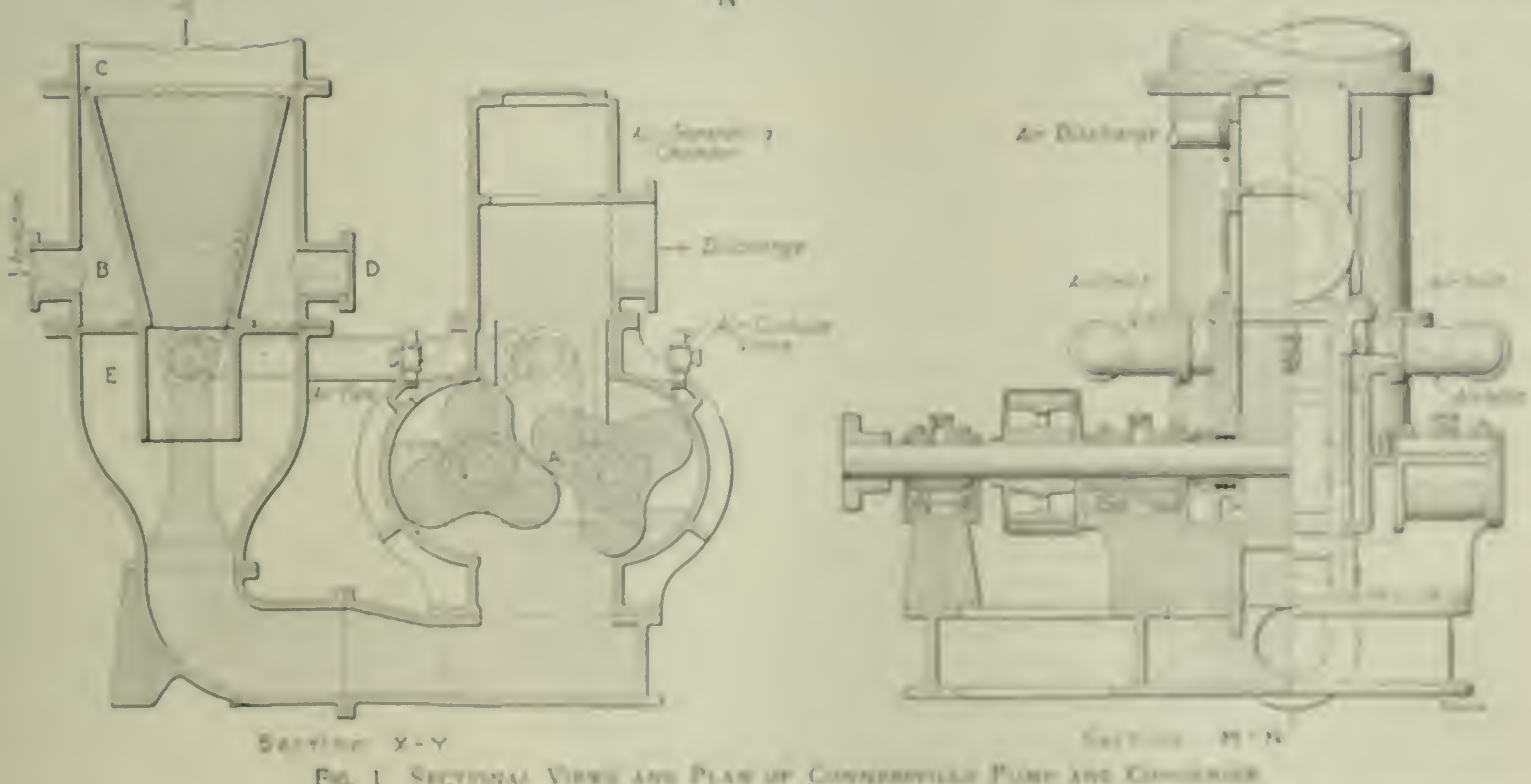
Although a rotary pump has hitherto received little consideration as a vacuum pump, it offers particular advantages for high-vacuum work.

The Connersville condenser, in which a modification of the well-known Connersville cycloidal blower is used as a pump, is shown in the accompanying engraving. Looking at the end elevation it will be seen that there is an uninterrupted communication between the condensing chamber and the vacuum portion of the air pump. That for the water is well shown in the end elevation. The air is taken off above the discharge of the condensing cone by two air pipes shown in the plan and delivered below the center of the pump by cored passages, one of which is shown in section in the front elevation. As the lobes of the pump revolve they entrap portions of the water and air in the way made evident in the end elevation, and carry them around to the delivery side; and as the lobes revolve at a speed of from 100 to 300 revolutions per minute, depending on the size, with six deliveries to a revolution, the gaseous and liquid contents of the condenser are removed as fast as they accumulate and in a practically continuous stream. The communication between the air space of the condenser and the volume that is cut off by each lobe is so direct that any degree of exhaustion which the pump is able to produce will exist throughout. Although the rotating lobes do not come into contact with each other nor with the sides of the cylinder, there can be no air leakage backward, as all of the points of possible leakage are water sealed and the water is being hurried along to the delivery side. Even the shaft stuffing boxes are water sealed and do not have to be packed against a vacuum. What water leakage may occur at the point A is unimportant as long as no air can get back.

The Connersville Blower Company, of Connersville, Ind., has furnished these pumps for jet condensers alone for an aggregate capacity of over 60,000 horsepower, but has recently developed the condenser illustrated herewith on its own account. As shown in the end elevation, the condensing water is received in a chamber B, of sufficient volume to retain without interruption to the service such stones and other bodies as are sometimes brought in, preventing them from passing to the pump. A handhole D furnishes access to this chamber without breaking any of the connections. The water filling this chamber overflows into the condensing cone through the annular space C, so large that it will not be clogged by grass, eels, etc.

Rolling down the inside it forms a hollow cone of water, into the interior of which the steam is received and condensed, striking nothing but water-covered and water-jacketed surfaces. The air and uncondensed vapors are carried forward by the velocity acquired by the rush of the steam into the vacuum, drawn together and delivered through the throat into the lower part of the condenser, where they collect above the water in the chamber E. The body of constantly renewed cold water in the chamber B immediately above serves not only to water jacket the upper part of the condenser and to keep it cool, but to cool the air and condense the vapor in the chamber E which is exposed to the effect





Section X-Y Section M-N

Fig. 1 Sectional Views and Plan of Connersville Pump and Condenser of the division wall cooled by the direct contact of the entering water and the contiguous exterior wall surfaces, cooled by conduction. This cooling of the air is very desirable as it reduces its volume and the work of compressing it to and discharging it against the pressure of the atmosphere is measured by its volume, and not by its weight.

The water and the air are thus handled independently, allowing of this natural separation and cooling, and yet by a single pump having no valves, springs or small working parts. The pump can handle very hot water and maintain a vacuum very close to that corresponding to the temperature. Piston pumps are handicapped in this respect, because the pressure in the pump cylinder is necessarily less than that outside the valves, due to the resistance of the valves and ports, and to the differential pressure necessary to overcome the inertia of the water and make it follow the increasing movement of the piston. When, therefore, in a piston pump the vacuum is carried near to that corresponding to the temperature of the water, the higher vacrum inside the pump cylinder causes reevaporation of the water in the cylinder, filling the pump with steam and causing it to race.

RESULTS OBTAINED FROM TWO CONNERSVILLE PUMPS

Temperature of Inlet Water.	Temperature of Discharge Water.	Load in Kilowatts.	Speed of Vacuum Pump.	Barometer.	Vacuum Mercury Gage.*	Vacuum Referred to 30 Bar.	Theoretical Vacuum at Discharge Temperature.	Per Cent. of Theoretical Vacuum.
PUMP No. 3.								
$66\frac{1}{5}^\circ$	$93\frac{1}{5}^\circ$	1500	108	29.43	27.55	28.12	28.36	99.15
$66\frac{1}{5}$	$93\frac{1}{5}$	1550	108	29.43	27.55	28.12	28.36	99.15
PUMP No. 4.								
$66\frac{1}{5}^\circ$	$96\frac{4}{5}^\circ$	1200	118	29.40	27.40	28.00	28.18	99.37
$66\frac{1}{5}$	95	1400	118	29.43	27.55	28.12	28.27	99.47
$66\frac{1}{5}$	95	1600	118	29.43	27.35	27.92	28.27	98.76
$66\frac{1}{5}$	95	1550	118	29.43	27.30	27.87	28.27	98.57
62	78.8	800	104	29.86	28.6	28.74	28.93	99.34

*Vacuum gage attached to low pressure end of turbine.

The accompanying table shows the results obtained with two of these pumps, 24x20 inches, having a displacement of 56 gallons per revolution, running in the power station of the Memphis Consolidated Gas and Electric Company, at Memphis, Tenn. These readings were taken on June 10 last and represent regular running conditions. When used as a dry-vacuum pump, the cycloidal rotary type can handle any amount of water up to its full capacity without injury. When used as water pumps, the larger sizes have shown an efficiency of 84 per cent. of the indicated horsepower of the engine driving the pump. These condensing units are now available in all sizes from 100 horsepower up.

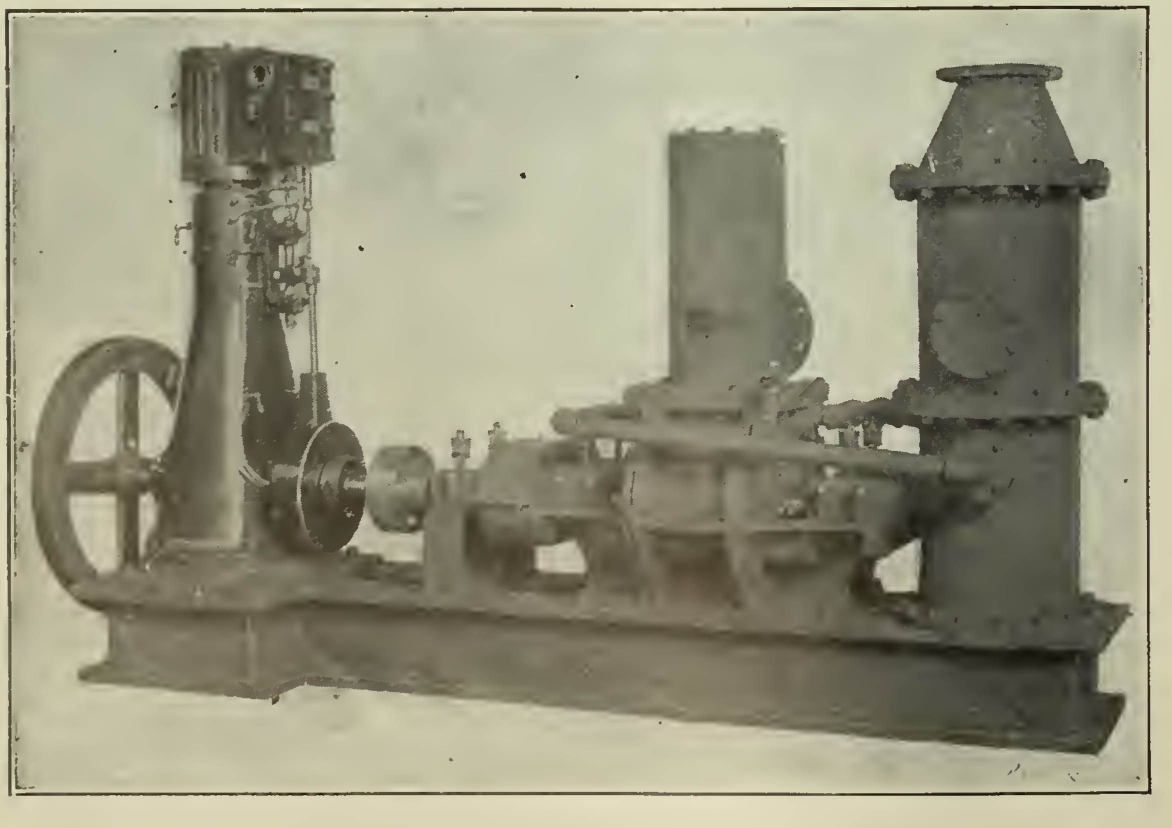


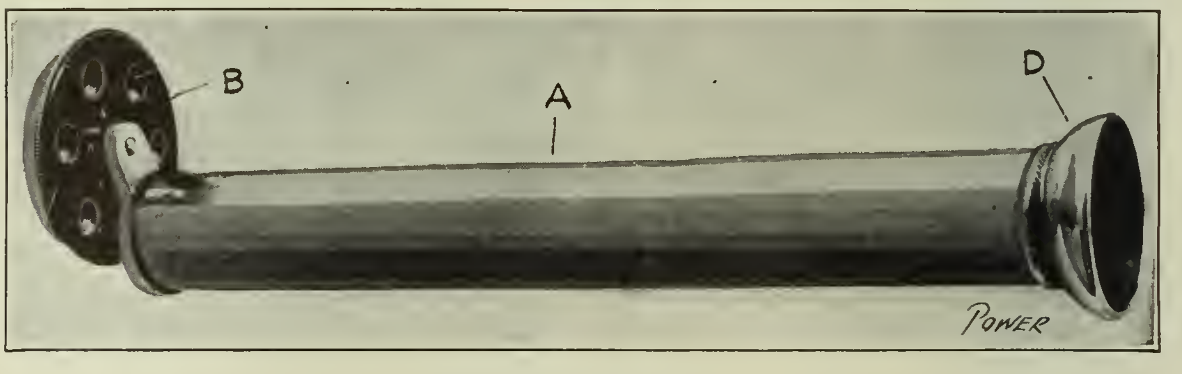
FIG. 2. PUMP DIRECT CONNECTED TO VERTICAL ENGINE

An air-separating chamber is provided on the discharge side of the pump, so the air and water can be discharged separately if desired.

The air-cushion valves on each cylinder are used to admit atmospheric air, so as to produce gradual rise to atmospheric pressure in the closed chambers, and prevent the water volumes meeting in a vacuum and producing a water hammer.

Smoke Tintometer

This smoke tintometer consists of a tube *A*, having at one end an eye piece *D*. The opposite end of the tube has two object apertures and in front of one is fixed a revolving diaphragm *B*, having five circular openings of the same diameter as one of the object apertures of the instrument. Four of the apertures are glazed with tinted glass corresponding to, and graduated from the standard tints of the Ringlemann smoke scale, while the first aperture remains clear.



SMOKE TINTOMETER

When examining the smoke from any particular chimney, the observer turns the instrument so that the aperture which is fitted with the revolving diaphragm looks toward the windward side of the smoke so that through this aperture he sees past the side of the smoke to the clear light of the sky beyond; or the same light which is illuminating the smoke column. Through the other aperture the observer sees at the same moment a circular patch which appears to be cut out of the column of smoke that it issues from the chimney. All that the observer has now to do is to revolve the diaphragm until both apertures appear to have equal illumination and a glance at the numbered scale on the instrument shows the number corresponding to "light gray," "drak gray," "black," etc., of the Ringlemann chart.

The tintometer is manufactured by John Lowdon, Reform street, Dundee, Scotland.

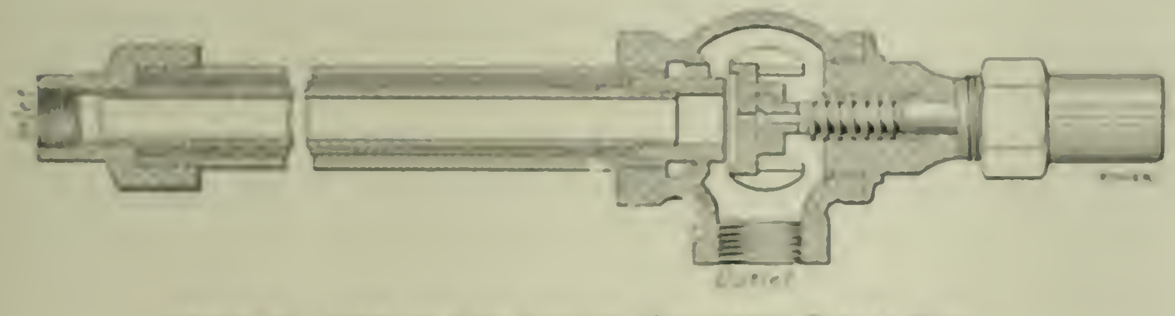
The Barton Expansion Steam Trap

The Barton trap consists of an inner and an outer expansion tube, into the inner tube of which the steam flows from the intake end. The inner tube at the outlet end supports the valve seat, which butts against the valve disk. When filled with live steam the inner tube is held by its expansion against this valve disk and is sealed. When condensation takes place the tube contracts and draws away from the valve disk, allowing the escape of the water, and closing again immediately after the discharge is made.

The outer tube, also an expansion tube, makes possible the use of the trap both with a vacuum or a gravity system, as follows: With a vacuum system there is maintained between the inner and outer tubes a vacuum, which insulates the outer from the inner tube, so that the outer tube is always cooler than the inner, and the inner tube takes care of the condensation, as already described. When the vacuum pump ceases to work, or where a gravity system is used, the outer tube is acted upon more directly by the steam flowing from the coil, and by its expansion opens the valve by drawing the valve disk away from the valve seat on the inner tube. The inner tube has a greater coefficient of expansion than the outer, so that when the water has escaped under these conditions the inner tube will expand sufficiently to reach the valve disk and close the outlet.

This trap is placed in a horizontal position at the lower end of the coils to be drained so that the water of condensation will flow to the trap. The end of the coil must be connected to the small opening in the trap marked "inlet."

This trap is manufactured by John W. Barton, 2707 Vestry avenue, Cleveland, O.



SECTIONAL VIEW OF THE BARTON EXPANSION STEAM TRAP

Idle boilers should be thoroughly washed out and dried. Trays with unslaked lime should be placed inside and the boilers should be closed air tight. If the boiler is to stand ready for immediate use it should be filled with water to which burnt lime has been added, but unless the boiler is one of a battery and is kept warm, it is likely to condense atmospheric moisture from outside and corrode if filled with water.—Ex.

Convention of the National Association of Cotton Manufacturers

The semi-annual convention of the National Association of Cotton Manufacturers was held in Boston on April 12 and 13 and was largely attended. A number of interesting papers were read upon textile matters and one upon "Power from Producer Gas" was of particular interest. The honorary medal was awarded to Charles T. Main, of Boston, in recognition of his services as a mill engineer and for his paper upon the "Choice of Power for Textile Mills," which was delivered at the fall meeting. Franklin W. Hobbs, of Brookline, Mass., was reelected president of the association.

Technology Congress

On April 10 and 11 the alumni of the Massachusetts Institute of Technology held a reunion at Boston to commemorate the fiftieth anniversary of the founding of their alma mater. The exercises were opened with an address by President Maclaurin, of the Institute, which was followed by the reading of a number of papers upon various engineering subjects, some of which will follow in a later issue.

The congress ended with a banquet in Symphony hall at which a number of men prominent in public, educational and engineering circles, responded to toasts.

The Institute was founded in 1861 by Professor Rogers, and from a small beginning with one building and only a handful of students, it has grown to be one of the leading technical schools with an enrollment of over fifteen hundred students and numbering among its graduates some of the most prominent engineers of this country.

Turin Exposition

In connection with the Turin International Exposition, which opens on April 29, 1911, there will be held an international competition for internal-combustion engines as applied to agriculture, entries closing on April 30. The object is to extend to various branches of agricultural work the use of petroleum motors, benzine motors, illuminating-gas motors, crude-oil motors, etc., in connection with plowing, sowing, harvesting, irrigating, etc. Various societies offer prizes, and the Italian government will purchase the articles winning first prizes in classes 1 and 2. Copies of the program for the competition in question may be obtained from the Bureau of Manufactures.

NEW PUBLICATIONS

ENGINEERING DIRECTORY, 1911. Compiled and published by the Crawford Publishing Company, Chicago, Ill. Leather; 1381 pages, 4x6½ inches. Price, $5.

This is the eighteenth annual publication of this work which was formerly known as the "Domestic Engineering Directory." The book aims to be a complete directory of the plumbing, heating, lighting, power plants and mill-supply industries in the United States. It contains a list of wholesale dealers in plumbing, heating and lighting supplies, a list of jobbers and dealers in mill, steam, mine and railway supplies, tools and machinery and, in addition, mailing lists of water works and gas companies, power plants, wholesale dealers in hardware and electrical supplies and purchasing agents of railroads, besides a classified list of the products of these various manufacturers. The various directories appear to be complete, and the book as a whole should prove of value to those interested in the fields mentioned.

STEAM TURBINES. By Walter S. Leland. Published by the American School of Correspondence, Chicago. Cloth, 120 pages, 6x9½ inches. Illustrated. Price, $1.

The book was written for the practical man who, though perhaps less interested in the finer points of theory than in the results and the way in which they are secured, is still deeply interested in the fundamental principles, both of construction and operation. No comparisons have been made between the designs of the different types. Facts have been stated and the reader has been left to draw conclusions on all points where a difference of opinion might occur.

The first five pages are devoted to the history of the turbine and a discussion of the kinetic principles upon which it is designed.

All types are accurately described and illustrated, making with its practical discussion of various installations and their respective performances, a comprehensive and valuable standard of reference. Turbine speed regulation is intelligently and thoroughly treated in the last chapter.

THE TEMPERATURE-ENTROPY DIAGRAM. By Charles W. Berry. Published by John Wiley & Sons, New York, 1911. Cloth; 410 pages, 5x7½ inches; 127 illustrations. Price, $2.50.

This is the third edition of Professor Berry's excellent little textbook, which is now expanded into a treatise on graphical thermodynamics, within the limits set by the title. In this edition the chapter on the Θ-Φ diagram for the flow of fluids has been expanded nearly four pages by a discussion of the total heat of dry saturated steam, based on Doctor Davis' classic determinations. The chapter on gas-engine cycles contains twenty additional pages devoted to the effect of different methods of speed regulation upon the efficiency at underloads and an analytical comparison of the several gas-engine cycles; the one on the nonconducting steam engine (Rankine cycle) has been improved by elaborating the tables of Rankine efficiency and specific steam consumption and extending their range downward to cover steam-turbine conditions. The old chapter of 16 pages on refrigeration and the Kelvin warming engine has been developed into two chapters covering 36 pages, one on each subject. An entirely new chapter on entropy analysis in the boiler room has been added and there are also short tables of Napierian and common or Briggsian logarithms at the end of the book.

For the benefit of those who are not familiar with previous editions it may be well to say that the book is an ideal college text but not at all adapted to "home study" or useful as a practical reference book.

Solenoids, Electromagnets and Magnet Windings. By Charles R. Underhill. Published by D. Van Nostrand Company, New York, 1910. Cloth; 350 pages, 5x7½ inches; 221 illustrations; many tables. Price, $2.

This is the first adequate exposition of the principles and practice of electromagnet design and construction thus far published, unless one has been brought out by the Chinese, Turks or Russians. It is a pity, therefore, that the author did not either omit the purely academic phase of the subject or submit his work to a competent editor. Some of his fundamental definitions are obscure and some statements based on them are absolutely wrong. His style is neither lucid nor fluent.

The practical formulas and data contained in the book are priceless to anyone who has much to do with making electromagnets. Unfortunately, some of the charts are so small and poorly reproduced as to be useless, notably those on pages 314, 315 and 316.

Notwithstanding the weak points, the book is highly praiseworthy in general. It could be improved by condensation and the omission of didactic material. A man who needs a practical manual on this subject has passed the strictly elementary grade.

At the recent exhibition held by the Physical Society, of London, A. C. Cossor showed an improved form of W. R. Cooper's patent speed indicator. A glass tube, branched below like the traditional anchor, is partly filled with mercury and is turned together with its vertical spindle within the cup, which holds it, by the flexible drive. The liquid above the mercury in the long, central tube falls when the device is rotated; should the maximum speed that can be recorded be exceeded, no harm would be done; the liquid would simply not descend more. The motion is taken from a shaft through a friction wheel. The new type of X-ray tubes of A. C. Cossor is provided at the anode with several radiating disks of aluminum intended to cool the anode. The bulb is further fitted with a branch tube, which serves as a regulator. This tube contains a length of a smaller glass tube wrapped with asbestos, over which aluminum wire is coiled; inside the tube is a strip of aluminum, and wires from this strip extend outside to near the terminals of the bulb. The idea—first applied by Gundlach, we believe—is that too strong currents will liberate an air bubble from the asbestos lagging as soon as a spark passes from a terminal to the branch circuit; the liberated air would enter the main bulb.—*Engineering.*

SOCIETY NOTES

The second annual meeting of the American Association of Refrigeration will be held in the "east room" of the La Salle hotel, Chicago, Ill., on May 9 and 10, 1911. The first session will be called to order at 10:30 a.m., Tuesday, May 9.

On Thursday evening, April 13, J. C. Jurgensen delivered a paper on the "Economic Aspects of the Institute of Operating Engineers," before the New York branch No. 1 of district No. 2, in the Engineering Societies building. The meeting was attended by some 70 members and friends.

On Saturday evening, March 25, the members of the Institute living on Long Island, met at the rooms of the Modern Science Club and organized the Isherwood branch No. 2 of district No. 2. The officers elected were: F. L. Johnson, chairman, and Frank Martin, secretary-treasurer. This branch starts out under extremely favorable circumstances as it is made up largely of the men interested in the education at the Modern Science Club during the past winter.

On Thursday evening, May 11, at eight o'clock, the second monthly meeting of the New York branch No. 1 of the Institute will be held in the Engineering building. F. L. Johnson, associate editor of Power, will deliver a paper on the "Necessity for Industrial Education."

PERSONAL

A. Bement, consulting engineer, has moved from the Fisher building, Chicago, to 206 South La Salle street.

Alex. Crawford has been appointed purchasing agent for the Hyatt Roller Bearing Company, of Newark, N. J., and assumed the duties of the office on April 17.

Rodman Gilder, secretary of the Crocker-Wheeler Company, of Ampere, N. J., has resigned to become associated with the brokerage house of Dick Brothers & Co., 30 Broad street, New York. His seven years' experience in a high-class industrial concern should be of value to him in the analysis of bonds of industrial and other corporations.

BOOKS RECEIVED

Current Railway Problems. By Samuel O. Dunn. Railway Age Gazette, New York. Paper; 85 pages, 5x6¼ inches.

The Ignition Handbook. By H. R. Van Deventer, Sumter, S. C. Paper; 73 pages, 4¾x7½ inches; 40 illustrations. Price, 50 cents.

The Principles of Scientific Management. By Frederick W. Taylor. Harper & Bros., New York. Cloth; 77 pages, 6x9 inches.

Engines and Boilers. By W. McQuade. D. Van Nostrand Company, New York. Cloth; 87 pages, 5¼x8¼ inches; 62 illustrations; indexed. Price, $1.50.

Three-Phase Transmission. By William Brew. D. Van Nostrand Company, New York. Cloth; 178 pages, 5¼x8½ inches; 82 illustrations; tables; indexed. Price, $2.

Machine Shop Mechanics. By Fred H. Colvin. McGraw-Hill Book Company, New York. Cloth; 172 pages, 4¼x6¾ inches; 116 illustrations; tables; indexed. Price, $1.

The Temperature-Entropy Diagram. By Charles W. Berry. John Wiley & Sons, New York. Cloth; 393 pages, 4¾x7¼ inches; 125 illustrations; tables; indexed. Price, $2.50.

High-Efficiency Electrical Illuminants and Illumination. By Rollin W. Hutchinson, Jr. John Wiley & Sons, New York. Cloth; 278 pages, 5x8 inches; 147 illustrations; indexed. Price, $2.50.

POWER

NEW YORK, MAY 2, 1911

THE baseball season is now at hand and everybody is alive to the relative merits of the various teams.

Did you ever stop to consider what goes to make up a successful team? Is it individual playing or the earnest co-operation between all the members, each affording the other active support?

In answer to this question, it might be said that both are desirable, although the latter is the more important; in fact, it is absolutely essential to success. A collection of individual stars, each playing his own game without regard to the other or without any definite system, would be at the mercy of a well balanced team in which each member actively supported the others.

In short, the keynote to success is team work.

This holds true not only in athletics but in all business enterprises. To insure success all must work for the common cause.

Applied to the power plant it means that from the general manager down to the fireman all must strive toward producing better and more economical service.

Frequently, the men of one watch are detected in an attempt to let things slide over for the next watch, or if anything goes wrong they will sometimes attempt to shift the responsibility for it to the preceding watch. Such practice is sure to promote dissension and petty jealousies spring up which have no place in the operation of any plant.

Another important factor in economical operation is that of co-operation between the office and the operating force in the matter of purchasing supplies.

The motto, "A dollar saved is a dollar gained," does not always hold true in the power plant. The purchasing agent is apt to look to the price of an article without due regard to its adaptability, hence it may prove more expensive in the end.

On the other hand, if the purchasing agent, or general manager, and the engineer get their heads together and consider the subject from both points of view, that of price and that of durability and adaptability, they are very apt to effect a compromise which will prove satisfactory to all concerned and cheaper for the company.

Moreover, it will be found advantageous to acquaint the entire operating force with the cost of supplies.

If the oiler is appraised of the sum which the small daily waste in oil amounts to annually, he will take more pains to eliminate this waste. And if the fireman is impressed with the saving he can effect by more economical methods of firing, much will be saved in this respect.

Similarly, the engineer will be able to reduce the yearly packing bill.

It is the small losses that add up to an amazing figure at the end of the year. But by proper treatment of employees and system on the part of the management, reciprocated by team work on the part of the employees themselves, the losses can be cut down to a comparatively small figure.

Comparing Steam Turbine Tests

By A. G. Christie

When it is desired to compare the performances of two or more turbines operating under different conditions of pressure, superheat and vacuum, it is first necessary to reduce them to a common basis. This involves the determination of the "efficiency ratio" of each machine. By this is meant the ratio of the heat converted into useful work, per pound of steam, to the heat available through adiabatic expansion from the initial to the final pressures.

Anyone who has endeavored to compare the results of various steam-turbine tests understands the difficulty in making a fair comparison, especially when the tests have been performed under widely differing conditions. For instance, suppose turbine *A* has been tested at 200 pounds gage pressure, 150 degrees superheat and 28.9 inches vacuum, referred to a 30-inch barometer, and showed a steam consumption of 11.1 pounds per electrical horsepower-hour. Turbine *B* was tested under practically the same load with steam at 150 pounds gage pressure and 98 per cent. quality and with a vacuum of 27.8 inches and produced one electrical horsepower with 14.6 pounds of steam. A comparison of the steam consumptions per electrical horsepower-hour of these two turbines would require certain corrections to be made in the results of turbine *A* due to the steam pressure, superheat and vacuum being higher than in the case of turbine *B*. These corrections can be found only from the results of a long series of special tests under varying conditions of steam pressure, superheat and vacuum. Should such a series of tests be run on turbine *A*, the results might be misleading, for this turbine may have been designed to operate at its maximum efficiency under the conditions of the first test; hence, tests under other conditions would be in error to the extent of the variations in efficiency. As a rule, the results of such a series of tests are not at hand for every class of turbine and engineers have not agreed upon any standard corrections to be applied to any one class of turbine.

In the case of the test of turbine *B*, a correction must be made for the quality of the steam. The correction for dry steam would be as follows: The dry steam per electrical horsepower-hour equals

$$0.98 \times 14.6 = 14.308$$

It is generally agreed that turbines do not operate as efficiently with steam of 98 per cent. quality, as with steam at 100 per cent. quality, as the presence of moisture increases the friction and reheating effects, hence lowers the efficiency. For the purpose of illustration let it be supposed that turbine *B* is designed for maximum efficiency with dry steam at 150 pounds gage pressure and 28 inches vacuum, referred to a 30-inch barometer.

From the foregoing it is evident that the usual method of correcting the results of steam-consumption tests does not provide a satisfactory means of making comparisons which are fair to all turbines. On the other hand, there is a method of comparing the results of such tests which can be applied readily to any set of tests and is not liable to errors in the correction factors. This method involves the determination of the "efficiency ratio" of each machine; and, although not new in this country, it has not been used to the extent that it has in Europe.

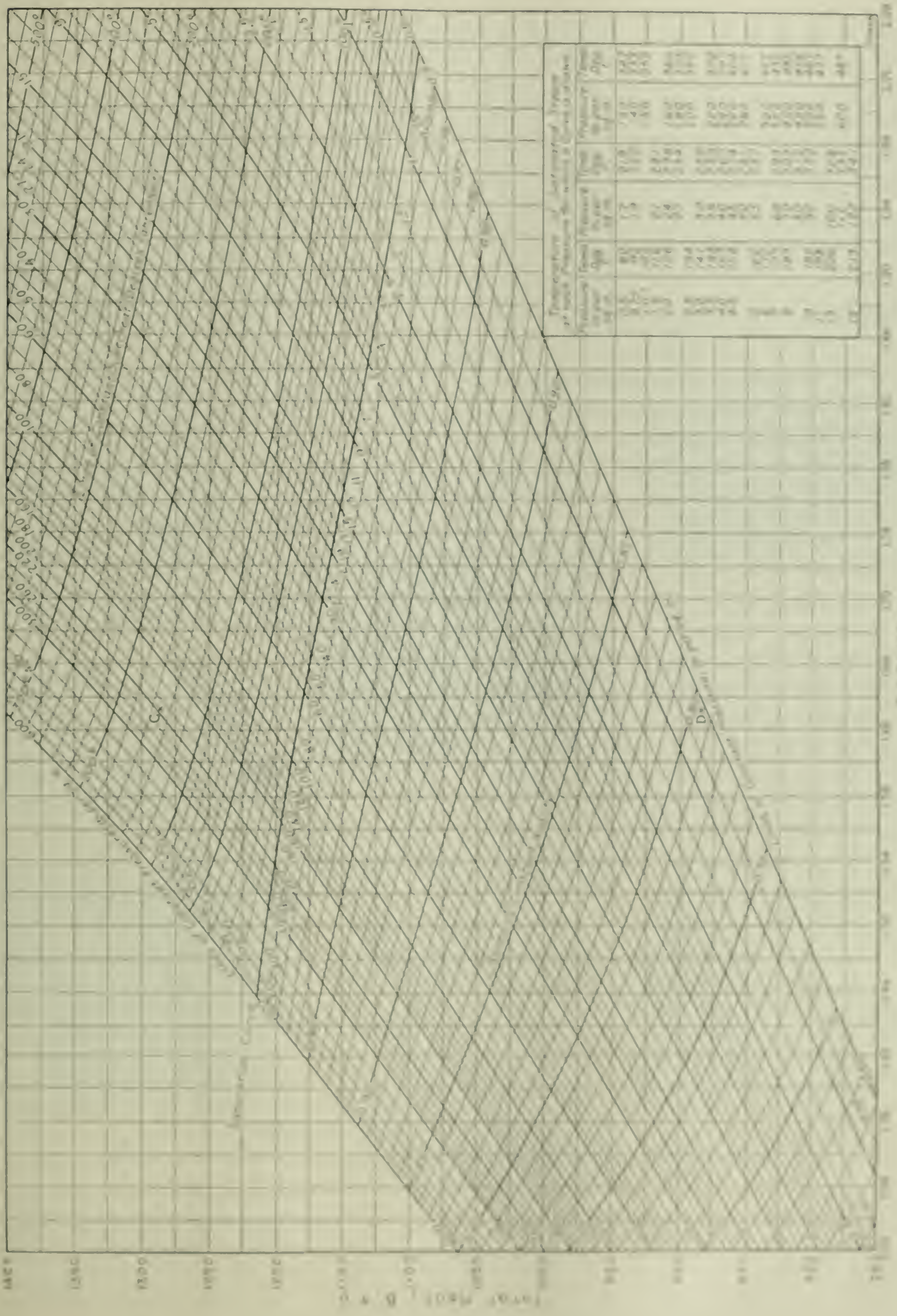
By "efficiency ratio" is meant the ratio of the heat converted into useful work, per pound of steam in the turbine, to the heat available through adiabatic expansion of the steam from its initial conditions of pressure, superheat and quality to its final pressure in the condenser. This may appear at first to be a complicated determination but, as will be shown later, it can be made very simple by the use of the heat charts which are now available.

A vapor is said to expand adiabatically when it neither receives heat from, nor gives up heat, except as work, to any outside body during expansion. All heat appearing as work must be supplied from the total heat in the vapor at the beginning of expansion. Hence, the heat, available as work, can be measured as the difference in the total heat in the steam at the beginning and at the end of expansion. In other words, with a given initial quantity of heat, the adiabatic expansion represents the maximum work that can be gotten out of a pound of steam in expanding from one condition to another. It represents the condition of maximum efficiency in all heat engines which depend for power upon the expansion of a vapor or gas, for there are present neither radiation nor internal losses. This forms a standard of efficiency with which actual results can be compared. The ideal turbine can be considered as working by adiabatic expansion of the steam and with neither radiation nor internal losses.

In the preceding discussion work has been referred to as a quantity of heat. Ordinarily, work is reckoned in foot-pounds of energy or in horsepower when the rate of its accomplishment is involved; but all these various units of work or power can be resolved into foot-pounds. It has been shown experimentally that 778 foot-pounds equal one B.t.u.; hence, work measured in foot-pounds, in horsepower or in other units can be readily transformed into equivalent B.t.u.

On a temperature-entropy diagram, an adiabatic expansion is represented by a line of constant entropy; for if the entropy increases during expansion, heat must have been added to the vapor or if the entropy decreases, heat must have been given up by the vapor. But, as adiabatic expansion is possible only when all the heat units given up during expansion are transformed into work, this condition occurs only when the entropy is kept constant. The term "isentropic" means equal or constant entropy and may be used instead of "adiabatic." There are several forms of entropy diagrams, the most convenient of which employ entropy and total heat per pound of steam as coördinates; of this type the Mollier diagram is the most widely known. This, which is here reproduced within the limits of the problem under discussion, contains curves of constant absolute pressure, constant quality and constant superheat. Such diagrams upon larger scales can be found in Stodola's *Steam Turbines*, Marks & Davis' *Steam Tables* and Thomas' *Steam Turbines;* Peabody's *Temperature-Entropy Tables* also give the values of such a diagram in tabular form.

To use the diagram for the determination of the heat available from adiabatic expansion, follow along the curve of constant absolute pressure to its intersection with the curve of constant quality or constant superheat, representing the initial conditions of the steam. The total heat in one pound of steam at that condition, can be read from the scale of coördinates at the left of the diagram. Note this amount of heat. Next, from this initial condition follow down the vertical ordinate of constant entropy until it intersects the curve representing the absolute terminal pressure of the expansion. Note the total heat at this condition. The difference in heat contents at the initial and the final conditions of the steam represents the heat available as external work per pound of steam due to the adiabatic expansion between the given limits. The absolute pressures are found in every case by adding the pressure corresponding to the barometer to the observed gage pressure.



Mollier Diagram

In a steam turbine, the expansion is not strictly adiabatic, owing to the internal losses and radiation. The radiation loss is usually small, but the internal losses are the real measure of the efficiency of a turbine and vary somewhat with different machines. These losses are often designated by such terms as blade friction, windage, eddying, etc., but all are manifestations of fluid friction. This may be due to the friction of the steam against the walls of the steam passages, to the friction between particles of the steam, or to leakage past the diaphragms and over the tips of the blades.

When friction losses occur in a vapor, a cycle of events occurs as follows: With steam flowing at a given velocity over a curved surface, such as a turbine blade, friction is set up between the steam and the blade and some of the energy due to the velocity of the steam is converted into heat. This heat increases the temperature of the metal surface. The next instant a cooler particle of steam comes in contact with this surface and absorbs this heat. Hence the heat loss due to this friction is returned to the steam itself, increasing the quality in the case of saturated steam and the temperature in the case of superheated steam. This increment of heat does not increase the capacity of the steam for doing work, as may be demonstrated by throttling steam from boiler pressure to atmospheric pressure. The volume at atmospheric pressure would then be many times greater than that at boiler pressure and the steam would probably be superheated. However, it would be useless to attempt to use this steam in a noncondensing turbine or engine for, although the heat in the steam may exceed that of dry steam at atmospheric pressure, no flow can occur until a drop of pressure is provided; therefore, no work can be done. Hence, internal friction of the steam in a turbine is a loss unless this steam is used for heating purposes. In most cases, this reheating of the steam in a turbine, through friction, has one beneficial effect in that it reduces the friction loss in later stages by supplying these stages with drier steam. It is well known that moisture in the steam materially increases the losses due to friction. The loss due to blade and diaphragm leakage is similar to that of throttling previously referred to.

When the heat available from adiabatic expansion has been determined, all that remains is to find the heat equivalent to work per pound of steam.

The results of the tests on any turbine will show the pounds of steam per electrical horsepower-hour or per brake horsepower-hour. If the turbines to be compared are both connected to electric generators, then it is necessary only to compare them on the basis of electrical horsepower, for as a rule, one contractor supplies both the turbine and the generator and makes his guarantee on the combined unit. If brake tests have been made on both units, comparison on a brake-horsepower basis is satisfactory. If one set of tests have been made with an electric generator furnishing the load and the other set with a brake load, then it will be necessary to reduce these to a common basis, in which case the efficiency of the electric generator must be known.

Assume that the tests have been made with electric generators as stated for turbines A and B. One horsepower equals 33,000 foot-pounds per minute, or

$$33{,}000 \times 60 = 1{,}980{,}000 \textit{ foot-pounds per hour}$$

Also, one B.t.u. equals 778 foot-pounds. It follows that

$$\textit{One horsepower} = \frac{1{,}980{,}000}{778} = 2545 \textit{ B.t.u. per hour}$$

Test results show for turbine A that 11.1 pounds of steam were required to produce one electrical horsepower of work which is equivalent to 2545 B.t.u. Hence, the heat per pound of steam actually converted into work equals

$$\frac{2545}{11.1} = 229.2 \textit{ B.t.u.}$$

From the Mollier diagram it will be found that there are 402 B.t.u. available per pound of steam due to adiabatic expansion from 214.7 pounds absolute and 537.8 degrees Fahrenheit to 0.54 pound absolute. This is found by first locating the point C at the intersection of the 214.7-pound pressure curve with the curve representing 150 degrees superheat; that is,

$$537.8 - 387.8 = 150 \textit{ degrees superheat,}$$

the 387.8 being the temperature of saturated steam at 214.7 pounds. Next, locate point D vertically below C and on the curve representing 0.54 pound. Referring to the scale on the left of the diagram, point C will be found to lie on the abscissa representing 1285 B.t.u. and D on the line representing 883 B.t.u.; therefore, the heat drop is

$$1285 - 883 = 402 \textit{ B.t.u.}$$

This shows an efficiency ratio of

$$\frac{100 \times 229.2}{402} = 57 \textit{ per cent.}$$

In the same way it can be shown for turbine B that the heat equivalent to work per pound of steam is 174.6 B.t.u. and the heat available from adiabatic expansion from 164.7 pounds absolute and 98 per cent. quality to 1.08 pounds absolute is 315 B.t.u.; hence, the efficiency ratio is

$$\frac{100 \times 174.6}{315} = 55.4 \textit{ per cent.}$$

Thus the efficiency ratio is a correct measure of the absolute efficiency of each turbine as it represents the ratio of the heat equivalent of useful work to the heat available, were the steam to expand freely with absolutely no losses in an ideal turbine.

Suppose, however, that one turbine has been tested with an electric generator and the other with a brake and it is desired to compare results on the basis of efficiency ratios. As stated before, the generator efficiency must be known. This can be obtained usually from the manufacturers and should include iron losses, copper losses, windage and friction. Assume that the tests of two 500-kilowatt turbines are to be compared. One is connected to an electric generator whose efficiency is 93 per cent. at full load; and in the test with a load of 670 electrical horsepower this unit required 9514 pounds of steam at 148 pounds gage pressure, 99 per cent. quality and 27.4 inches of vacuum, referred to a 30-inch barometer. The equivalent brake horsepower equals

$$\frac{670}{0.93} = 721 \textit{ b.h.p.}$$

and the steam consumption is 13.19 pounds per brake horsepower-hour.

The heat available through adiabatic expansion from 162.7 pounds absolute and 99 per cent. quality to 1.275 pounds absolute, is found from the chart to be 307 B.t.u. The heat utilized per pound of steam is

$$\frac{2545}{13.19} = 192.9 \textit{ B.t.u.}$$

and the efficiency ratio is

$$\frac{100 \times 192.9}{307} = 62.83 \textit{ per cent.}$$

The second turbine was tested with a brake. When running under steam at 155 pounds gage pressure and 98 per cent. quality, with a 28.5-inch vacuum, referred to a 30-inch barometer, the results showed a steam consumption of 13.05 pounds per brake horsepower-hour. The heat available from an adiabatic expansion from 169.7 pounds absolute and 98 per cent. quality to 0.737 pound absolute is found from the chart to be 330.5 B.t.u. The heat utilized per pound of steam was

$$\frac{2545}{13.05} = 195 \textit{ B.t.u.}$$

and the efficiency ratio is

$$\frac{100 \times 195}{330.5} = 59 \textit{ per cent.}$$

Hence, it would appear that the turbine tested with the generator is the more efficient unit.

By means of "efficiency ratios," a standard, varying only within the limits of the steam pressures used, can be determined; to this each turbine can be referred and an absolute efficiency ratio determined. A comparison of these efficiency ratios for several turbines will determine which is the most efficient regardless of the steam conditions under which they have been tested.

Friction Clutches and Their Use

By H. A. Jahnke

A continuation of the clutch descriptions appearing in the April 11 number, including clutches for gas and oil engines.

Dodge Clutches

Figs. 20, 21, 22 and 23 show the Dodge clutches. The Dodge clutches are of the disk type and are made in both split and solid patterns. The split clutch, Fig. 20, has one disk plate and is filled with hard-maple blocks the end-grain faces of which are pressed against the driving and clamping plates. The driving plate is keyed to the shaft while the outside clamping plate, by means of the levers shown, brings the wooden blocks in contact with the driving plate. When the clutch is in full, the wood-filled disk is securely clamped between the plates. The adjustments are made by tightening or loosening the locknuts on the draw bolts. A desirable feature of this clutch is its interchangeability. A pulley, sheave or gear used in connection with it may be of any size within the capacity of the clutch. Where much power is to be transmitted by the Dodge clutch, it is recommended that a sleeve be used which is long enough to permit the rise of two bearings, one on either side of the pulley. This will prevent all bending stress in the shaft due to the weight of the pulley.

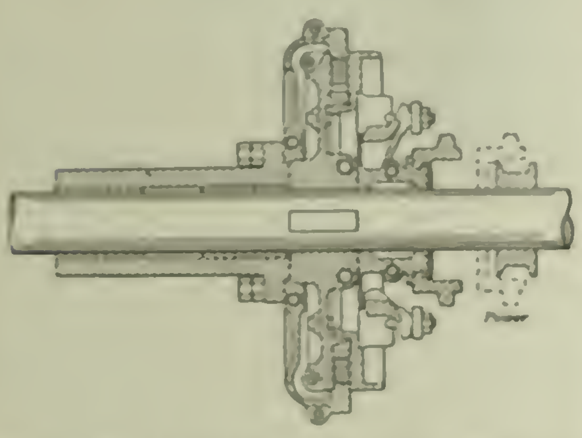


Fig. 20. Section of Dodge Friction-clutch Cutoff Coupling

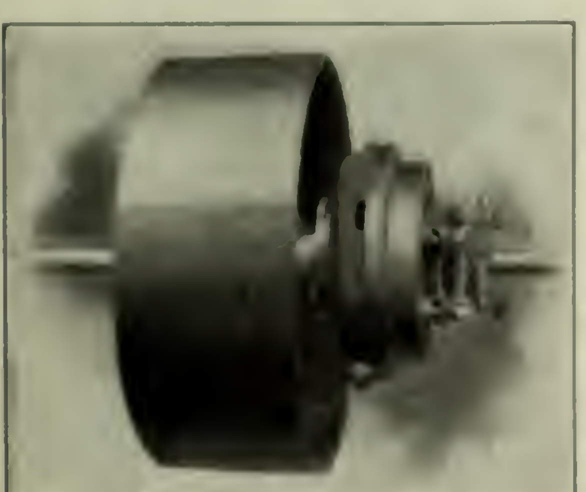


Fig. 21. Dodge Clutch with Steel Pulley

These clutches are made by the Dodge Manufacturing Company, Mishawaka, Ind.

The Hunter Clutch

Fig. 24 shows the Hunter clutch, which may be used as a friction-clutch cutoff coupling, or in connection with a pulley. A novel feature of the Hunter clutch is that when not in use the friction hub can be withdrawn; thus, should the shaft get out of line there would be no contact between the friction surfaces, thereby avoiding all unnecessary wear.

Fig. 22. Dodge Clutch with Wood Pulley

This clutch is made by the James Hunter Machine Company, North Adams, Mass.

The Medart Clutch

All of the operating mechanism of the Medart friction clutch, Figs. 25 and 26, is in full view, and self-locking. The clutch can be thrown in or out without shock or jar. All of the Medart clutches are furnished with stop bolts to limit the throw of the slide collar, making a set collar unnecessary. All clutch pulleys over 30 inches in diameter are fitted with V-shaped friction shoes as shown in Figs. 25 and 26.

The Medart Patent Pulley Company, St. Louis, Mo., manufactures this clutch.

The Lemley Clutch

Figs. 27 and 28 show the Lemley clutch. The Lemley clutch is provided with two or more sets of toggles, depending on the size of the clutch. The clutch has a universal adjustment which makes it necessary to move only one part to adjust all toggles. In this way equal pressure is secured on all friction surfaces.

The friction blocks are made of hard maple. These are riveted to the friction plate with copper rivets. The blocks are supported on both sides by flanges on the friction plate.

The Lemley clutch is made by the W. A. Jones Foundry and Machine Company, Chicago, Ill.

The Davis Clutch

Figs. 29 and 30 show the Davis clutch. This clutch is made with a friction ring or hub with a sleeve on which a pulley or gear can readily be mounted. On the body piece there are hinged two friction wings which extend all the way around the hub, and are operated by compound levers acting against set screws. The wings terminate in two sets of lips through which are passed steel bolts through springs; this arrangement assures plenty of clearance when the levers are dropped. The clutch is perfectly balanced and, therefore, vibration is practically absent.

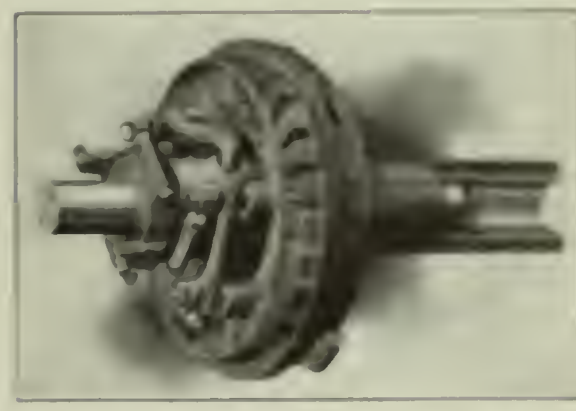


Fig. 23. Part Phantom View of Dodge Clutch, Showing Contact Blocks

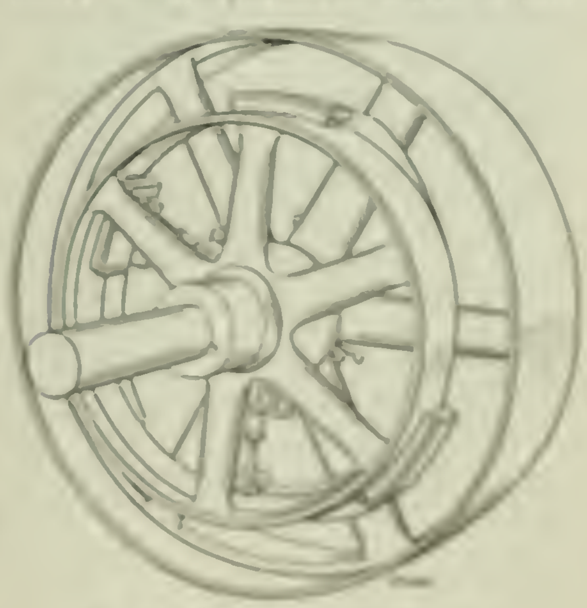


Fig. 24. The Hunter Clutch

The adjustment of this clutch is very simple and of almost unlimited range.

The Davis clutch is made by the Worcester Machine Company, Worcester, Mass.

The Reeves Clutch

The Reeves clutch is shown in Figs. 31 and 32. Extreme simplicity is one of the claims made for this clutch.

The metal friction wheel is clamped solidly to the shaft; the power is delivered by means of the wooden friction shoes,

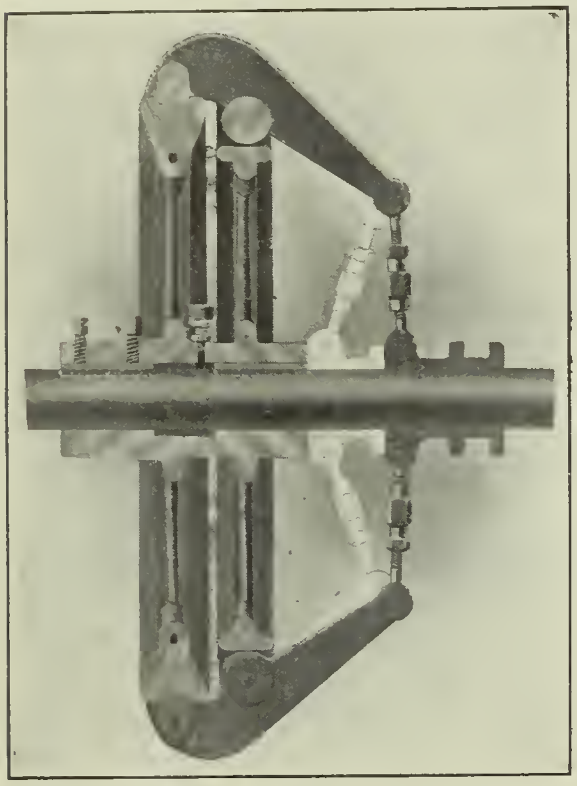


Fig. 25. Sectional View of the Medart Clutch

which are connected to the belt wheel, and which, when the clutch is thrown in, bear upon the face of the friction wheel.

The pulley is fitted with a babbitted bushing and when the clutch is thrown out all of the working parts and the

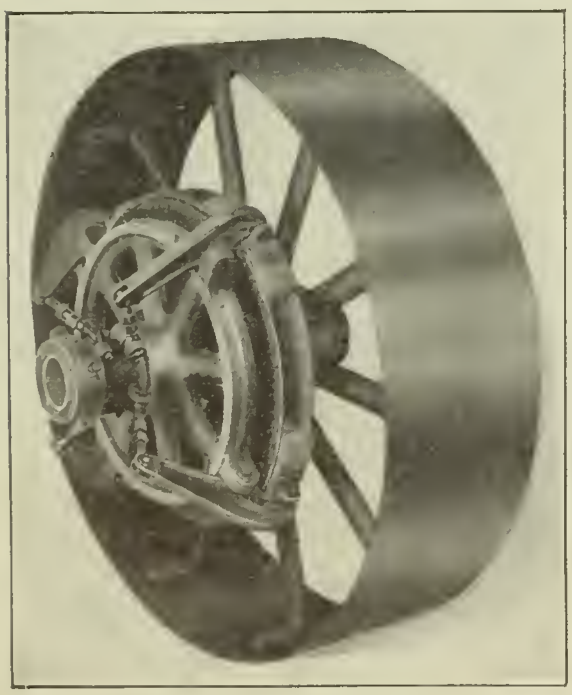


Fig. 26. Medart Clutch Attached to Pulley

pulley stand still. The friction shoes are operated by a toggle joint. The manufacturers of this clutch, the Reeves Pulley Company, Columbus, Ind., claim that, to the best of their knowledge, this is the only clutch which combines a wood split pulley with the clutch mechanism.

The Frisbie Clutch

The simple design of the Frisbie clutch is shown by the sectional view in Fig. 33. The pulley runs loose on the shaft; the

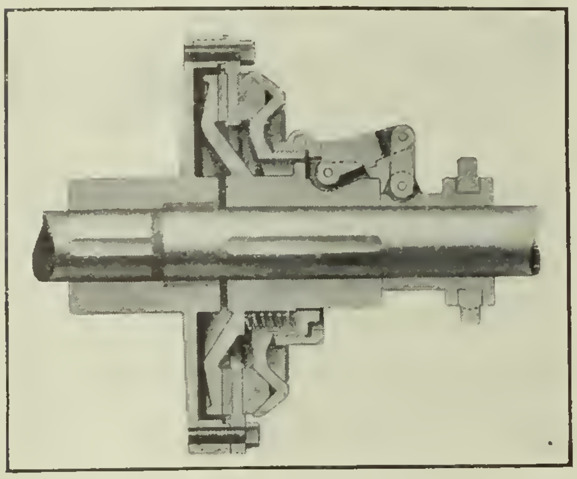


Fig. 27. Sectional View of the Lemley Clutch

hub of this pulley has a renewable bushing which takes all of the wear. The V-shaped friction ring is cast onto the arms of small pulleys and bolted onto those of the larger ones. The system of levers in the clutch spider, which is keyed solidly to the shaft, together with the friction shoes inside of the ring, forms the

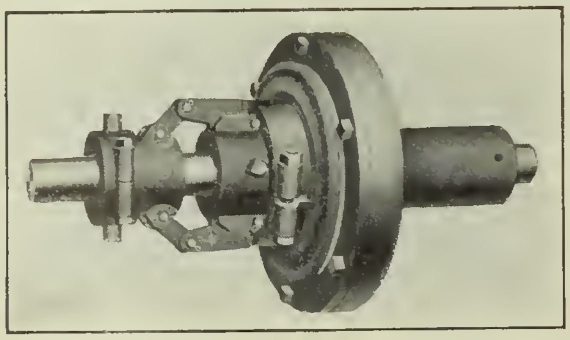


Fig. 28. Exterior View of Lemley Clutch

operating mechanism. Movement of the sliding sleeve operates the latches which move the heavy dogs, and by means of the shoe bolts draws the four friction surfaces of the pulley and spider together in position and powerful contact. The amount of pressure is regulated by the clamp nuts on the shoe bolts, which also take up lost motion caused by wear. The shoes and spider are fitted

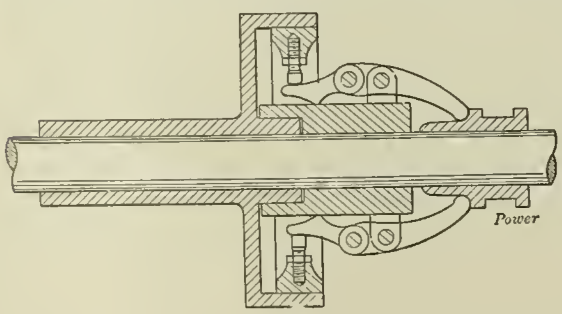


Fig. 29. Section of Davis Clutch

with thoroughly seasoned maple contact blocks.

The Frisbie cutoff coupling is shown in section in Fig. 34. Both of these devices are made by the Eastern Machinery Company, New Haven, Conn.

The Warner Clutch

Fig. 35 shows the design of the Warner clutch. This clutch has two or more crucible spring-steel rings or bands which

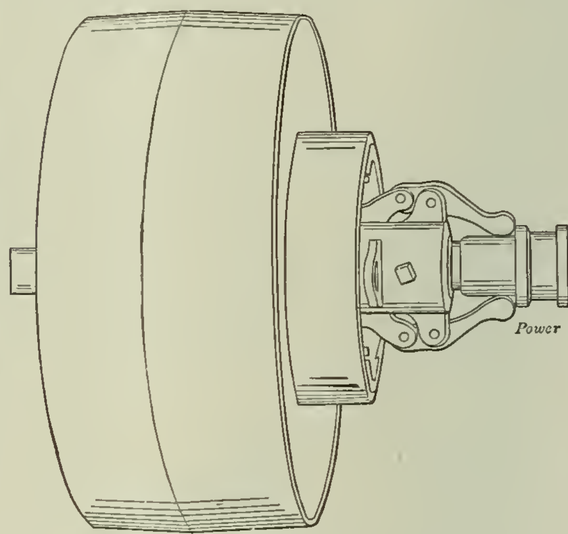


Fig. 30. Davis Clutch with Pulley Attached

are forced into frictional contact with the polished surface of a chilled-iron drum. The clutch mechanism is inclosed in a dust-proof case, and runs in an oil bath; the steel rings are practically unbreakable. The wear, which is very slight, occurs on the steel rings. The rings act one after another, thus insuring smooth engagement. When the clutch is used in connection with a pulley or gear it is fitted with a sleeve to which the pulley or gear can be keyed.

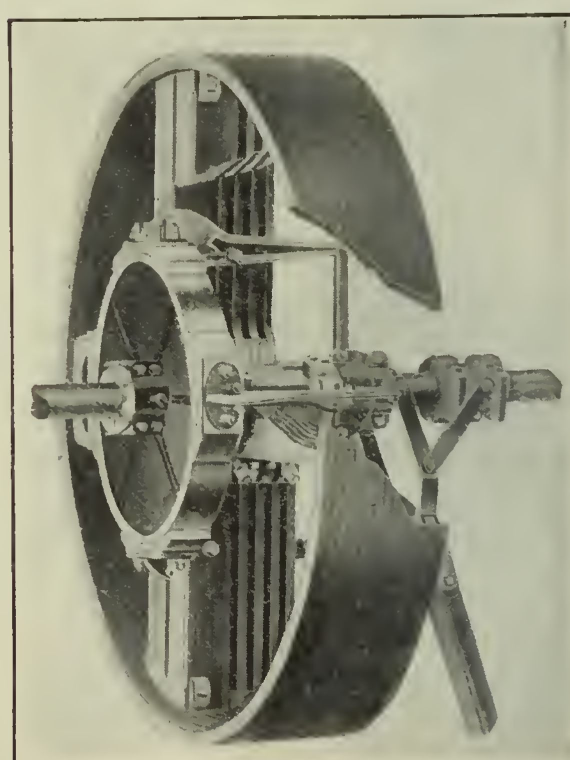


Fig. 31. Part Sectional View of Reeves Clutch with Pulley

When the clutch is used for a cutoff coupling, it is furnished with a hub, the driving shaft being keyed to the hub, while the driven shaft is keyed to the drum.

The Warner Clutch Company, Chicago, Ill., makes this clutch.

The Plamondon Clutch

A sectional view of the Plamondon clutch is given in Fig. 36. This clutch

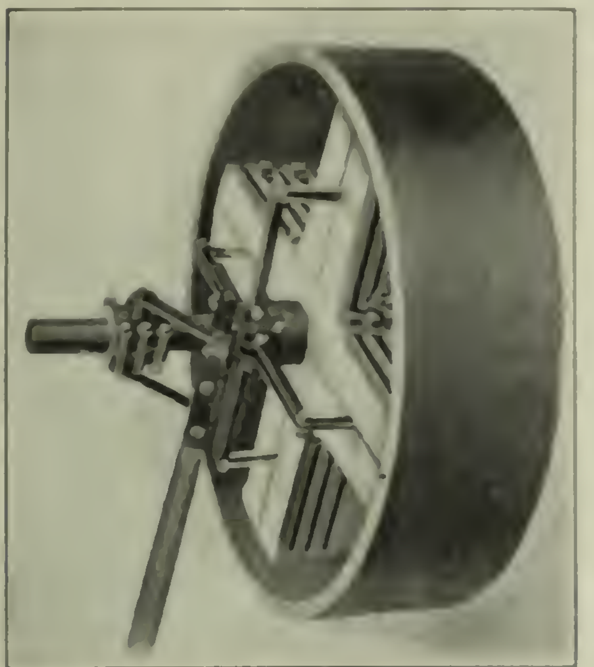


Fig. 32. Reeves Clutch and Pulley, Showing Mechanism

is powerful and simple, has few parts, contains no springs or bolts and is of such design as not to be affected by cen-

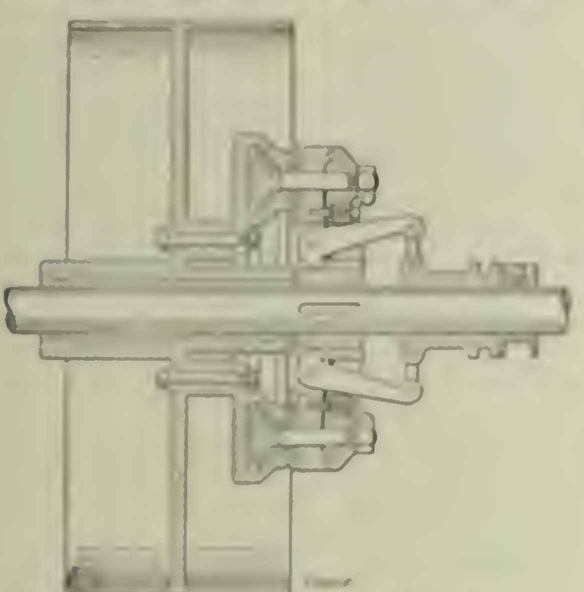


Fig. 33. Sectional View of Frisbie Clutch

trifugal action. Further, it is proof against dust and dirt, which fact makes it valuable for service in cement mills and the like.

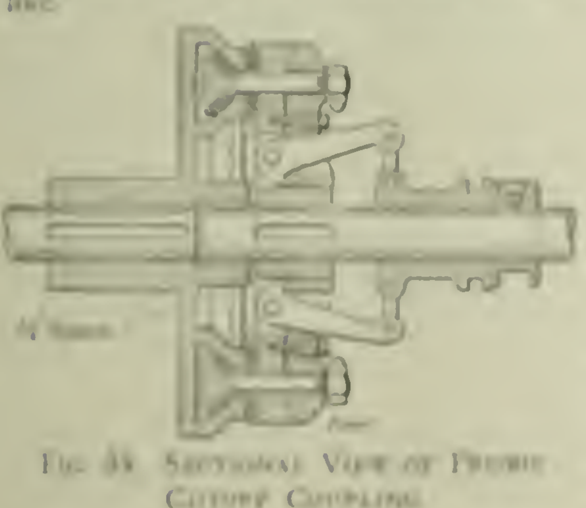


Fig. 34. Sectional View of Frisbie Cutoff Coupling

The friction plate C is lined on both sides with hard-maple segments, and is made in halves so that it can be removed for relining. In operation, the disks A and B are pressed against the plate C by means of the compound toggle arrangement G, H and I.

This clutch is made by the Plamondon Manufacturing Company, Chicago, Ill.

The Moore & White Clutch

Fig. 37 shows a sectional view of the Moore & White friction-clutch pulley, and

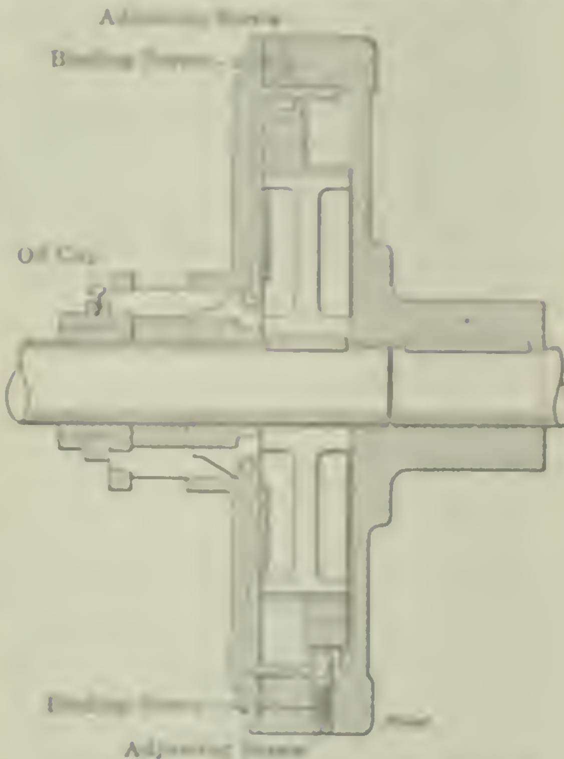


Fig. 35. Design of Warner Clutch

Fig. 38 shows the friction disk used in this clutch. The pulley is made with a long hub to give ample wearing surface. To the hub of the pulley is keyed a collar with lugs on one side which engage with lugs on the friction disk;

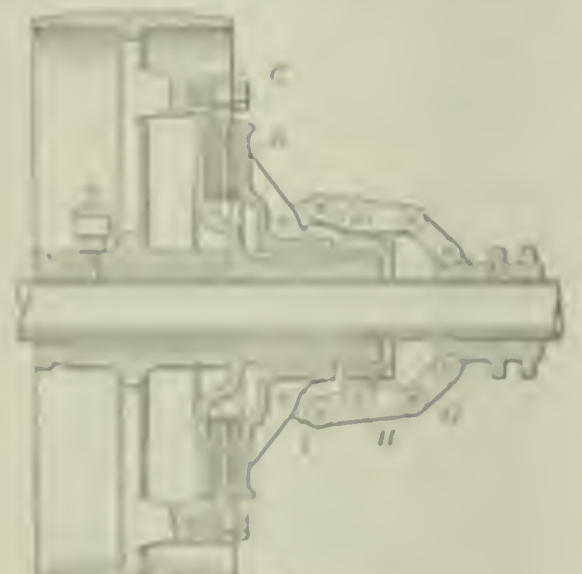


Fig. 36. Sectional View of the Plamondon Clutch

this causes the disk that fits loosely on the hub of the pulley to revolve with the pulley and at the same time leaves the disk free to take up wear if necessary. The advantage of the disk being loosely connected to the pulley in this manner becomes manifest when the pulley wears loose on the shaft, or when the shaft, pulley or hub falls to run true. With this design wear of the friction surface is prevented when the clutch is disengaged.

The friction disk is filled with hard

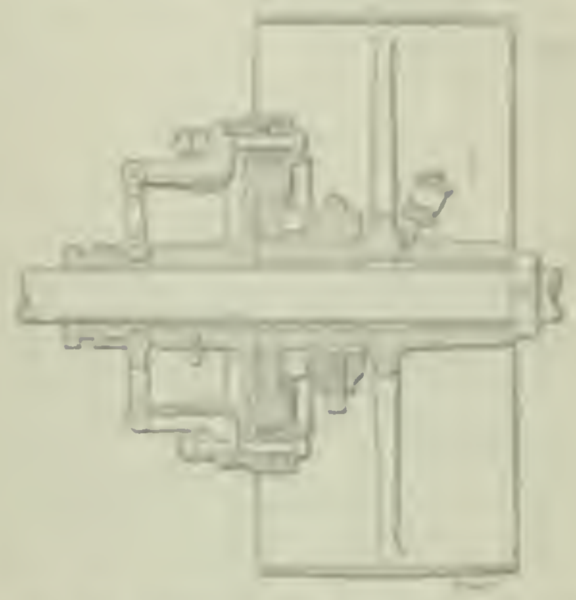


Fig. 37. Section of Moore & White Friction-clutch Pulley

wood and presents two end-grain wood surfaces for contact with the two iron surfaces. The iron surfaces are drawn into contact with the wood surfaces of the disk by a powerful mechanism. The

Fig. 38. Friction Disk of the Moore & White Clutch

clutch can be made in halves if necessary, and applied to wood pulleys, gearing and sprocket wheels. It can also be applied as a cutoff coupling for stopping

Fig. 39. The [illegible] Friction-clutch Pulley

and starting parts of line shafts. This clutch is manufactured by the Moore & White Company, Philadelphia, Penn.

The Falls Clutch

Figs. 39 and 40 show the Falls friction-clutch pulley, and Fig. 41 shows the

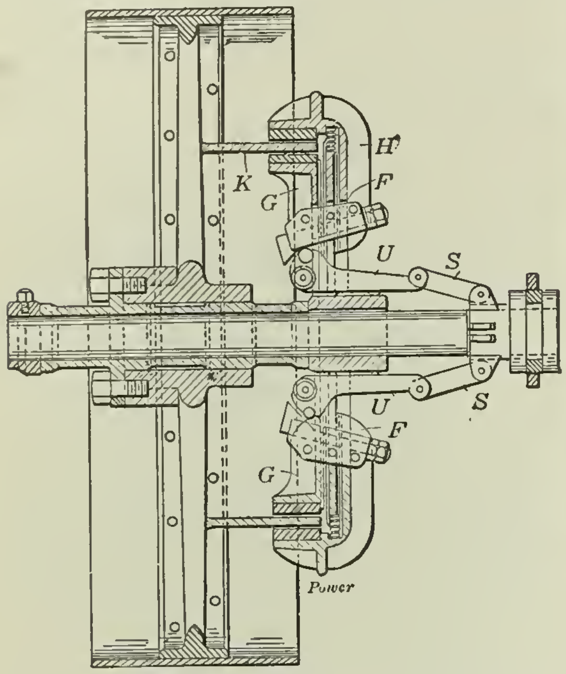


Fig. 40. Sectional View of the Falls Friction-clutch Pulley

friction-clutch cutoff coupling. These clutches are made with four or six arms according to the amount of power to be

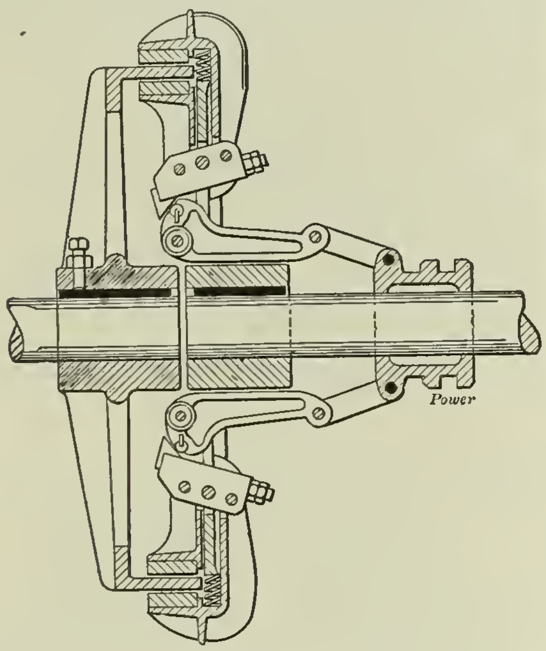


Fig. 41. The Falls Cutoff Coupling

transmitted. The pulleys are furnished with babbitted split sleeves for bearings; they are turned on the outside to fit the

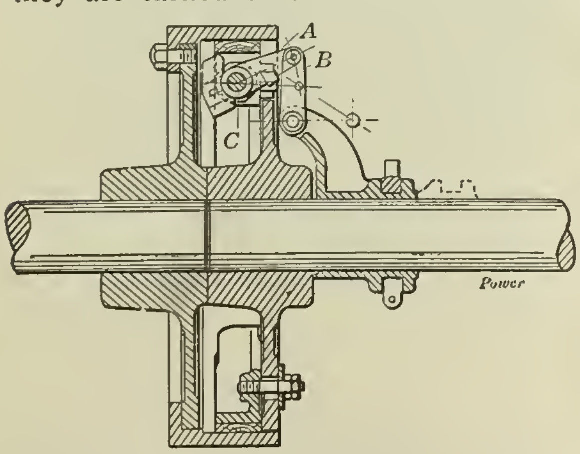


Fig. 44. Section of A. & F. Brown Friction-clutch Pulley

hub of the pulley and bored on the inside to fit the shaft. The sleeves are held in position by two cap screws.

The clutch ring *K*, Fig. 40, is generally made one-half the diameter of the pulley onto the arms of which it is cast.

Fig. 42. Allis-Chalmers Friction-clutch Pulley

The inner jaw *G* of the clutch arms is forced outward, and the outer jaw *H* inward, by means of the toggle levers *S*

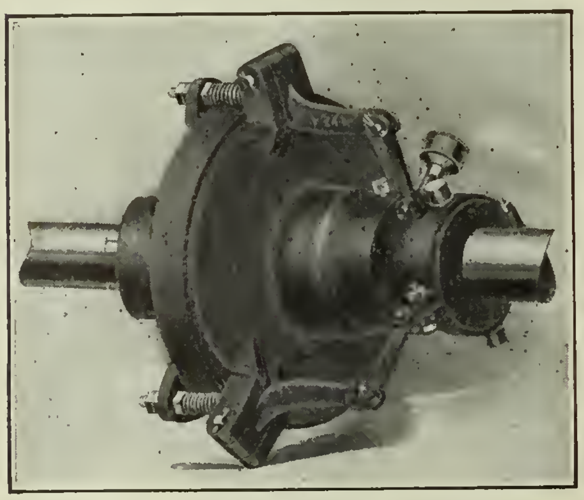


Fig. 43. Allis-Chalmers Friction-clutch Coupling

and *U* which act upon the lever *F*. The clutch jaws are adjusted by means of the steel wedges in the lever *F*. Seasoned maple is used for the clutch shoes.

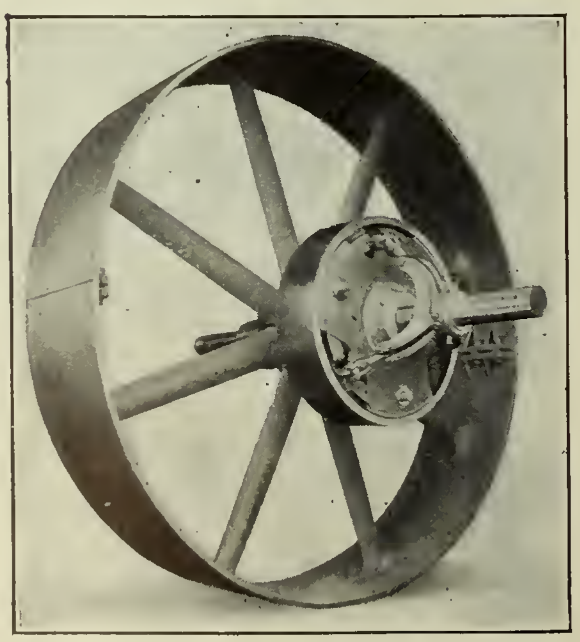


Fig. 45. A. & F. Brown Clutch with Pulley Attached

The Falls Rivet and Machinery Company, Cuyahoga, O., makes the clutch.

The Allis-Chalmers Clutch

The Allis-Chalmers friction-clutch pulley is shown in Fig. 42 and the friction-clutch coupling in Fig. 43. These clutches are of the disk type. Although they are designed to be capable of carrying very

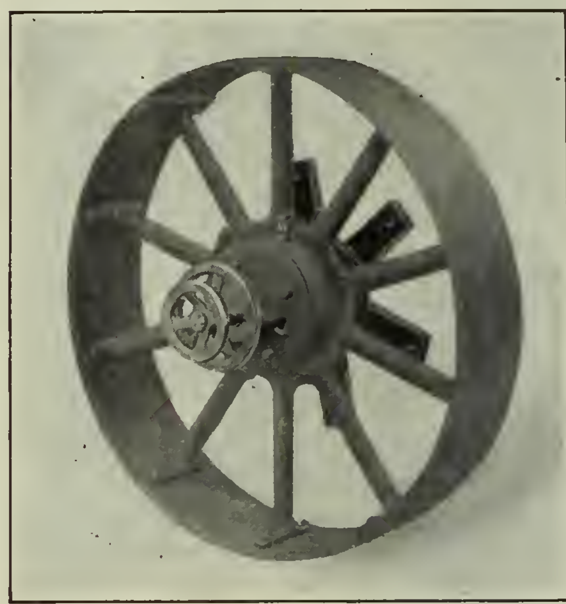


Fig. 46. The Springfield Clutch for Gas Engines

heavy load, they are made in sizes adapted for use in any place where power is employed.

The adjustment of two set nuts compensates for any wear of the friction surfaces. The cast-iron driving disk is clamped between two continuous wood surfaces. The clutches are made with either three or six arms, and, as the pressure is distributed uniformly over

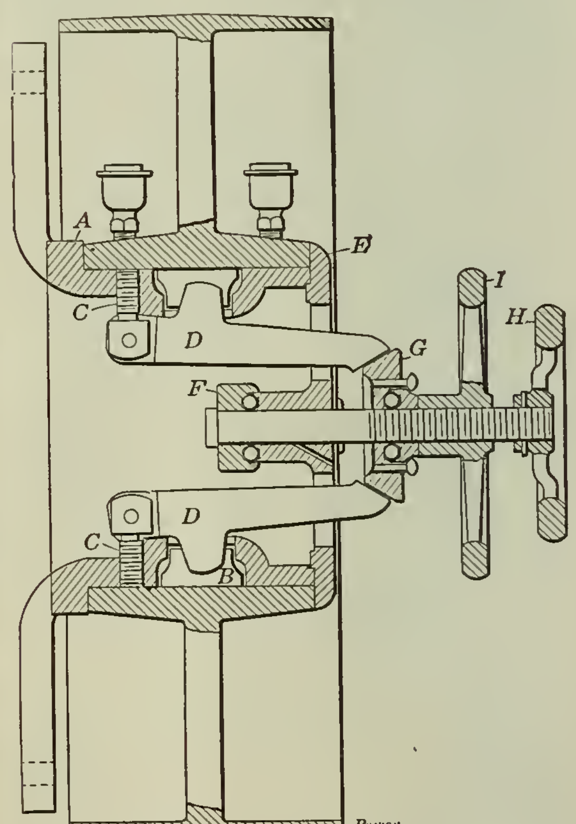


Fig. 47. Section through Springfield Clutch

the entire friction surfaces, the clutches do not have to carry any one-sided strains. There are no springs in the mechanism. The pressure is regulated according to the load the clutch has to carry, by means of adjusting nuts on the eye bolts.

These clutches are made by the Allis-Chalmers Company, Milwaukee, Wis.

The A. & F. Brown Clutch

The A. & F. Brown clutch is shown in Figs. 44 and 45. This clutch is simple in construction and durable. The shifter collar, Fig. 44, operates the counterweighted lever *A* through the link *B*. The pin *C* carries a worm which, when the clutch is thrown in, forces the frame carrying the wood shoes against the friction hub. The object of the counterweight on the lever *A* is to prevent centrifugal force from influencing the action of clutch.

Fig. 45 shows a three-arm clutch with split pulley attached.

The A. & F. Brown Company, New York City, manufactures these clutches.

Clutches for Gas, Gasolene and Oil Engines

There are many points in favor of placing a friction clutch on gas and gasolene engines, especially where the load is heavy. One advantage is that the engine may be started slowly and gradually speeded up before any load is thrown on the engine. Another desirable point in having a friction clutch on the engine is that in case of an accident it is not necessary to stop the engine; the machines can be stopped or started by the friction clutch, thereby saving time and expense.

Springfield Clutch

Figs. 46 and 47 show the Springfield clutch pulley ready to be attached to the flywheel of a gas or gasolene engine. The pulley proper is mounted on a hollow bearing or spider *A*, Fig. 47, having arms which bolt to the flywheel. In the bearing is a recess or groove in which lies a friction ring *B* which is divided into two parts. Attached to the bearing by means of studs *C* are two levers *D* having wedge-shaped lugs extending between the ends of the friction ring. A faceplate *E* is bolted to the bearing or spider and provides a journal for the spindle. The inner end of the spindle is fitted with a ball-bearing thrust collar *F*. Mounted loosely on the spindle is a cone *G* which also forms part of the ball bearing.

To engage the clutch the handwheel *H* is held stationary and the wheel *I* is turned down on the spindle. This causes the cone *G* to force apart the ends of the arms *D* so that lugs enter the openings between the halves of the friction ring *B* and force it into contact with hub of the bearing.

The Springfield Gas Engine Company, Springfield, O., manufactures the clutch.

Lemley Gasolene-engine Clutch

Fig. 48 shows the Lemley gasolene-engine clutch pulley. The upper part of the figure shows the clutch designed to be bolted to the flywheel arms and the lower part shows the clutch as it is built to be keyed to the shaft.

The friction blocks are made of hard maple riveted to the clutch plate and make a continuous friction surface around the plate. To engage the clutch the handwheel is pulled out; to release, it is pushed in.

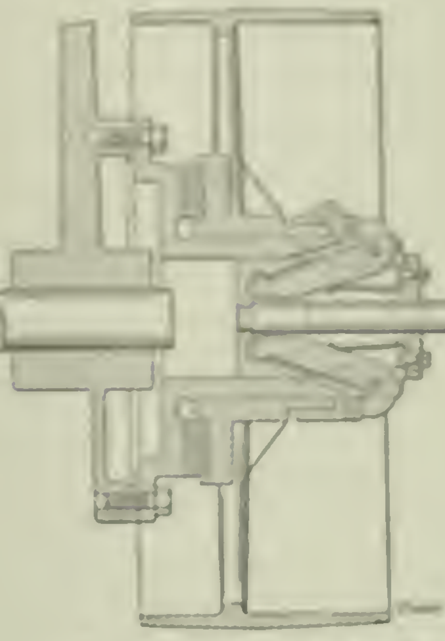


Fig. 48. Lemley Clutch

The Lemley gasolene-engine clutch is made by the W. A. Jones Foundry and Machine Company, Chicago, Ill.

Notes on Power Plant Betterment*

By H. H Hunt

A consideration of the work of the engineering expert, who, through specialization in economic plant management, is able to introduce new methods which minimize waste and cut down operating expenses. To be effective, the regular operating force should be trained in these methods, which should be carried on with zeal after the expert leaves.

The general tendency toward consolidation has extended to power plants, and many of the smaller ones have been replaced by large central stations of modern design, operated by high-priced men and with great refinement. There are, however, many of the smaller plants which for good and sufficient reasons are still in operation and which must be operated in the future. In the face of the upward tendency of wages, cost of apparatus and materials and the downward tendency of rates and increasing demands for improved service, the public service company of today is in a position where the question of economy all along the line, and particularly in that most important part of the property—the power plant, is one of vital importance.

A casual inspection of one of these small power plants often reveals a more or less heterogeneous collection of apparatus and machinery, some of which date back to the early days of the business. This, together with the fact that such a plant is usually operated by a force of engineers and firemen of only ordinary intelligence and ability, might naturally lead to the conclusion that, even under most favorable conditions high power costs are to be expected.

On the other hand, a careful and detailed examination by an expert in power-station operation will almost invariably reveal many features which are capable of marked improvement, enabling him to report recommendations which, if properly carried into effect, will result in material reductions in costs.

In undertaking the betterment of operating conditions, attention should first be given to the personnel of the operating force. The chief engineer should be a man of both operating and executive ability, and capable of enforcing strict discipline. He must be capable of receiving instruction, as must also the other members of the force. Each man who does not possess the possibility of becoming a thoroughly efficient and alert member of the force should be replaced as soon as possible. Careful study is required in arriving at correct conclusions in reference to each individual of the operating force in order that justice may be done. It not infrequently happens that certain men develop unexpected ability as they gradually become familiar with the methods by which actual improvements are brought about. Furthermore, every reasonable opportunity should be given the existing employees to measure up to the new requirements in order to avoid the demoralization to the organization which would be caused by the needless discharge of men.

A thorough physical examination of the plant should be made and immediate steps taken to correct such defects as can be remedied without excessive cost. Starting with the fire room, for instance, the boilers should be thoroughly overhauled and cleaned, leaky tubes replaced,

*From a paper presented at the Congress of Technology, at Boston, April 11, 1911.

blowoff cocks and valves made tight, gage glasses and dampers put in order, air leaks in boiler settings stopped, furnace linings, bridgewalls and grate bars put in order, safety valves adjusted, steam gages calibrated, etc. The work should be continued, in like manner, to the engines, paying particular attention to valve setting, steam piping, pumps, condensers, heaters, oiling systems and electrical machinery.

In connection with this general overhauling of the machinery, all gages, meters and measuring instruments should be calibrated and tested, so as to give accurate information regarding the operation of the plant. Attention should also be given to the matter of tools, and it should be seen that a suitable assortment is provided, both for the engine room and the fire room. Finally, the station should be thoroughly cleaned.

All the firemen should be individually instructed in handling the particular kind of coal used, in the use of the proper fire tools, the operation of the dampers and control of the draft. A thorough course of training along these lines will usually be found necessary, and it will be further necessary to instruct the chief and watch engineers in every detail of the proper handling of the fires in order that they may be able to maintain intelligent supervision over the room.

Special attention should be given to maintaining the necessary boiler pressure and feed-water temperature, in order to avoid the usual fluctuations which so largely affect station economy. Recording pressure gages and feed-water thermometers and a bulletin board in the boiler room, on which are posted the coal consumption and pressure records of each watch, will serve a useful purpose in exciting rivalry among the men.

Presumably, the engineers understand such matters as the starting and stopping of their engines and generators; nevertheless, the expert should give some attention to the engine room. In this connection a most careful study of the load conditions should be made and charts prepared which will show clearly just what combinations of apparatus and machinery should be used to meet the various conditions of the load, the idea being to so arrange the schedules that each piece of apparatus, when in use, will be operated as nearly as possible at its point of maximum efficiency.

A carefully arranged station log should also be provided which will contain the daily operating data of the plant, recorded in a systematic manner. In such a station log it is desirable that the main factors, such as coal consumed per kilowatt-hour, water evaporated per pound of coal, etc., be shown so clearly that the manager of the company, by spending a few minutes daily in perusing the station log, may become fully acquainted with the daily operation of the plant and be in position to intelligently discuss matters with his chief engineer.

The coal problem is one of the most important, and at the same time one of the most troublesome, which is encountered in power-plant operation. The quality of coal depends, to a certain extent, upon the location of the power plant as related to the sources of coal supply. It will be found profitable to have a careful investigation made of the possible sources from which coal may be secured at reasonable prices. Full data should be gathered regarding the analysis of the various coals available, and that coal selected which will meet local conditions with the best results. While not always practicable, it is desirable to purchase coal on the analysis basis under specifications which provide for a penalty or bonus according to whether the coal falls short of or exceeds the requirements of the contract. Under such a contract an analysis of each shipment of coal is necessary. Where the annual consumption is comparatively small, however, it is not practicable to purchase coal on the analysis basis, in that event the best that can be done is to buy it of responsible dealers who handle the best coal to be had under the circumstances.

To account for the coal purchased, while seemingly simple, proves in practice more or less troublesome. Coal is frequently purchased and paid for according to bill of lading weights. The consumer is apt to suffer shortage under this method of purchase and to start out with substantially less coal in than is called for by his books. It is obvious that ultimately the cost of the coal consumed must check with the cost of coal purchased, and in order to bring about this agreement, frequent checks between station records, coal on hand and fuel accounts are necessary. It will be found desirable to arrange proper scales for weighing in bulk the coal which is delivered to the yard; and if a contract can be so arranged as to make payments on the basis of the company's weights, one question of coal shortage will be removed. Bins should be provided which will permit the coal supply to be accurately measured at any time. Also the coal passing into the fire room must be carefully weighed and these weights recorded. With these precautions there should be no excuse for coal shortage.

Low cost of maintenance does not always indicate thorough or economical maintenance, for while it may be possible to run for months on abnormally low maintenance costs, the time will come when the accumulation of deferred maintenance will produce a condition of affairs which will require excessive expenditures, if not for new apparatus, certainly for the overhaul and repair of the old apparatus. Therefore, it is desirable to prepare a proper maintenance schedule which shall be carefully and conscientiously followed by the operating force. Such a schedule will set forth definite dates for the inspection of all apparatus; the schedule to be so arranged that each and every part will receive periodical attention as often as is necessary to keep it in good operating condition.

As to what may be expected as a result of this power-plant betterment work, it may be summed up as follows: first, accurate knowledge of the maximum efficiency of which the particular plant under consideration is capable; second, the securing of this efficiency through the efforts of a well trained and efficient operating force; third, systematic and economical maintenance producing maximum life of all apparatus and continuity of service; fourth, in case of failure to continue to produce the desired results, it is possible to trace the cause.

Experience has shown that the saving in power costs, resulting from power-station betterment work, will cover the cost of the necessary expert services in a comparatively short time, depending upon the amount of saving effected.

The continued operation of a power plant under the conditions established by successful betterment work, by which maximum economy in operation and maintenance are secured, calls for most active and energetic work on the part of the operating force. In fact, from the manager of the company all along the line down to the coal passers, every man must work under high pressure. After the novelty of the improved condition wears off, the operation of the plant becomes not only monotonous but exceedingly strenuous. It is so much easier to slip back a little than to maintain the required pace, that frequent checking of the plant operation is necessary. The manager must give his personal attention to this matter, and he will doubtless be surprised to note the effect of his failure to carefully follow up the matter of daily checking of the plant, if for any reason it becomes necessary for him to temporarily discontinue his critical study of the daily station log.

In spite of all reasonable efforts, it is quite likely that the economy of a plant will gradually decrease because of a combination of little things which creep into the operation unnoticed by the engineers. This has been noted in actual experience and has led to the belief that a periodical power-plant audit by a competent expert is necessary just as it is found necessary to periodically audit the accounting department. Such an audit will require much less time than the original examination, especially if both examinations and audits are made by the same man, and should not, therefore, be very expensive.

Limitations of Scientific Efficiency

By Henry G. Bradlee

While recognizing that the efficiency engineer can improve operating and manufacturing methods in certain instances, the author calls attention to the limitations in this line and cites cases where the cost of reorganization and the introduction of new methods far exceed the benefits derived therefrom.

During the past year much has been said and written about "efficiency," and, in fact, quite recently the public was startled by the statement that the steam railroads of this country are wasting a million dollars a day—three hundred and sixty-five million dollars a year—which might be saved through the adoption of so called scientific methods of management.

This whole question has recently jumped into prominence because a group of men, who have been doing some very excellent and successful work, have been tempted into the realm of prophecy, and have possibly allowed their enthusiasm to outstrip their judgment.

In view of the statements which have been made it certainly seems reasonable to consider whether there are not some practical limitations which have prevented a general adoption of these methods in the past and which may prevent the wholesale overturning of present industrial systems.

Stripped of technicalities the method of the modern efficiency engineer is simply this. First, to analyze and study each piece of work before it is performed; second, to decide how it can be done with a minimum of wasted motion and energy; third, to instruct the workman so that he may do the work in the manner selected as most efficient. There is nothing fundamentally new in this method. The underlying principle is being used today to a greater or less extent in all industries and has, no doubt, been used at all times in the past.

The method as employed by the modern efficiency engineer is distinctive, not because it is new, but because it is carried to much greater detail. He is not content to plan work along broad general lines, but proposes to attack it in a more scientific spirit and obtain maximum efficiency through preventing waste and loss at each and every point. With this in view he watches every motion of the workman's hands and body. If any unnecessary movement is made he tries to change the conditions under which the work is carried on or gives instructions to the workman so that the wasteful act may be avoided in the future.

The form of organization adopted naturally has the same end in view. The number of overseers, supervisors, experts and specialists, in proportion to the number of workmen, is materially increased. Special accounting systems are adopted to show at a glance what proportion of the cost of a piece of work is necessary and what proportion is caused by wasted energy. The information so obtained is used as a guide to prevent waste in the future. The workman is often encouraged to coöperate through the use of a bonus system which aims to give the highest pay to the most efficient worker.

These methods in certain cases have produced surprising and satisfactory results, but it is by no means a necessary conclusion that they can be universally applied with equal success.

Upon considering these methods of careful study and analysis, and of detail instructions to workmen, one is first impressed by the fact that such study and instruction must be expensive; it must be performed by men of considerable ability, and consequently high pay, otherwise it will not be effective. Such methods, therefore, can be used to advantage only where a material saving can be made.

If a piece of work is to be performed but once the manner in which it is to be done may be planned in a general way, but should one attempt before starting the work, to decide the exact manner in which every detail is to be handled the cost of planning may exceed any possible saving in the cost of labor. If the work is to be repeated several times, but each time is to be performed under new conditions, the same difficulty will be found. On the other hand, if the work is to be repeated a number of times under uniform conditions, instead of only once, it may be profitable to carry out the preliminary planning in greater detail. But not until the work is to be repeated over and over again should the full program of the efficiency engineer be adopted.

Next, consider the territory covered by the work of any industrial organization. Imagine a factory employing a thousand men under a single roof. Then imagine an industry employing an equal number of men distributed through forty different cities, an average of twenty-five men in each city. Can there be any doubt that the introduction of the methods of scientific efficiency would be fraught with a hundred difficulties in the second case for every one in the first?

To what class of work, then, may efficiency methods be successfully applied? Work of this character will presumably be found in certain large mills, factories and shops and in some special departments of other industries. In fact, from the examples quoted by these engineers it is in just such places and under such conditions that the best results have been secured.

But this is only one side of the problem; further study will show that even where conditions are favorable to efficiency methods, limitations often exist which will prevent their adoption.

Low cost of operation or of manufacture, is, after all, only one factor out of many to be considered in measuring industrial efficiency. It frequently happens that the lowest cost can only be secured through sacrificing other and more important factors, for example:

Steam railroads increase their operating costs per ton mile by operating express service. By doing this they have helped to build up industries which could not otherwise exist. People are glad to pay this extra cost so that they may no longer be dependent upon a local supply of fruits and other perishable goods.

In construction work methods are frequently adopted which might be considered extravagant if the advantages which come from completion of the work by a certain date were overlooked. Delay in completion is often far more serious than a considerable increase in the cost of the work.

An electric lighting company will spend a large amount of money to purchase and maintain a storage battery solely to prevent momentary interruptions in service. Continuity of service, even at increased cost, is necessary to retain public good will and patronage.

It is often more economical for a street railway to attach trailers to its regular cars to handle rush hour business than to operate additional cars. The public, however, do not like trailers and here again, the railway decides that public good will is more important than a slight saving in expense.

These few examples illustrate that diversified industries, public health, safety and welfare, speed of service, time of completion, quality and quantity of service, public good will and patronage, all enter into the measurement of success and efficiency.

Moreover, an attempt to increase economy in one detail of operation often decreases it in another. This may be illustrated by the fact that one of the first steps taken by an efficiency engineer is

*From an address delivered before the Congress of Technology, and also the National Association of Cotton Manufacturers.

to establish an elaborate system of cost accounting; a second step is to increase the number of supervisors and specialists employed to oversee and direct the work of the laborers. This increased cost is deliberately and intentionally incurred for the purpose of saving a greater amount in other items of expense. If the accounting department were considered by itself without reference to the rest of the business, or if the number of supervisors and specialists were compared with those employed by some other concern doing a similar business, it might appear that the efficiency engineer is most extravagant and uneconomical. However, to be fair and just to the engineer, one must consider the results of his work as a whole and not condemn him because of increased expenses in certain departments.

It has always been recognized that there is an element of danger in fixing one's attention too closely on detail economies, which is in line with the "man who was penny wise and pound foolish." The writer once knew the manager of an electric lighting company who directed his business with the greatest economy. He frequently remarked that he would much rather save a dollar in operating expenses than secure a dollar of new business because, when he had saved a dollar in expense he had saved the whole dollar, but, when he had obtained a dollar from new business he had to spend half of it in serving the customer. In due course of time this manager resigned and a new man was appointed in his place. The new manager was not very economical, but he was a hustler for new business and he kept in very close touch with his customers. As a result the business immediately began to grow and increased very rapidly, and the public received more and better service at slightly lower rates. The dividends of the company increased, but the cost of operation per kilowatt-hour increased also. Measured by operating costs only, the efficiency was less than under the old manager, but the efficiency of the business, as a whole, was greatly increased.

The question will naturally be asked—why not secure a manager who will push the development of the business, keep the public satisfied, maintain a high quality of service, and, at the same time, direct his organization and business along the lines of maximum economy? There is no doubt that men of this kind would be desirable but, unfortunately, they are few and far between.

Flow of Water in Clean Iron Pipes

By Albert E. Guy

The method of developing and plotting a chart showing the flow in gallons per minute for any size of pipe between 2 and 72 inches with a velocity anywhere between 0.5 and 25 feet per second. An introductory discussion and a similar chart, applicable between different limits, appeared in the April 4 issue.

It is not possible for an investigator to cover in experiments the complete range of conditions with which the practical engineer has to deal at some time or another; this is particularly true with hydraulics. Prior to Darcy's investigations of the subject, many experiments on the flow of water in pipes had been conducted, but the results were not coherent until Prony, of the Prony brake fame, took up the problem, and finally succeeded in establishing a complex formula with constant coefficients, which embodied approximately all the experimental results at hand at that time. Prony's achievement appeared to many engineers more as the result of an accidental compensation between all the causes of divergence than as the revelation of a positive law.* Darcy's experiments confirmed the deductions of Prony and enabled him to simplify the latter's formula.

More recent investigators, however, have endeavored to establish a formula still less complicated than Darcy's. This complication, so far as concerns the present treatment, lies in the fact that each pipe diameter is expressed in the complex form,

$$\frac{D}{\sqrt[6]{0.62\,(D+1)}}$$

It would be very desirable to have, instead of this, one of a simpler form D^n.

Several engineers have boldly cut across lots, and have each brought out a formula which, expressed by a graphical chart of the type described here, has for the diameters a continuous scale much easier to establish than that of chart No. 1.† Besides, the diameter function being continuous, it was possible to show on the same chart an additional scale, very much needed, giving the velocity per second corresponding to a given quantity of water passing through a pipe of certain diameter.

It is easy to so transform Darcy's formula that D becomes a continuous function; but in order to do this, an approximation must be introduced. Solving the expression $\left(\frac{D}{\sqrt[6]{0.62\,(D+1)}}\right)$ for a series of values of D ranging from 2 to 48 inches, and then considering each of the values obtained thereby as representing the corresponding diameter raised to a certain power, the expression may be written,

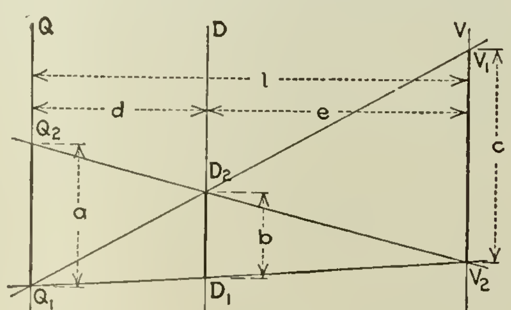


Fig. 2

$$\frac{D}{\sqrt[6]{0.62\,(D+1)}} = D^n$$

or, using logarithms

$$\frac{\log.\left(\frac{D}{\sqrt[6]{0.62\,(D+1)}}\right)}{\log.\ D} = n$$

For the range of diameters considered, n appears to be almost constant; that is, n increases from 0.851 for a diameter of 2 inches, to 0.864 for one of 4 inches, and then gradually decreases until it becomes 0.852 for a 48-inch pipe. The average value is 0.8567, which permits Darcy's formula to be written with a very close approximation, as follows:

$$\textit{Gallons per minute} = (D^{0.8567})^3 \sqrt{h} \quad (13)$$

or,

$$\textit{Gallons per minute} = D^{2.57} \sqrt{h} = D^{\frac{18}{7}} \sqrt{h} \quad (14)$$

However, the writer preferred to make chart No. 1 conform strictly to Darcy's original formula and to construct chart No. 2, showing the relation between the volume and the velocity of water passing through a given pipe.

Let

V = Velocity in feet per second;

D = Diameter of pipe, in inches.

The area of the pipe, in square feet, is:

$$\frac{\pi D^2}{4 \times 144}$$

The velocity in feet per minute equals $V \times 60$.

One cubic foot equals 7.48 United States gallons.

Substituting these values,

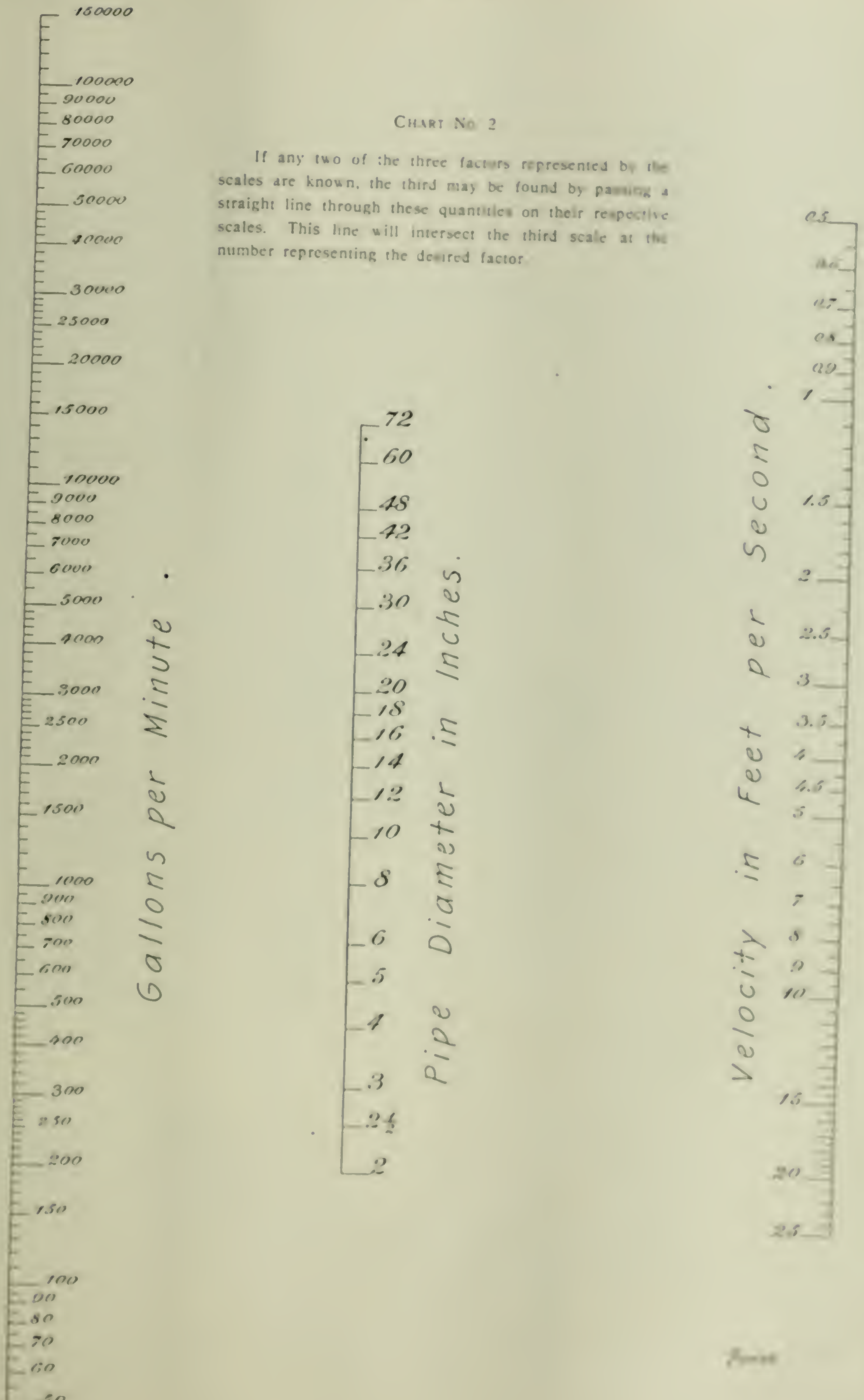
$$\textit{Gallons per minute} = \frac{\pi D^2}{4 \times 144} \times 60 \times V \times 7.48 = \frac{D^2 V}{0.4085} \quad (15)$$

*E. Collignon, "Hydraulique."

†Chart No. 1 appeared in the April 4 issue of Power.

CHART No. 2

If any two of the three factors represented by the scales are known, the third may be found by passing a straight line through these quantities on their respective scales. This line will intersect the third scale at the number representing the desired factor.



The chart is intended to cover a range of volume from 50 to 150,000 gallons per minute, for pipe diameters from 2 to 72 inches, the velocity ranging from ½ foot to 25 feet per second.

Proceeding as with chart No. 1, let Fig. 2 represent the chart to be established. On three parallel lines *Q, D, V,* it is proposed to lay off scales such that on *Q* will be read gallons per minute; on *D,* the diameter of the pipe in inches, and on *V,* the velocity in feet per second. Now, any straight line such as $Q_1 V_1$ placed across the three scales is to indicate that a quantity Q_1 in gallons per minute, will pass through a pipe of diameter D_2, with a velocity of V_1 feet per second.

Assume that the scale of numbers on a slide rule measures exactly 10 inches. Such a length may be understood to represent the value of the number 10. The values of the numbers 2, 3, 4, 5, would be represented, according to logarithmic tables, respectively, by 3.0103, 4.7712, 6.0206 and 6.9897 inches. Adding the lengths representing 3 and 4, the result is

$$4.7712 + 6.0206 = 10.7918 \textit{ inches}$$

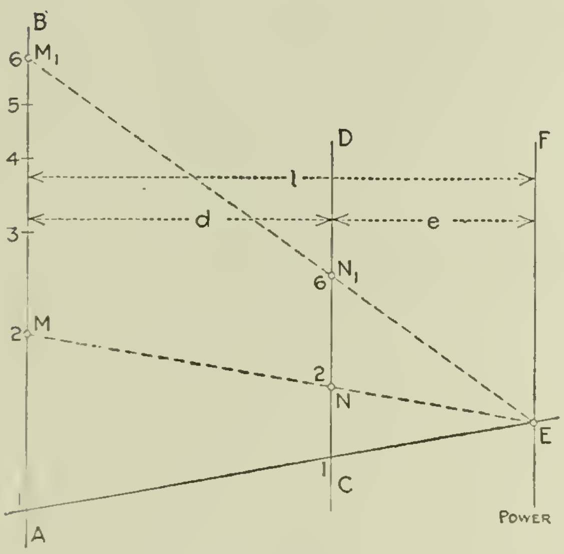


FIG. 3

This length represents the value of the number 12.

In Fig. 3, the three parallel lines *A B, C D* and *E F* represent scales of the same kind as used on the slide rule, the origin of each scale being at the intersection with the datum line *A E.* The three scales being fixed, if the line *A E* is made to pivot about point *E* and occupy successively the positions represented by the dotted lines *M E* and $M_1 E$, it will cut on *C D* the lengths *C N*, $C N_1$, respectively proportional to *A M*, $A M_1$; and if the length *A M* represents the logarithm of the number 2 and $A M_1$ that of 6, the lengths *C N* and $C N_1$ will represent these numbers respectively on a smaller scale.

The logarithm of 10 may be drawn on *A B* with a modulus, or length in inches or millimeters equal to m_1; on *C D* with a modulus equal to m_2, and on *E F* with a modulus equal to m_3. Let *A M* represent the logarithm of 2, and $A M_1$ the logarithm of 6; then,

$$\log. 2 \times m_1 = A\,M$$
$$\log. 6 \times m_1 = A\,M_1$$
$$\log. 2 \times m_2 = C\,N$$
$$\log. 6 \times m_2 = C\,N_1.$$

But,

$$\frac{A\,M}{C\,N} = \frac{l}{c} = \frac{\log. 2 \times m_1}{\log. 2 \times m_2}$$
$$\frac{A\,M_1}{C\,N_1} = \frac{l}{c} = \frac{\log. 6 \times m_1}{\log. 6 \times m_2}$$

Hence,

$$\frac{l}{c} = \frac{m_1}{m_2}$$

When pivoting the straight line *A E* about point *E* it was first stopped at *M,*

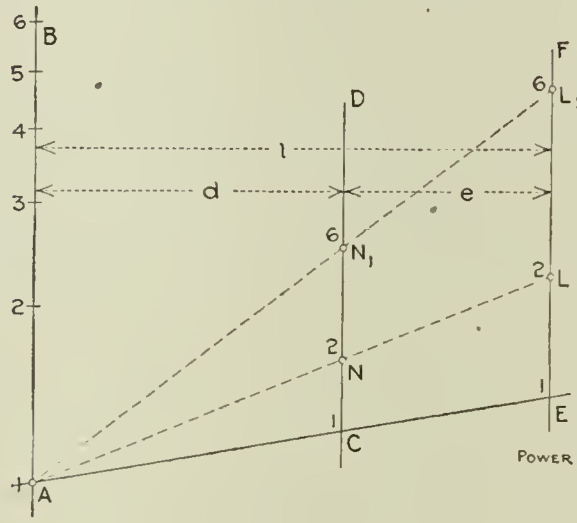


FIG. 4

determining on scale *A B* a length *A M* equivalent to the logarithm of 2; at the same time determining on scale *C D* a length *C N* also equivalent to the logarithm of 2, but of length

$$C\,N = c \times A\,M$$

If *A M* represents the logarithm of 2, and $A M_1$ represents the logarithm of 6, then $M M_1$ represents the length of the log-

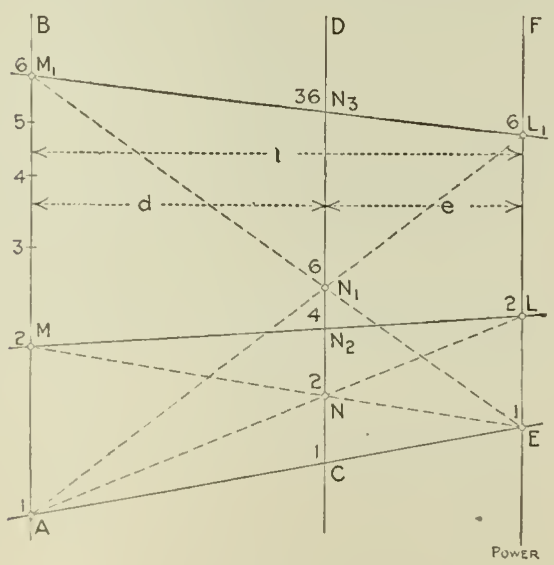


FIG. 5

arithm of 3. Hence, just as with the slide rule, when different lengths are added on one scale, the total length represents the product of the numbers represented by these lengths.

Fig. 4 has the same and similarly placed scales as Fig. 3. By pivoting the straight line *A E* about point *A* and stopping first at point *N,* the length *E L* is determined on *E F.* It is evident, from the foregoing, that *E L* represents, on a large scale, the same logarithm that is represented by *C N;* hence:

$$\frac{E\,L}{C\,N} = \frac{l}{d} = \frac{\log. 2 \times m_3}{\log. 2 \times m_2}$$

whence,

$$\frac{m_3}{m_2} = \frac{l}{d}$$

The same reasoning holds true for points N_1 and L_1.

Fig. 5 is a combination of Figs. 3 and 4. Here, the straight lines *E M* and *A L,* starting respectively from the origin of the scales *E F* and *A B,* and intersecting at a common point *N* on *C D,* determine on the three scales the lengths *A M, C N, E L,* which represent the logarithm of the same number. Similarly, lines $A L_1$, $E M_1$, intersecting at N_1 on *C D,* determine the three lengths $A M_1$, $C N_1$, $E L_1$, each representing the logarithm of the number 6. By joining *M* and *L* a length,

$$C\,N_2 = C\,N + N\,N_2$$

is cut. But *C N* is the logarithm of 2, and obviously $N N_2$ is also the logarithm of 2, for

$$\frac{E\,L}{N\,N_2} = \frac{E\,L}{C\,N} = \frac{l}{d}$$

therefore,

$$C\,N_2 = \log. 2 + \log. 2 = \log. 4.$$

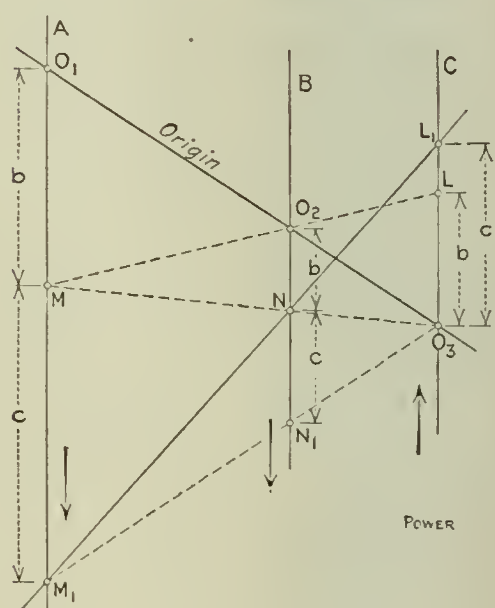


FIG. 6

By joining M_1 and L_1 the length

$$C\,N_3 = C\,N_1 + N_1 N_3$$

is cut on *C D.* But,

$$C\,N_1 = N_1 N_3,$$

and

$$C\,N_3 = \log. 6 + \log. 6 = \log. 36.$$

However, the scales do not always run in the same direction; they may run in opposite directions. Generally speaking, a three-line diagram is intended to solve an equation of the form:

$$a = constant \times b \times c$$

where *a, b* and *c* are the variables. Passing to logarithms, and neglecting the constant,

$$\log. a = \log. b + \log. c$$

If *b* is on the first scale and *c* on the third, *b* added to *c* must equal *a* (as read on the middle scale). In this case, as shown by Fig. 5, the three scales are graduated in the same direction.

If a is on the first scale, b on the second, and c on the third, the problem seems, at first, a little more complex. These scales are shown in Fig. 6. Line O_1M cuts O_2N on scale B, and O_1M on scale A; each of these two lengths, as measured on its own scale, represents the same number, b. Similarly, length O_3L, determined on scale C by line ML, represents the same number b. Let O_3L equal c, then line LM, passing through N, cuts on scale A the length O_1M equal to $O_1M + MM_1$; or, as stated before, O_1M represents $log.\ b + log.\ c$, or the product $b \times c$. In this instance, the two scales, A and B, are graduated in the same direction, while the other, C, is inverted. The position and direction of the scales depend obviously upon the conditions of the problem at hand which they are intended to solve.

Reverting now to Fig. 2 and equation (15), let

$Q_1 = 1000$ *gallons per minute;*

$Q_2 = 10{,}000$ *gallons per minute;*

$D_1 = 8$ *inches.*

Neglect the constant factor (0.4085) for the present. The formula then becomes

$$Q = D^2 V$$

$$Q_1 = 1000 = 8^2 \times V$$

$$V_1 = \frac{1000}{64} = 15.625 \text{ feet } (log = 1.19382)$$

With this value of V_1

$$Q_2 = 10{,}000 = D_2^2 \times V_2 = D_2^2 \times 15.625$$

$$D_2 = \sqrt{\frac{10{,}000}{15.625}} = 25.298 \text{ inches}$$

$$(log = 1.40309)$$

To obtain V

$$1000 = 25.298^2 \times V_2$$

$$\frac{1000}{(25.298)^2} = V_2 = 1.5625 \text{ feet } (log = 0.19382)$$

It is then possible to write:

$a = (log.\ Q_2 - log.\ Q_1)\ m_1 = (4 - 3)\ m_1 = m_1$

$b = (log.\ D_2 - log.\ D_1)\ m_2 = (1.40309 - 0.90309)\ m_2 = 0.5\ m_2$

$c = (log.\ V_1 - log.\ V_2)\ m_3 = (1.19382 - 0.19382)\ m_3 = m_3$

Because of the similarity of the four triangles,

[illegible]

whence

[illegible]

There remains only to determine the moduli. For convenience m_1 was taken equal to the length of the scale of cubes on a 10-inch slide rule, and m_3 equal to the length of the scale of squares, that is, respectively 83⅓ and 125 millimeters. Then,

$$\frac{a}{c} = \frac{m_1}{m_3} = \frac{83\frac{1}{3}}{125} = \frac{2}{3}$$

whence,

[illegible]

[illegible]

$$m_1 = \frac{2}{3} \times 1.25\ m_2 = \frac{5}{6}\ m_2$$

With

$$m_1 = 83\tfrac{1}{3}$$

$$m_2 = \frac{83\frac{1}{3} \times 6}{5} = 100 \text{ millimeters}$$

In constructing Chart 2, the elements adopted were:

$m_1 = 83\frac{1}{3}$ millimeters, d = [illegible] millimeters

$m_2 = 100$ millimeters, $e = 102$ millimeters

$m_3 = 125$ millimeters, l = [illegible] millimeters

One point on the diameter scale was figured out for a given quantity and a given velocity, taking then the constant factor into account, the location of the origin of the scale was thereby determined. This scale of the modulus equal to 100 millimeters was laid out by projecting an ordinary slide-rule scale of a modulus equal to 125 millimeters.

The attention of the reader is called to the fact that, although Chart 2 is correct, and correctly drawn according to the foregoing calculations, it does not seem to meet the requirements exemplified by Fig. 5. The trouble seems to be with the D scale. However, the discordance is more apparent than real; it exists because the pipe diameters themselves, such as 6, 8, 10 and 12 inches, are marked, but it ceases when it is known that the exact numerical values represented by each of these sizes is really its square. Thus, 6, 8, 10 and 12 inches represent respectively 36, 64, 100 and 144. With this correction the chart agrees entirely with Fig. 5. The point raised, however, is so important that it will be taken up again in Part III, where the general formulae applying to this kind of diagram will be shown and demonstrated.

Gears for Steam Turbines

The Hon. Charles A. Parsons, in a recent lecture before the Royal Institution, spoke interestingly regarding the use of gears upon steam turbines, and exhibited the pinion which had been used to transmit 900 horsepower to the propeller of the "Vespasian" while making over 12,000 miles. The evidences of wear were very slight, and it was said that the drive had been entirely successful. As compared with the original machinery, the geared turbine had shown an economy of 22 per cent. with the same boilers and propeller. The turbine is run at 1400 revolutions per minute, and the speed is reduced by gearing to 70 at the propeller. The efficiency of the gear is very high. Measurements of the rate at which heat is generated indicated that it is over 98.5 per cent., and the friction is too small to be satisfactorily measured with a transmission dynamometer. In marine use the geared turbine is very effective in preventing racing, as the inertia of the swiftly rotating parts prevents a material increase of speed, even when the propeller is raised out of the water.

German Market for Lubricants

According to Consul General Robert P. Skinner, of Hamburg, in the *Daily Consular and Trade Reports*, there is an extensive demand in Germany for lubricating materials of every description. Such as are obtained from the residues of the distillation of mineral oils containing paraffin, or are of a tarry or pitchy nature, the latter provided that they do not sink in water, are dutiable in Germany at the rate of $1.428 per 220 pounds. Other lubricants manufactured with fats or oils, liquid or solid, molded into shapes or not, are dutiable at the rate of $1.785 per 220 pounds.

Some difficulty attends the importation of lubricants manufactured from fats or oils, for the reason that such products must be denatured, upon arrival, with petroleum.

Various American concerns are engaged in all branches of this business, usually having well organized Hamburg branches to handle the trade at first hand, and apparently with successful results.

The introduction of a new American grease would be difficult, but by no means impossible. Quality, special advantages and price might sell it, if energy and perseverance were manifested by the exporters in entering the market, and intending exporters should ascertain whether an identical or very similar article is not already on sale in Germany.

It would also be advisable that the intending exporter obtain samples and prices of different lubricants of the same class manufactured or sold in Germany and study the comparative merits of each. The exporter should send a competent representative to the German market to work out the practical details of securing a sale for his product for himself. An article of this kind is almost impossible to place by means of ordinary correspondence.

The imports into Germany of lubricating oil, paraffin, vaseline and vulcan oils during the first 11 months of 1910 amounted to 202,052 tons, valued at $6,550,280, as compared with 191,300 tons, worth $6,212,270, for the corresponding months of 1909. Of the quantity imported in 1910 the United States supplied 90,894 tons, Asiatic Russia 60,327 tons, Austria-Hungary 29,000 tons, European Russia 10,063 tons and Belgium 1614 tons. The German imports of lubricants manufactured from fats and oils during the first 11 months of 1910 amounted to 7419 tons, valued at $797,480, against 7003 tons, worth $713,442, for the same period of 1909. Of the quantity imported during 1910 the United States supplied 5008 tons, an increase of 208 tons over 1909. Thus in 1910 the United States supplied 45 per cent. of the mineral oils imported by Germany and 70 per cent. of the oils made from fats.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

A Difficult Case of Parallel Operation

By H. R. Mason

The parallel operation of 60-cycle alternating-current generators, especially of the older types, often presents very interesting problems to solve. The station in which the following difficulties were encountered is of about 12,500 kilowatts capacity, about 3500 kilowatts being in 600-volt direct-current railway generators and the others 60-cycle 2300-volt alternators supplying rotary converters to a capacity of about 4500 kilowatts and an alternating-current lighting and power system of about 4500 kilowatts.

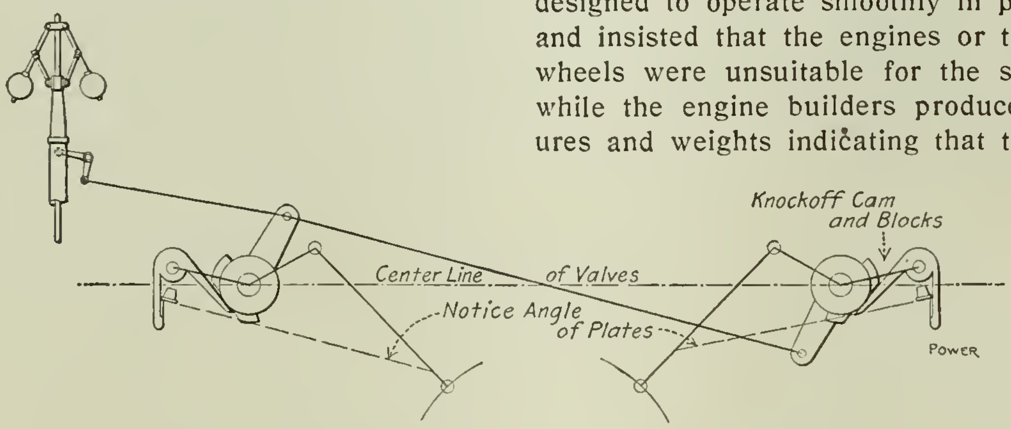


Fig. 1. Original Arrangement of Valve Gear

There are two 1500-kilowatt alternators, one driven by a 36 and 60 by 60-inch cross-compound Corliss engine and the other by a 36x60-inch twin Corliss engine; also, two 3000-kilowatt turbine units. It was found impossible to secure satisfactory parallel operation of the engine-driven units with each other or with the turbines and it was accepted as an impossibility for some years, as the load was not so heavy that parallel operation was absolutely necessary. There was no difficulty in getting the two turbines to operate in parallel with each other and, as there are two sets of busbars, the load could always be divided so that the two turbines were on one set during the peak while one engine unit on the other set carried the city arc lamps and enough rotary converters to take care of the remainder of the load. This was often troublesome and expensive, as it resulted in an unsatisfactory engine load at times and required close attention in balancing the load between the two sets of busbars.

The load recently increased to such an extent that it became imperative either that the alternators be made to operate in parallel, or that a third set of busbars be installed so that the remaining engine could be operated, which meant considerable expense and undesirable complication. The builders of the alternators maintained that the machines were designed to operate smoothly in parallel and insisted that the engines or the flywheels were unsuitable for the service, while the engine builders produced figures and weights indicating that the engines were not to blame and claimed that the generators were deficient in synchronizing ability.

Upon trial, it was found that no matter how carefully the generators were got into synchronism they would set up enormous cross currents within a revolution or two after being connected to the same busbars and it had happened a number of times that rotary converters were caused to flash over and interrupt part of the service in the brief time required to change the switches in transferring the load from one alternator to another.

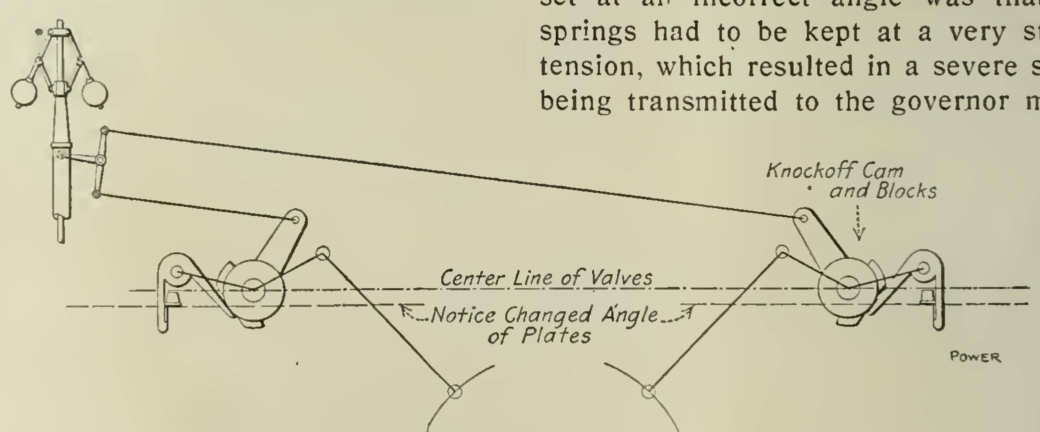


Fig. 2. Corrected Arrangement of Valve Gear

Indicator diagrams were taken, which disclosed some serious faults in the steam distribution, due to unequal cutoff and unequal and excessive compression. In this connection, there is a point which seems never to have been taken into consideration in all of the endless arguments for and against compression, and that is its effect upon the angular velocity of the flywheel. In this case the compression figured up to nearly 600 horsepower, which seemed an unreasonable amount even for a 2000-horsepower engine, and as this energy was necessarily absorbed from the flywheel near the end of the stroke, it was thought to be at least partly responsible for the trouble in operating the units; therefore, the eccentrics were moved so as to give much less compression and the cutoff was equalized as far as possible.

After taking additional indicator diagrams it was found that the governor rods were connected to the knockoff cams at unequal angles, the undesirable method of connection shown in Fig. 1 being used. With this kind of connection, it is impossible to adjust the cutoff of the crank-end valve without disturbing the adjustment of the head-end valve, and in this case the unequal angles of the knockoff cams caused the point of cutoff to change at different rates on the two ends of the cylinders, which also added to the trouble in paralleling the generators.

Upon still closer examination of the valve gear it was observed that the latch plates were set at an improper angle, as also represented in Fig. 1, frequently causing the block to slip off the hook before the tail of the hook struck the knockoff cam; although this could scarcely be observed by watching the engine, it showed on the indicator diagrams and resulted in unequal crank efforts. Another effect of the latch plates being set at an incorrect angle was that the springs had to be kept at a very strong tension, which resulted in a severe shock being transmitted to the governor mechanism every time the hook encountered the knockoff cam. These defects were all corrected and the valve gear changed to the arrangement shown in Fig. 2, which gave reasonably good indicator diagrams.

After this was done, determined efforts were made to operate the units in paraldrives under all conditions. I believe that there are places, and a large number of them, where the belt or rope drive is more economical than the electric drive. I believe that there are places, and many of them, where it is cheaper for the factory owner to purchase power than to generate it. I believe, too, that there are places, and many of them, where the factory owner can generate his own power and use it through electric motors more cheaply than he can either buy it or operate by belt drive. Every plant must stand on its own merits and no factory owner can say because "John Jones operates his plant more cheaply by belt drive than Tom Smith does his by electric drive, I can put in belt drive and operate more cheaply than I can by electric drive."

HENRY D. JACKSON.

Boston, Mass.

The Giddings Engine Valve

Allen J. Stocks illustrates an engine valve in the issue of March 28 and asks if anyone ever saw anything like it. This is the well known Giddings valve and was used very successfully for many years by several engine-building concerns prominent in the manufacture of high-speed engines.

Fig. 1 shows a section of the valve and valve face. It will be observed that the valve takes the form of the Allen valve with the difference, however, that the steam enters the middle of the valve through the port *S*. With this arrangement there would be a tendency to throw the valve from its seat unless it were

FIG. 1. SECTION THROUGH GIDDINGS VALVE

counterbalanced by a pressure on the back of the valve. This pressure was secured by means of a needle-hole port from the steam inlet of the valve. In order to keep the pressure within certain limits, there was a needle-hole port of slightly larger area communicating with the exhaust chamber of the valve. It usually took about 15 per cent. of the boiler pressure to keep the valve from slapping on its seat.

One remarkable feature of this valve was the supplementary passage or carry-over port which increased the volume into which the steam was compressed without increasing the clearance space from which the steam was exhausted as this port was never in communication with the exhaust.

Fig. 2 shows a pair of indicator diagrams from an engine with this type of valve. The compression curve starts to rise when the edge of the valve covers the exhaust port and it continues to rise until communication with the supplementary port is established, increasing the volume into which the steam is compressed and enlarging the area of the diagram over that shown by the dotted lines.

The engines built at the time when this valve was used were of comparatively long stroke, the sizes ranging as follows: 6x10 inches, 8x12 inches, 10x16 inches, 12x18 inches, 14x20 inches, etc. As single-valve engines they were hard to beat in the matter of economy. The large sizes could be run on 30 pounds of steam per indicated horse-

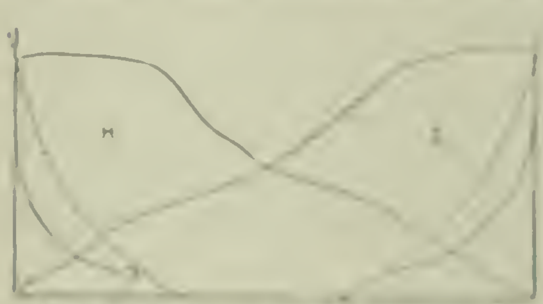


FIG. 2. DIAGRAMS FROM ENGINE WITH GIDDINGS VALVE

power with a pressure of 100 pounds at throttle, noncondensing. They were much more economical than the high-speed engines at that time with the so called piston valves (which were simply a plug in a hole) which leaked scandalously, or the many forms of flat valve balanced by a pressure plate.

CHARLES A. CAHILL.

Milwaukee, Wis.

In POWER for March 28 Allen J. Stocks has a letter, some diagrams and a cut of an engine valve about which he seems to be puzzled. I operated a Russell engine for three years that was fitted with this valve. The valve is balanced; there are two needle-hole ports in the top of the valve, one that admits steam from the face to the back of it and the other, which is a little larger, forms a communication between the back of the valve and the exhaust of the engine. These small ports retain enough steam back of the valve when the engine is running to balance the valve and keep it on its seat.

By means of an angle valve in a ½-inch pipe, steam may be admitted from above the throttle to the back of the valve when starting and stopping the engine; this keeps the valve from slamming on its seat.

The valve takes and exhausts steam at its face. I cleaned the burned oil from the face of the valve and found fine lines to correspond with the edges of the ports on the face of the valve by which the valve could be set.

If Mr. Stock's engine is a Russell he will find that there is an adjusting nut where the rod connects with the eccentric and that the length of the rod can be changed either way.

The diagrams show all events of the valve to be early, also the valve to be one sided, although not very much so.

The engine mentioned had a Giddings governor which is quite complicated and if taken apart is liable to be put together wrong, which might leave the valve setting off.

This may be the trouble in Mr. Stocks' case as a long rod would make the events early on one side and late on the other.

JAMES W. BLAKE.

New York City.

The Position "Higher Up"

In the issue of March 21 there are two articles under the above heading. The one by L. F. Wilson is right to the point and contains some very good advice.

I wish to call special attention to what Mr. Wilson says about "blind advertising." Only a few weeks ago I ran a blind advertisement for a position and I got two answers. One came from Philadelphia and one from Boston. The one from Boston asked me to "call around" and see a certain party! Perhaps I might have secured a good position, but it is not an easy matter for me in New Orleans to call around in Boston!

The other letter in the March 21 issue, written by Edward Adams, tells how the writer stepped out of the fire room into his first job as chief. All this may be interesting but it is of little value to the man trying for the position "higher up" unless he is in the same fire room that Mr. Adams left. But his first paragraph hits the nail on the head.

In the first-page editorial of POWER for March 21 there is more horse-sense concerning this matter than can be found on any other page of POWER. It says "Pick out your goal, keep your eye on it and work to get there." Everyone who expects to better his position should read this article over and over, and study it.

He who says "There isn't no chance these days for a fellow to get along" will never get any higher. Turn to the first-page editorial of the March 28 issue and read that carefully. Do you fully grasp its meaning? No, not at a first reading. This editorial you should be studying. Do you realize that "there are more opportunities than ever going a-begging for lack of men to see and make use of them?" But who tells of that? "These are wonderful times," times of progress, and a fellow must keep up with this progress. He cannot "wish" himself into the position "higher up"; he must go after it.

of fire on the outside and mud (sediment) on the inside of the plate. The cover of the cleaning nozzle (the nozzle is connected to the lower front part of the boiler) can be taken off and the sediment scraped and washed out. A lamp can be brought into the boiler through this opening and nearly the whole of the bottom sheet and the bottom part of the lower row of tubes can be inspected. The boiler is set with an inclination toward the front; the blowoff valve is placed on the cleanout cover, oftentimes the feed valve too.

JOHN ZEUERLUND.

Eskilstuna, Sweden.

Belt versus Electric Transmission

In the March 21 issue, Franklin Van Winkle takes exception to my article in the February 14 issue on central-station versus factory-plant service, making the statement that the friction in many hundreds of plants has been found nearer 10 than 20 per cent. of the total power required.

This does not agree with the results of tests of many of the plants that we have investigated, nor the results that are reported in many of the papers and which are mentioned in connection with the shafting losses in a number of handbooks. In many factories the friction loss amounts to considerably over 60 per cent. of the total power generated at the engine and these plants are pretty fairly operated. There are, of course, many textile mills and many mills in which the shafting is laid out accurately and carefully and in which recent additions have not been made to disturb the operating conditions, where the shafting losses are very small, but such conditions do not hold for any considerable length of time, nor are such conditions possible except through excessive waste of space in belt- or power-transmission towers or wells.

It is interesting to study what the actual losses are in a plant using belt drive, starting with a pretty small loss from shaft to shaft and from floor to floor until the engine is reached. Suppose, for instance, it is assumed that on the top floor of a four-story factory 20 horsepower is required, divided between four lines of shafting. On the next floor assume the same conditions and requirements and so on down to the lowest floor, where the main jack shaft is situated. This is an arrangement very frequently found. If 5 per cent. loss from shaft to shaft is allowed, the losses are cumulative and the power required at the engine is to a very considerable extent larger than would ordinarily be required if the shafts were driven direct from the engine. The following table shows to what extent this cumulative friction increases and it will be noted that 5 per cent. is used as the average loss of power for each transmission belt; this is by no means a figure accomplished under average conditions.

Top floor, 20 horsepower; 4 shafts, 5 horsepower each; 5 per cent. loss between shafts.

	Horsepower.
Power required at the main shaft on 3d floor for top floor	22.06
Power required, 2d floor for 3d floor	45.22
Power required, 1st floor for 2d floor	69.54
Power required to operate 1st, 2d and 3d floors from engine	97.33
Total power required at shafting	80.00
Loss	17.33

or 21.7 per cent., which is quite different from the loss that would exist with individual drives to each shaft. It should be noted also that this loss is to a considerable extent represented by slip, so that the speed of the shafting is continually dropping from what would be expected on pulley ratios, materially influencing the production factor of the machinery. As vertical drives are of frequent occurrence in a factory of this character, figures of 5 per cent. loss on an average between shafts is considerably below that met with in practice, although it is not below what could be accomplished by proper arrangement in many cases.

In machine shops the conditions are radically different and so are they in many types of plant where the machinery is not constantly in operation so that the power lost in driving the shafting may be, and frequently is, a very heavy item of expense. Under such conditions the power required to operate with belt drive would be much larger than that required to operate with electric drive. Each plant has its individual characteristics, and it is necessary to make a careful study of each plant to determine what is the proper type of drive. It not infrequently happens that with a plant already installed, a rearrangement of belting is much cheaper than the installation of electric drive, and that a belt-driven plant can be operated more cheaply than electrically driven, either by power purchased or power generated in the plant itself.

When motor drives are installed, they should be installed with a thorough knowledge of the influencing conditions so that the motors will be adapted to the purpose in hand and every precaution should be taken to reduce the friction losses to the minimum. The efficiency of the motors is an important consideration, also the efficiency of the drives connecting the motors to the shafting. It frequently happens that unless the engineer installing the drives is thoroughly conversant with the motors and the machinery to be operated, very much larger motors are installed than are necessary. It also happens that in order to save first cost, the owner and engineer install motors which are of far too high a speed to operate satisfactorily or install the motors on too short centers with too large ratio of driver to driven pulley. All of these things militate strongly against the success of the electric drive. On the other hand, similar mistakes work against the belt drive; there is just as much danger of a poor layout in a belt-driven plant as there is in an electrically driven plant and there are quite as many belt drives throughout the country which are failures, if their owners and engineers but knew it, as there are electric drives.

Mr. Van Winkle's statement that he was called in to consider a case where the proprietor of a plant was greatly disappointed is exactly in line with conditions which are frequently met. The electric motors in this case were probably not installed properly and the central-station salesman was probably thoroughly onto his job as a salesman and very far from onto his job as an engineer. The factory owner who bites at the salesman's figures of operating cost in his plant as driven by belts and at the economies which are likely to accrue from the installation of electric motors and makes no further investigation, usually gets stuck and there is every reason why he should expect to get stuck. This same factory owner would not allow the agent for some company supplying him with materials to estimate what it would cost him to get materials from half a dozen of his competitors but he would actually get competitive prices. Why, then, should not this man take the same precaution when it comes to the matter of power? If he is not capable of making up his own figures as to what power costs him, why should he take the figures of the central station and buy material of which he knows nothing?

The electric drive has many advantages over the belt drive. So, too, has it many disadvantages unless properly installed. Mr. Van Winkle leaves out one item in his tabulation of advantages, which is of very considerable importance, that is, uniformity of speed, resulting in a considerable increase in production. This production factor alone, if properly looked into, is, in many cases, a sufficient cause for the introduction of the electric motor and, further, is very often a sufficient explanation for a considerable increase in the cost of power. In a number of cotton mills in the South where electric drive is installed, under the first year's operation the factory owners were very much disappointed to find that the total cost of power during the year was considerably greater than the cost of power during preceding years. Their engineer, however, was far-sighted enough to go a little bit into the figures for output during those years, with the result that he discovered that the total cost per unit of goods manufactured was less than in previous years.

While I am strongly in favor of the electric drive where it is suited to conditions, I am not a believer in electric

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Operating Cost of a Small Water Works

Having read the editorial, "Publicity of Operating Costs" in the issue of March 7, I will do the best I can to give the readers of POWER the actual running costs of the station of which I am in charge.

This is a small town of about 6000 inhabitants. It has a direct-pressure system with a standpipe located at the highest point in the village. We pump from a receiving basin fed by gravity from springs. The average suction lift is 20 feet and the discharge head averages 160 feet.

The pumping station contains two horizontal return tubular boilers, 60 inches by 16 feet. These are used alternately and are in fairly good condition considering their age which is 24 years. They were operated for 13 years at their full capacity for during that length of time electric current was generated for use in the town. They are of the lap-seam design and since reading the recent articles and editorials in POWER I am sure that they have seen their best days although they are given a pretty good standing and are allowed 85 pounds pressure by one of the leading boiler insurance companies.

The pumps are Worthington direct acting, one is a compound 12 and 18½ by 10½ by 10 inches in size and the other is a simple 16 and 10½ by 10 inches (this one is held in reserve for emergencies). There is one boiler-feed pump 5¼ and 3½ by 5 inches, delivering water through a Baragwanath heater to the boilers at a temperature of 210 degrees.

We operate, on an average, 10 hours out of the 24 and, being subject to a fire call at any time, have steam up with banked fires between. The night engineer reads the service meters monthly. We use run-of-mine coal which costs $2.05 per ton delivered in the coal bin.

The cost of operating the station for the year ending Feb. 28, 1911, was as follows (Not including interest and depreciation):

310 tons coal @ $2.05	[illegible]
Oil and waste	[illegible]
Packing	[illegible]
Repairs	[illegible]
Engineers and ...	[illegible]
	[illegible]

In the year we delivered to the mains 80,830,000 gallons of water against an average total head of 160 feet using 310 tons of coal. This shows the duty of the plant to be slightly over 21,000,000 foot-pounds of work per 100 pounds of coal. The cost of pumping was, then, 2.379 cents per 1000 gallons delivered.

The water end of the pump shows an efficiency of 90 per cent. and I think it will be of interest to some to hear how I find this as we have no meter on the delivery line.

When the receiving basin, which is 27 feet in diameter, is pumped down and we are not running I note the level of the water and the time. Taking the level again one hour after, it is easy to calculate the number of gallons running in per hour. On starting up I note the counter reading of the pump, the time and the water level in the basin, taking them again after the pump has run one hour.

The efficiency is then found by dividing the water actually delivered (which is the amount which runs into the basin plus the amount taken out by lowering the level) by the displacement of the plungers of the pump.

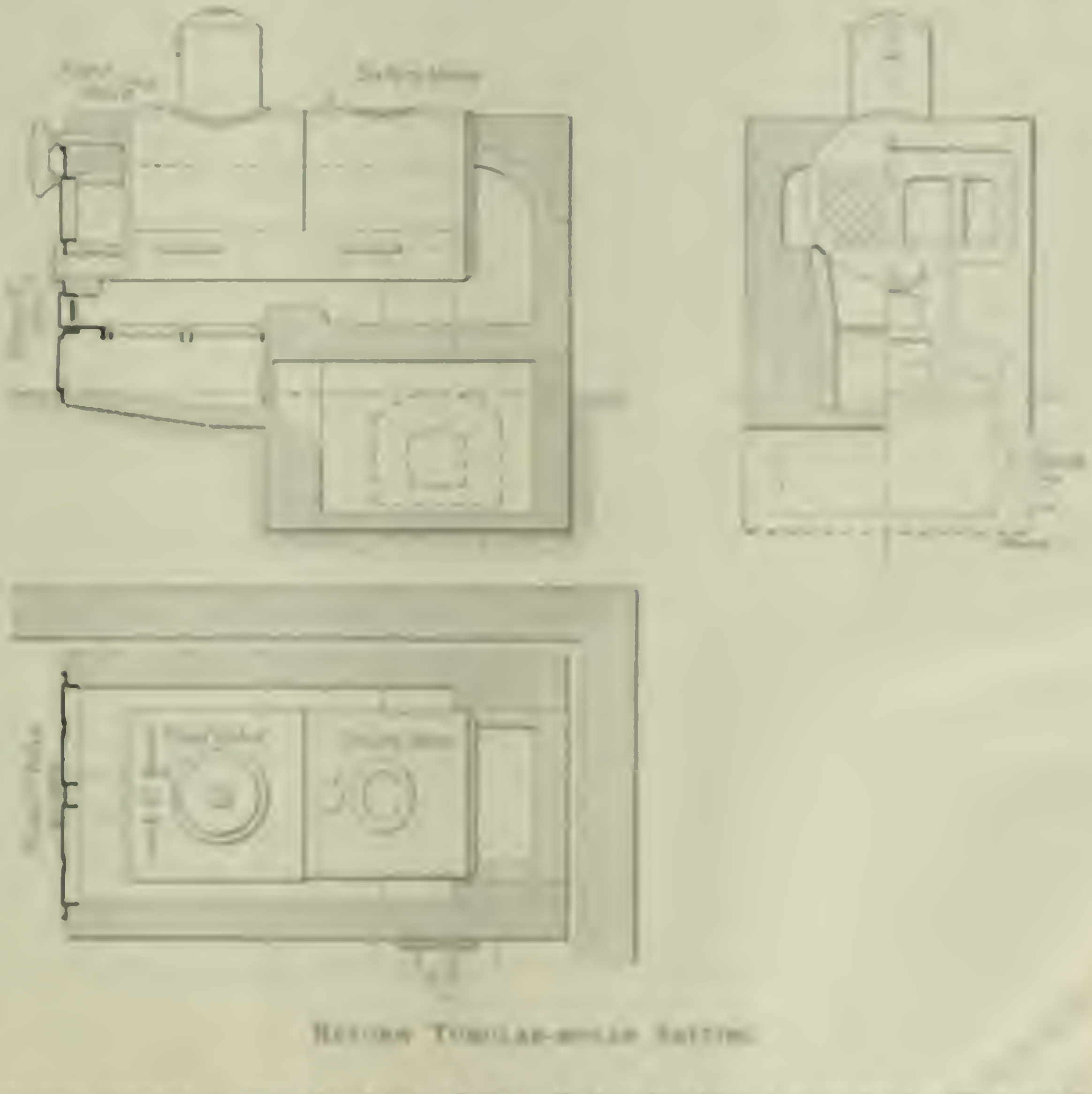
These figures are not given as models of economy but as actual running expenses of a small old-fashioned pumping plant and I should very much like to see them compared with those of a modern uptodate plant of about the same size running under similar conditions.

S. SCARTH

Newark, N. Y.

Boiler Setting

Some time ago there appeared in POWER a very complete paper by S. F. Jeter on "Setting Horizontal Tubular Boilers," which I have read with a good deal of interest.



RETURN TUBULAR-BOILER SETTING

Herewith is a design of a horizontal tubular boiler setting which is used very extensively in this country with satisfactory results. The bottom sheet of the boiler is in one piece; the sheets are ... bottom with rivets exposed to the ... [illegible] thority over their own force, and yet they were paid a good salary and were well thought of.

How is a man to make known his ability, beyond the more or less successful operation of his plant with what the employer chooses to give him, unless he is consulted and given an opportunity to show what he can do? Some may say, let him take his ability where he can get full value for it, but that is much easier said than done.

Regarding engineers preparing themselves for the demands made upon their ability, I think that if employers would give the engineers a chance to show whether they are worthy of the name and can operate more cheaply than the central station can supply electricity, it would be a simple matter to answer the question when the time comes. It would seem to be more of a question of coöperation between employer and engineer than one of whether the engineer can beat the central station. The engineer alone cannot beat the central station, so let the employer get busy as well as his engineer.

WILLIAM N. WING.

Brooklyn, N. Y.

Low Charge of Electrical Energy

When the first bonds were to be voted for the municipal plant at Pasadena, Cal., the Edison company, backed by $20,000,000 of capital and owning the electric-light plants in thirty-five cities, would not give out any information to the citizens of Pasadena as to the cost of producing electrical energy or what a profitable selling price would be. As a result, the city built its own plant which contains the very best of machinery, has been enlarged three times in four years and has made good.

The plant now furnishes electrical energy to 3650 private consumers and takes care of all the public and street lighting. There is a sliding scale of from 5 cents down to as low as 3 cents per kilowatt-hour for larger quantities of energy used for lighting purposes; for power the rate runs from 4 to 5 cents per kilowatt-hour. The plant with the distributing system reaching into every part of the city cost $450,000 in round numbers.

During the fiscal year ending June 30, 1910, the city plant paid out of its earnings the principal and interest on the bonded indebtedness incurred for its construction, in addition to all operating expenses, and had left for depreciation and new construction an amount equal to approximately 5 per cent. of the cost of the plant.

I am informed that it cost the Southern California Edison Company $0.0216 per kilowatt-hour to furnish electricity in the city of Los Angeles during the year 1909. During the same period the Pasadena municipal lighting plant produced electrical energy at an average cost of $0.020 per kilowatt-hour. The residents of Pasadena remember when they paid at the rate of 15 cents per kilowatt-hour for lighting their houses, and now the city plant furnishes them with light at a base rate of 5 cents per kilowatt-hour.

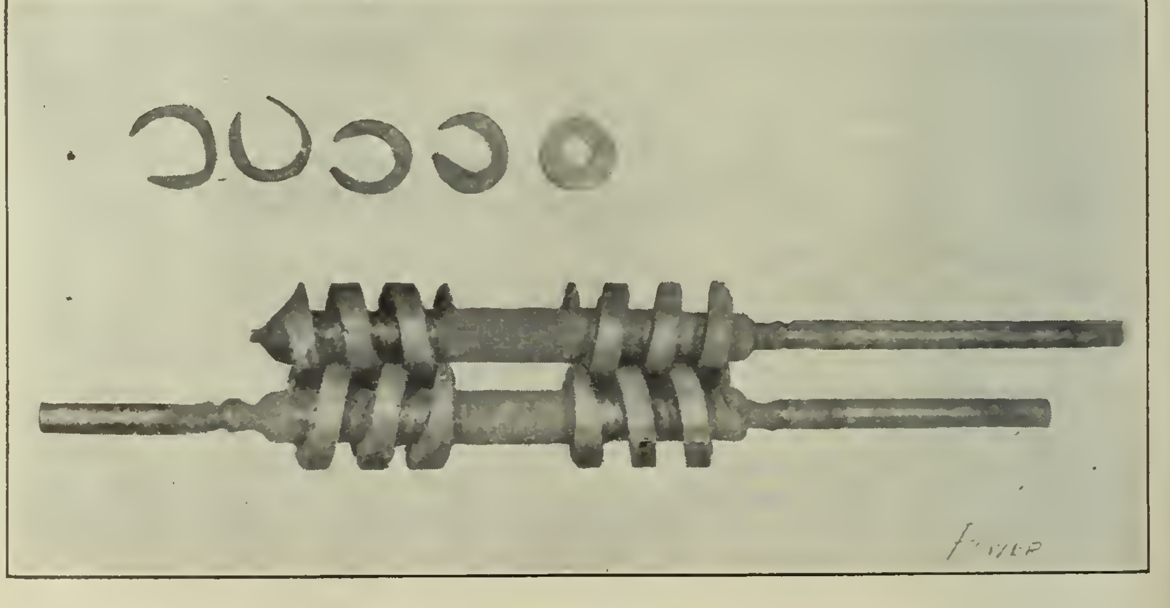
From the standpoint of the city as a whole, it may said that its people have, and are now, effecting a saving of not less than $100,000 per annum by reason of the difference in rates charged before the city built its plant and the rates which are now in effect.

W. M. GLASS.

Pasadena, Cal.

Worn Pump Worms

Readers of POWER may be interested in the long service that has been obtained from a screw pump. Nine years ago two screw pumps were installed in a 14-story office building to pump the water for four hydraulic elevators. The accompanying illustration shows the screws or worms which have been in continuous operation in No. 2 pump for eight years, operating ten hours a day, six days a week. In that time the pump has been idle about two months, due to motor repairs. The illustration shows the shafts worn more than half way through and one end entirely worn off by the action of the water, thrust washers and packing. The pump was operated for six weeks after the missing end of the shaft had broken off, the screw guiding itself in the cylinder.



WORN PUMP WORMS

The four horseshoe-shaped rings at the left show all that is left of the illustration of the thrust washers; the tap ring shows how a new thrust washer looks.

After the screws were removed, the cylinders were measured and showed but 1/64 inch more than their original diameter, and this was at the end of the end where the loose screw with the broken shaft revolved.

The screws were 7 inches in diameter; the pump has an 8-inch suction and a 7-inch discharge pipe and is supposed to pump about 700 gallons of water per minute at 800 revolutions per minute.

L. M. JOHNSON.

Glenfield, Penn.

An Old Belt

Some time ago I read of a belt that had been run for 25 years.

At the plant where I am engineer, there is a 20-inch belt running 2827 feet per minute that has been in service 10 hours each working day for 45 years. It is a double belt and is shown in the illustration. The engine is a Putnam and runs at a speed of 90 revolutions per minute.

SHOWING PRESERVED CONDITION OF BELT

CHARLES E. HARRIMAN.

Concord, N. H.

any one of the push buttons *M*, the circuit is closed through the batteries *N* and magnets *O*, which pulls the armature *K* and the trigger *J* down, thus releasing the trip *I*, whereupon the lever *C* drops, and, in so doing, throws the link *A* off of the stud *B*. The lever *C* then strikes the adjustable stop *P*, thereby forcing the arm *Q* down to the rubber-cushioned stop *R* and at the same time the arm *V* comes to rest on the stop *S* and assuming the position indicated by Fig. 3. This moves the rods *T* in the direction shown by the arrows, thereby throwing the valve cam into such position that the knockoff blocks come in contact with the hooks and prevent the steam valves from opening, thus stopping the engine.

George J. Little.

Passaic, N. J.

Carelessness Causes Accidents

A high-speed, center-crank engine pounded badly. The engineer, who was a new man trying to make good, had disconnected the crank-pin end of the connecting rod in order to ease away the brasses. He had then closed up the crank case and started up, but the engine began to pound and heat badly. Investigation showed that there was an accumulation of wood pulp, mixed with the oil inside of the case, and the connecting rod was also sprung, which caused the heating.

The engineer then remembered that he had used a piece of wood to block up the connecting rod while facing off his brasses and when connecting up again this block of wood had fallen down to the bottom of the crank case and he had failed to remove it. Just a little carelessness.

In another case a boiler-feed pump suddenly refused to feed enough water to the boilers. A small test gage was connected to the discharge line of the pump and upon starting the pump a higher pressure was obtained on the test gage than showed on the steam gage on the boiler, showing that there was an obstruction in the discharge, notwithstanding the pipe was new. Upon tracing up the pipe line it was found that in one out-of-the-way place the pipe went through a wall and a short piece of old pipe had been left in place, as it was difficult to get at. The new piping had been connected at each end and, as the old pipe was almost filled with scale, when the pump was started after the repair work had been finished a small piece of loose scale was forced into the small opening in the old pipe, partially closing the same and causing the trouble.

Failure to tighten the lock nut securely on the dashpot rod after making adjustments allowed the nut to work loose and the rod to lengthen, resulting in a bent rod.

In the case of a Greene engine, when putting new steel plates on the tappet the engineer failed to properly tighten the screws, which worked loose and allowed the plate to drop, breaking the tappet.

These accidents were all the result of carelessness and could have been prevented.

Charles H. Taylor.

Bridgeport, Conn.

Dusty Engine Room

Can any reader tell me how I can keep dust from collecting on the walls and ceiling of my engine room. Dust is drawn in by the driving belts of three engines, each belt 20 inches wide and traveling at a speed of 3500 feet per minute. I have a hardwood floor and have it scrubbed once a week, but this dust spoils the looks of the engine room.

Has any reader any suggestions to offer as to how I can rig up a suction vacuum cleaner to remove the dust from the walls and ceilings, as sweeping it does not make a good job?

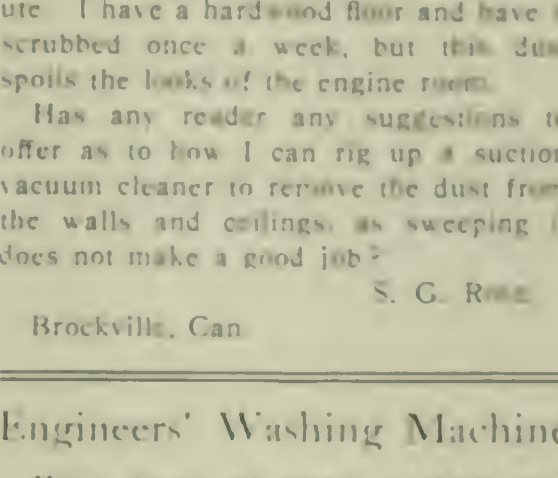
S. G. Ross.

Brockville, Can.

Engineers' Washing Machine

Many forms of steam washing machines for washing overalls, etc., have been made by the man on the job that have given more or less satisfaction.

The washer shown in the drawing herewith uses steam only, and will wash a garment, no matter how dirty, in two minutes. The garment is soaked in soapy water and, without wringing, is placed in the washer and the steam turned on. When the garment attains a speed of



Washing Machine

between 35 and 40 revolutions per minute, enough steam has been turned on. If one is particular the garment might be rinsed a little after washing.

The width of the front lid is two inches narrower than the opening. The sides of the washer, also the crosspiece through which the pipe to the jets enters, are made of 1-inch dressed lumber. A strip of galvanized sheet metal 14 inches wide and long enough to go around the bottom and circular sides of the machine is nailed to the edges of the wooden sides and crosspiece. The cover is made of the same material and is fastened by hinges to the crosspiece.

When the garment has been placed in the machine and the steam turned on, the garment follows a path shown by the arrows. The steam follows a circular path the same as the garment, but escapes through the opening in the front while the garment drops directly in the path of the jet of steam from the nozzles and is driven around again.

It is not necessary to construct the machine water-tight.

Louis T. Waters.

Pueblo, Colo.

Isolated Plant Engineering

The central station versus the isolated plant has become a very serious question for the consideration of the engineer who operates the latter plant. Engineers have been urged to keep records of the daily performance of their plants in such a way that they may be thoroughly understood by their employers and used to refute the very clever and persuasive statements made by the central-station solicitor.

This is all very well, but I would like to ask how the average engineer is to procure all these data? Suppose, for example, that an engineer is put in charge of a building where there is a heating and lighting plant and, as is generally the case, is under the supervision of a superintendent. The engineer carefully looks the place over for a while, taking note of the methods of the operating force, the kinds of fuel burned, lubricants used, when the boilers are cleaned and, in fact, makes a general survey of the plant and its operation. Discoveries are made and noted and the engineer decides upon some changes which in his best judgment will be to the benefit of the plant. Having the data in regard to this particular change he wishes to make, he goes to the superintendent and with all the confidence of a man who thoroughly understands his subject presents his plan.

It may be he will get recognition and he may get the necessary material to make the change, but in 99 out of 100 cases he will be turned down and gently but firmly sat upon.

Worse than this, at a later date an outside mechanic will appear with material and men to do the same job that the engineer suggested and he is told that the idea came from headquarters. Such methods are not conducive to a proper feeling on the part of the engineer, but yet such an occurrence is not an impossible or imaginary situation.

Another phase of this question which has always attracted my attention is the apparent lack of confidence of the employer in the engineer. I know of good engineers who were put in charge of plants and were not even given the au-

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

The Line Shafts Break

During the last two years there has been considerable trouble with the breaking of shafts, as nearly every shaft of any importance has broken during this time. A $2\frac{15}{16}$-inch shaft has let go three times, and three others of $2\frac{7}{16}$ inches have broken, all doing considerable damage. They all break in the hub of the driving sheave of the American system of rope drives. The sheaves are keyed to the shafts by a straight key with two set screws on top to hold the key firmly in place. The shafts are not out of line and are not overloaded. The $2\frac{15}{16}$-inch shaft drives but 50 horsepower, and the other shafts about 20 horsepower each.

The danger of maiming or killing employees is apparent. The expense of maintenance is great, as the ropes usually become tangled and the shaft comes down, taking everything with it before the power can be shut off. Good machinists have been employed for the repair jobs but the shafts keep on breaking. Can any reader of POWER suggest a probable cause or remedy?

Chicago, Ill. A. RATHMAN.

A Homemade Safety Stop

When I took charge of a certain steam plant, I recommended the installation of some kind of an automatic safety stop, so that in case of necessity the engine could be stopped by pressing a push button from various points in the factory without waiting to signal or telephone the engineer.

But as there was some delay in regard to the matter and feeling somewhat apprehensive that something might happen when none was near the engine to shut it down quickly, I came to the conclusion that I could make a safety stop, and it has proved reliable in every way. The accompanying illustrations will give a very clear idea of the construction and operation of the apparatus. The only parts that had to be purchased were the push button, batteries, wire and magnets. Any type of electric-gong magnet will answer the purpose; otherwise the rest of the material costs nothing, and the only expense is the machinist's time in making it. The method of making this safety stop is described herewith.

The brass knuckle on the end of the governor link *A*, Fig. 1, is slotted so that it can be disengaged from the stud *B*. The lever *C* is mounted upon the bell-crank bracket of the governor, and is secured by three set screws to the collar *D*, upon which it moves freely by means of the strap *E*. The link *A* passes between the grooved rollers *G*. The magnetic releasing mechanism is attached to the front of the governor column in the position indicated at *H* so that the lever *C* rests upon the trip *I*, Fig. 2. This trip is held down by the trigger arm *J*, which is secured to the top of the armature *K*, mounted between the two pivots in the top of the brass posts *L*. Upon pressing

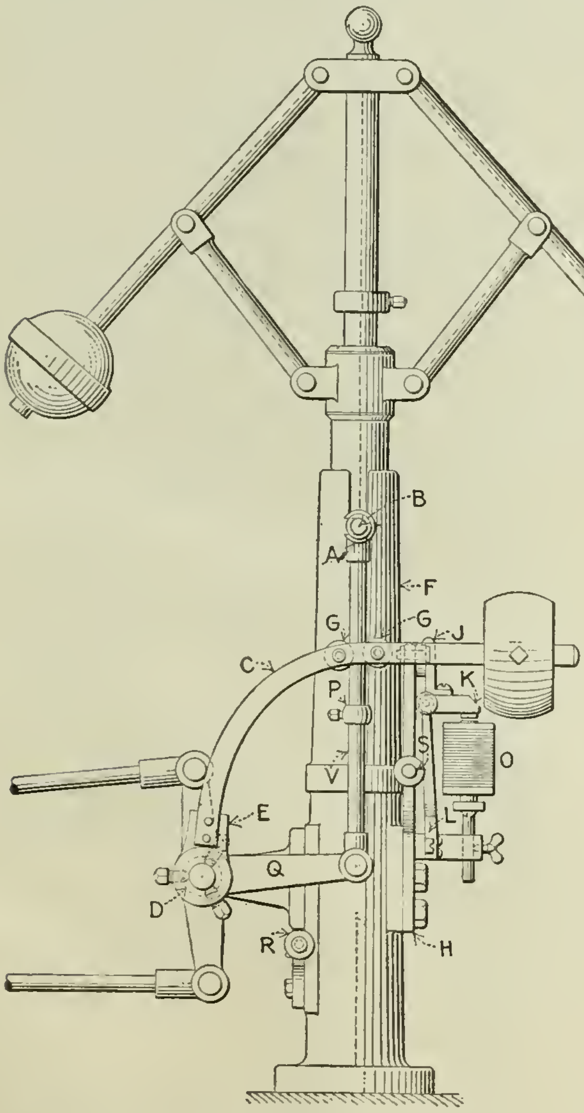


FIG. 1

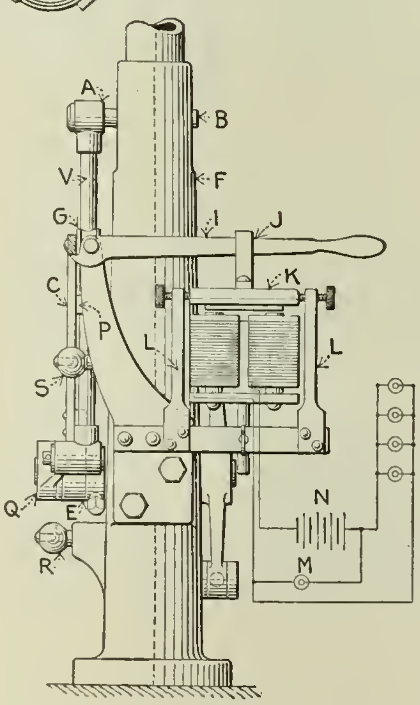


FIG. 2

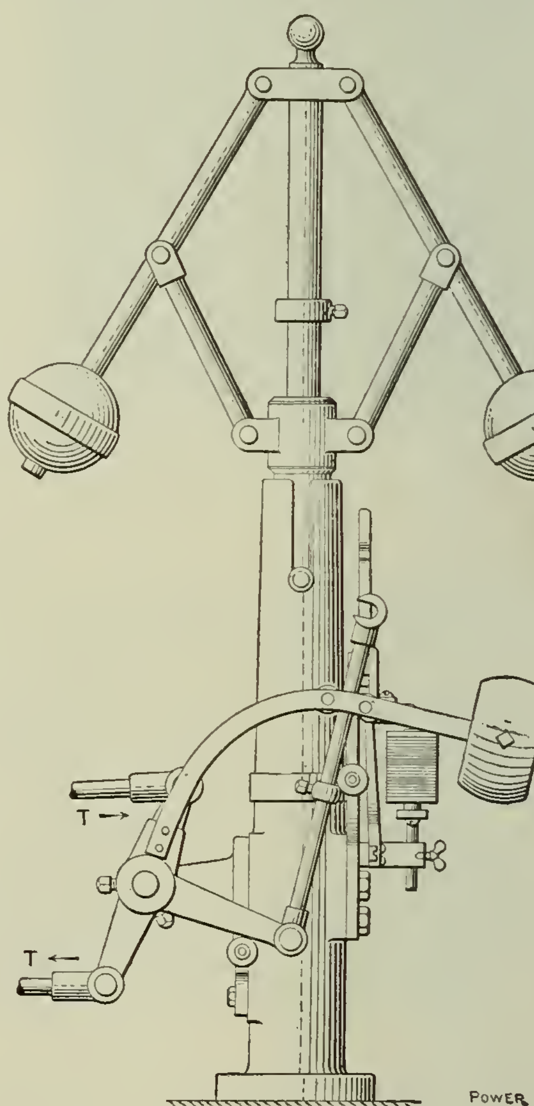


FIG. 3

DETAILS OF HOMEMADE SAFETY STOP

represent the cost of operating the whole system because, with the exception of the building and contents, no charges are made for interest, maintenance, depreciation and sinking fund for the general system. Office expenses, improvements, etc., are likewise not included, as these charges would remain the same with either gas or steam as the source of power. The cost of constructing the gas-power plant as compared with a steam plant of similar size, however, has been taken into consideration.

TABLE SHOWING COMPARATIVE COST OF PUMPING WATER BY STEAM AND PRODUCER GAS

Rate of pumping is 1,000,000 gallons per day.

	Steam Plant	Producer Gas Plant
Interest on cost of building and contents for one day, rate 4½%	$2.20	$2.86
Daily average charge for repairs and maintenance	0.35	0.41
Daily debit to sinking fund, interest at 4%, based on complete renewal in forty years	0.48	0.68
Daily cost of operation:		
(a) Labor, two men, 12 hours each, at $80 and $75 per month	5.10	5.10
(b) Fuel at $2.50 per ton	9.45	2.13
(c) Oil	0.30	0.25
(d) Waste	0.02	0.02
(e) Light, etc.	0.10	0.10
(f) Miscellaneous	0.20	0.20
Total daily expense	$18.20	$11.74
Estimated cost of pumping 1000 gallons water by steam		1.81 cents
Estimated cost of pumping 1000 gallons water by gas		1.17 cents
Estimated saving per 1,000,000 gallons water pumped	$6.40	

Producer Gas from Crude Oil*

By E. C. Jones

The production of gas from crude petroleum or its products is not sufficiently standardized to give figures necessary to exactly determine its economy. California with its immense deposits of petroleum is the natural and logical field for the exploitation and industrial use of oil producer gas. It is to be deplored that such an important subject was first considered by men not conversant with the manufacture of oil gas, who, in casting about for apparatus to make producer gas from oil, naturally gravitated to the old familiar methods of retorting the oil; any improvements that grew out of these methods seem to have retained the objectionable features of the retort system. Briefly stated, these features consist of the necessary shutdowns for the purpose of removing coke and frequently for burning out accumulated soot and lampblack. A typical analysis of gas made in this way is as follows:

CO_2	4.0	CH_4	12.8
CO	7.4	H_2	3.1
O_2	0.4	N_2	71.9

British thermal units per cubic foot, 172. Claimed thermal efficiency, 20 to 62 per cent. Operating thermal efficiency, 55 per cent.

*A paper presented at the San Francisco meeting of the American Society of Mechanical Engineers.

This gas has been applied to the operation of small gas-engine units up to and including 100 horsepower. Owing to the abundance of petroleum in California, it has superseded all crude material in the manufacture of illuminating gas.

The first oil gas manufactured on a large scale in California has the following analysis:

Heavy hydrocarbons	6.2
Marsh gas	20.6
Hydrogen	62.4
Carbon monoxide	3.0
Carbon dioxide	2.2
Oxygen	0.4
Residual nitrogen	2.2
	100.0
Specific gravity	0.390

By improvements in apparatus and refinements of operation the hydrogen content of the gas has been reduced to less than 40 per cent.; the marsh gas has been increased to 34 per cent.; the carbon monoxide has been increased to 9 per cent.; the specific gravity to 0.485, and the heat value from 624 to 680 B.t.u. per cubic foot. The oil gas generators used at present for manufacturing illuminating gas are so elastic in their operation that any of them can be immediately adapted to the manufacture of producer gas from oil, the chemical composition of the gas and its value depending only upon the manipulation of the generator.

The writer has carried on a series of experiments with oil producer gas, using a large generating unit, and the only change in equipment was the use of compressed air at from 35 to 40 pounds pressure for the injection of oil and to assist in the partial combustion of the oil. During these experiments producer gas was made having a thermal value as low as 103 B.t.u. per cubic foot and as high as 482 B.t.u. per cubic foot. Unfortunately no ready means was at hand for measuring the quantity of gas made and the amount of oil used to produce 1000 cubic feet. A typical analysis of this gas is as follows:

Carbon dioxide	4%	
Heavy hydrocarbons	2	or less
Oxygen	1	
Carbon monoxide	9	
Hydrogen	2	
Marsh gas	13	
Nitrogen	70	

This gas has a calorific value of 100 B.t.u. per cubic foot. To use this gas successfully in gas engines it is necessary that it shall be thoroughly cleaned by efficient scrubbing, and that it shall be uniform in calorific value and chemical constituents. This last can be readily accomplished in the operation of oil-gas generators, by careful measurement of the oil used and the air supplied for its partial combustion, and the maintenance of a fairly constant temperature in the generator.

This can be done as in oil-gas manufacture by a determination of the necessary temperature by the observation of color in the checker brick and the maintenance of this temperature by frequent observations through sight cocks by the gasmaker.

Making producer gas from oil in the ordinary gas generator has many advantages over any special process. The gas can be made in very large quantities and the amount made can be easily regulated to the needs. The operation is continuous and without interruptions for cleaning. This is essential in the manufacture of producer gas for power purposes. In any other known process the interruptions are not at stated intervals, but occur when the producer refuses to work, owing to the clogging up of its parts by coke or lampblack.

Oil-gas generators have no easily destructible parts, as the lining and checker brick are constructed with a view to resisting high temperatures and, although a much higher temperature is desirable in making producer gas than that employed in making oil gas in retorts, the checker brick are not seriously affected by the high temperature. In the decomposition of oil in the presence of air, there is complete disposition of all the gas-making constituents of the oil, so that producer gas can be made without a by-product of any kind. Any accumulation of carbon in the generator may be removed by adjusting the temperature and quantity of air supplied.

This method of making gas requires a small gas holder for momentary storage, and the process as at present understood could not be used as a suction gas producer. Producer gas made from oil and containing a small percentage of hydrogen possesses advantages over illuminating-oil gas inasmuch as it can be subjected to higher compression in gas-engine cylinders and, with a gas of uniform analysis, uniform piston speed can be obtained.

CORRESPONDENCE

Mr. Barker's Engine Speed

In the February 28 number, O. J. Barker asks if a speed of 300 revolutions per minute is too high for a vertical, single-acting engine of 9½-inches bore and 12-inches stroke, built with a crosshead. My opinion is that such a speed is too high for a single-acting engine. When the piston reaches the end of the expansion stroke it has no cushion against the open end to assist the sudden reversal of stress. At such a high piston speed (600 feet per minute) a sudden reversal of stress would most likely cause a pound at the end of the downward stroke. Especially is this true in this type of engine as the power stroke is downward and the inertia of the moving parts tends to increase the sudden reversal of stress.

Thomas H. Beckman.

New Orleans, La.

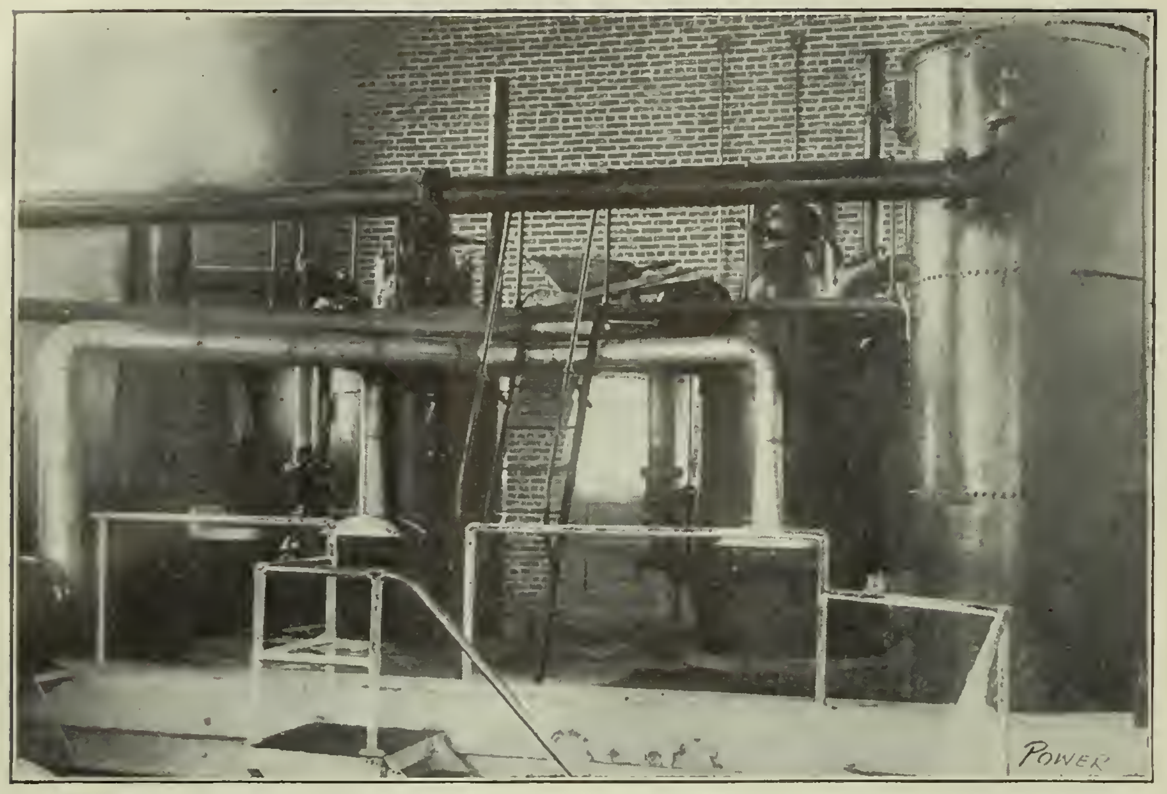


Fig. 4. The Producer Equipment

Whenever clinkers are drawn out of the fire, which is requisite only at intervals of several hours, the suction fan is started and draws all dirt away and discharges it outside the building. By this means the producer room is kept perfectly clean and no dust is ever carried over to the engines and pumps.

The supply of lubricating oil is kept in iron tanks with pipe connections leading outside to permit their being filled readily and without making any mess in the station.

As to the operation of the plant, the pumping units and gas producers are in complete duplicate; therefore, either set can be operated independently of the other or both may be operated at the same time. When the engines are not in operation, the fires in the generators are usually banked. While in this state, very little attention or coal is required for days at a time, but the plant can be placed in full operation on short notice.

a shutdown of several hours' duration. The compressor, blower and pump are all driven by the gasolene engine.

The suction pipes are laid beneath the floor in concrete channels which are covered by steel floor plates and the piping is so arranged and equipped with valves that either engine may be operated from either producer. A neat gage board, located on the east wall of the machinery pit, is in full view from both engines. Upon this board are mounted two sets of suction and discharge gages and a recording gage which indicates high and low water in the standpipe by means of an electric alarm and registers upon a paper disk the water pressure as it varies from hour to hour.

The operating engineer of the plant has installed an excellent system for removing the dust arising during the operation of stoking the fire at the grate level. As indicated in Fig. 3, a system of galvanized pipe extends from a suction fan to the fire doors of each generator, with a hood or extension over each door.

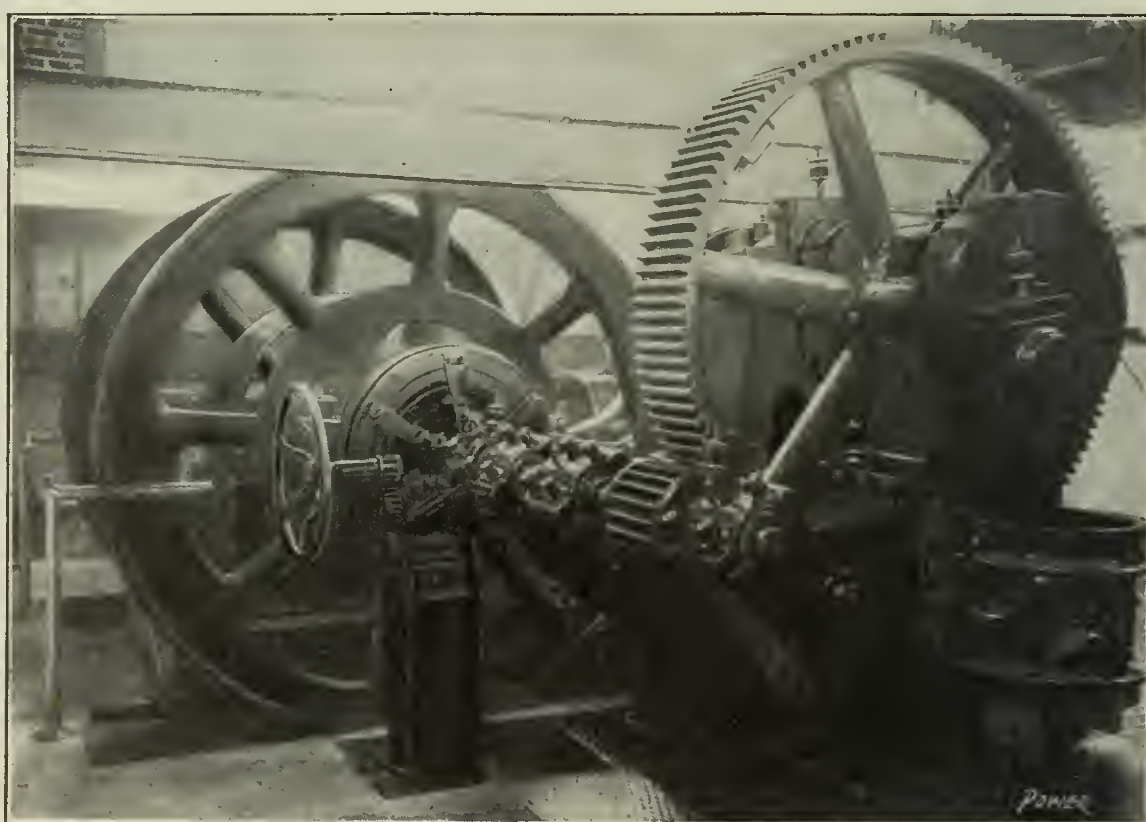


Fig. 6. One of the Pumps and Its Clutch Gear

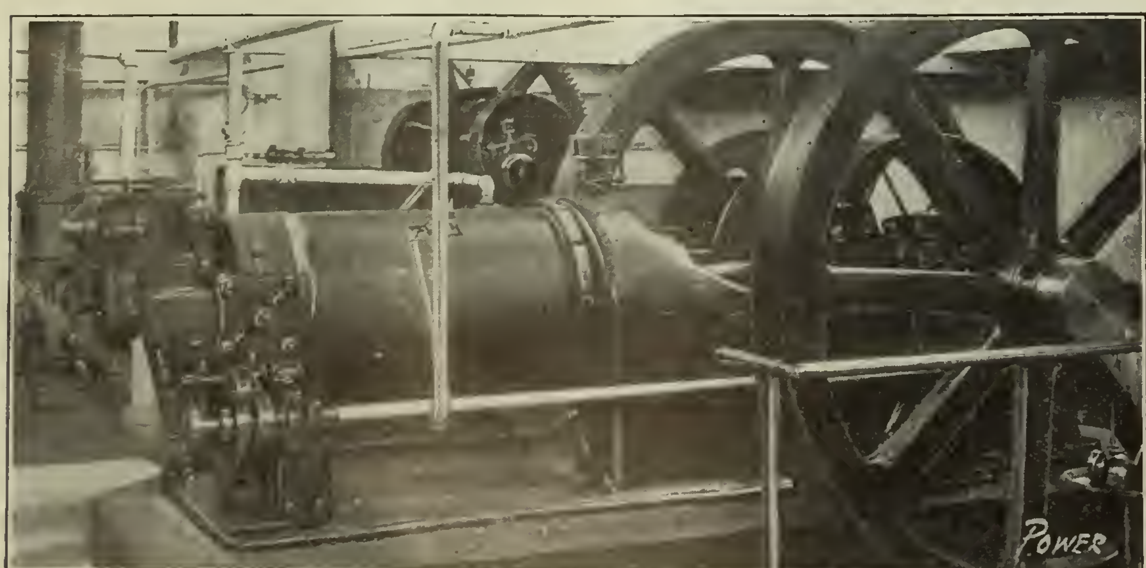


Fig. 5. One of the Engines

By actual experience it has been found that after a shutdown of seventy-two hours the engines could be started and water pumped within fifteen minutes. This is less time than would be required to get up steam from banked fires in ordinary boilers.

The accompanying table shows the cost of pumping 1000 gallons of water by producer gas as compared with the cost of pumping by steam. In making the comparison, data from steam pumping plants of similar size have been utilized to determine the cost of operation. The actual prices bid for a steam plant were used in determining the charges for interest, depreciation, sinking fund, etc. It should be understood, however, that the figures given do not pumping unit is composed of an 85-horsepower single-acting engine and a Deane triplex pump. Fig. 5 shows a view from the engine side of one of the units and Fig. 6 shows a view from the pump side. The engines are the standard heavy-duty single-cylinder machines built by the Otto Gas Engine Works and are direct-connected by friction clutches to the driving shafts of the pumps, to which are geared the pump crank shafts, as usual. The pumps are of the vertical single-acting type and each has capacity of one and a quarter million gallons in 24 hours against a head of 250 feet (108 pounds per square inch). The total capacity of the station is, therefore, 2,500,000 gallons per 24 hours.

On the basis of the figures just given, the water horsepower delivered by each pump is 54.3 and, with the ample allowance of 25 per cent. for friction in the pump and gears, the brake horsepower required from the engine is 72. This is only 85 per cent. of the rated power of each engine and as each of these has an overload capacity of more than 20 per cent. above its rating, the water pressure could be temporarily increased in case of fire to more than 150 pounds per square inch. This policy of operating a municipal pumping plant at moderate load and pressure, with a possibility of considerable increase in emergencies, is most excellent. It increases the life of the plant and insures its reliability, if well built.

The only auxiliaries required are a 3-horsepower Otto vertical gasoline engine, a compressor, a centrifugal blower and a drainage pump for the machinery pit. The compressor, together with a storage tank, is used to provide compressed air for starting the main engines. The blower provides a forced draft in brighting up the producer fires in the morning or after

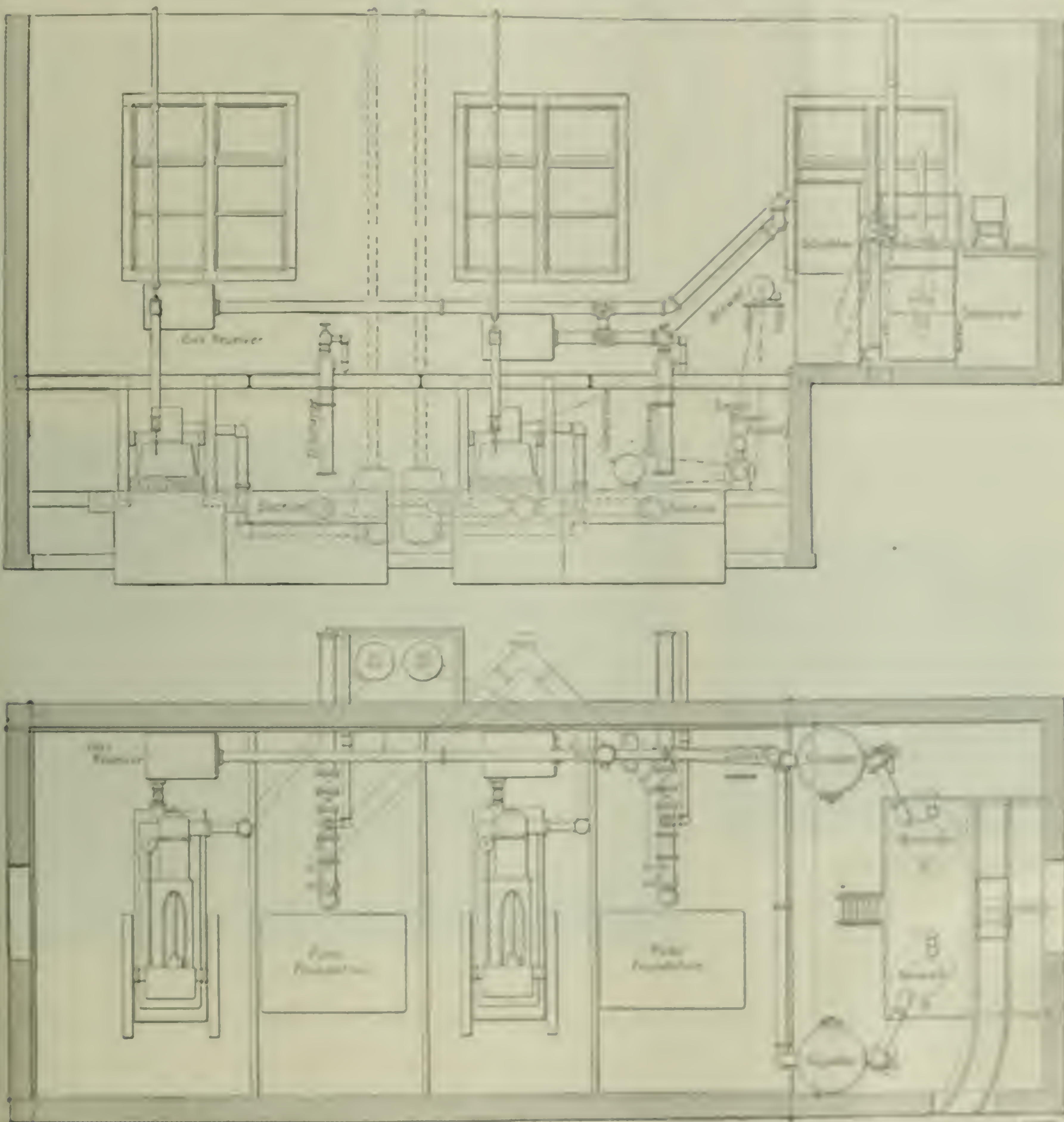


Fig. 3. Elevation and Plan View of Apparatus in Haddonfield Gas-power Plant

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

A Municipal Gas Power Pumping Plant

By Thomas E. Butterfield

A striking example of municipal progressiveness is embodied in the gas-power service and fire-pumping station installed within the past year by the town of Haddonfield, N. J. The new water-works system derives its water supply from four artesian wells which extend down about 220 feet. From each well a 6-inch branch leads to a 12-inch main extending from the well field to an absolutely water-tight concrete cistern 20 feet in diameter and 42 feet deep. The 12-inch main extends about 30 feet down into this cistern and as soon as the pumps lower the water level in the cistern more water is siphoned out of the wells.

The power house is built of hard burnt brick and the foundation walls are of concrete, reinforced according to requirements. Large double-width windows located between each pair of pilasters provide ample light and ventilation for the interior. The building is located at the foot of a hill, as shown in Fig. 1, and at the edge of a basin or depression in which the artesian wells were driven. The railroad spur track is on the crest of the hill and coal cars are dumped into the chute shown in the picture, the coal passing by gravity down the chute to the coal shed, whence it is wheeled by barrow across the bridge to the producer platform in the power house.

Fig. 1. Coaling Arrangement

The interior of the building is divided into two parts, the main producer floor and the pump pit. The producer floor is at the ground level and the floor of the machinery pit is located eight feet below and reached by iron stairways from the producer floor and the front of the building. An iron walkway along one side of the building (see Fig. 2) connects the front entrance with the producer floor. This iron walk also forms an excellent gallery from which the machinery on the floor below may be viewed.

As the floor of the machinery pit is five feet below the level of the ground water, it is constantly subjected to an upward pressure from beneath of over 300 pounds per square foot. To withstand this the floor was constructed of concrete several feet thick.

The power equipment of this station represents an innovation in small water-works construction. Instead of the usual steam boilers and uneconomical steam pumps, there are installed two complete, duplicate power units, each consisting of a triplex pump driven by an Otto gas engine and an Otto suction gas producer designed for gasifying anthracite coal. The gas generator is of the simple up-draft type with a vaporizer built in the top. The gas passes from the generator to a wet scrubber of the usual tower type. Fig. 3 shows the arrangement of the equipment.

Fig. 4 is a picture of the producers in which may be seen the charging platform, which is on a level with the tops of the generators and is reached from the producer floor by means of an iron stairway. This platform is of steel and is built entirely around the tops of both generators, giving access to them from all points. The platform extends to a door in the side of the building which opens on to the bridge leading to the coal shed, 20 feet away and on the same level. The capacity of the bin covered by this shed is 50 tons of coal. The floor of the bin is of concrete and the front and sides are of heavy timber. The rear wall of the bin is formed by a heavy reinforced-concrete retaining wall, 30 feet long by 7 feet 6 inches high, designed chiefly for the purpose of holding back the embankment, and beneath the front wall of the bin is another heavy concrete retaining wall.

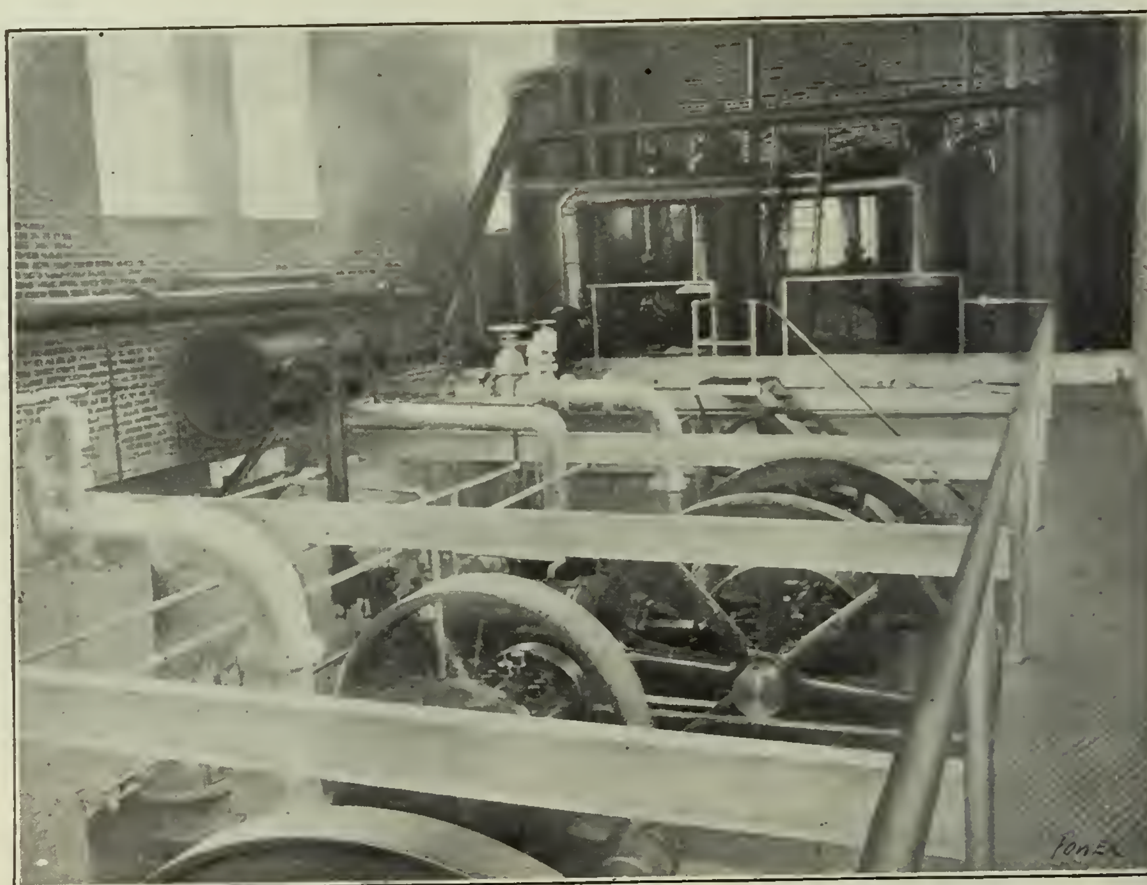


Fig. 2. Interior of Haddonfield Pumping Station

The floor of the machinery pit was put at a low level in order that the suction lift of the pumps would not be excessive, even with the water level in the cistern drawn down by pumping. Each watt-hour. In contrast to this, many modern stations are running upon about three pounds of coal per kilowatt-hour, and in some cases even less. This means that only 30 per cent. as much coal as was demanded twenty years ago is now needed to produce a unit of electrical energy.

In addition to the fact that the development of alternating-current apparatus has enabled the electric-lighting companies to distribute their product from the power station to the consumers at a much less cost, has also made it possible to transmit power for distances which were not dreamed of in the early days. Twenty years ago what little electricity was used was distributed by direct current and the radius of activity was seldom more than half a mile, or a mile at the most. This necessitated the generating stations being placed upon expensive land near the heart of the city, and since the voltage on a direct-current system is limited, it meant a large loss of power in transmission and required a large investment in copper. However, the introduction of high-voltage transmission has made it possible to locate factories, mills and shops at convenient places, instead as in the old days at or near the source of power, and has also greatly reduced the cost of distribution. These facts alone have had a wonderfully beneficial effect upon the entire industrial development of the country.

High-voltage transmission has further permitted the utilization of what were heretofore useless and almost inaccessible waterfalls. Without this development, Los Angeles would be forced to burn thousands of barrels of oil each day instead of using the mountain streams two hundred miles away, and Seattle would not be able to utilize the melting snow and ice from the glaciers of Mt. Rainier to operate all her street cars and other public utilities. Without high-voltage alternating-current apparatus, Niagara power could not be transmitted and used in the lake cities of Canada, or in Buffalo, Syracuse or Rochester. The utilization of Niagara power alone means a yearly saving of at least 2,500,000 tons of coal or the conservation of $5,000,000 to $7,000,000 of fuel annually.

Consider now the apparatus by which the electricity is converted into light, heat and power. Here again scientific study and research have done much to increase the efficiency of the apparatus used. The reduced price of electricity itself, therefore, does not indicate the total saving to the consumer. Are lamps of today are more than 100 per cent. greater in efficiency than those of a few years ago. Incandescent lamps in the early days consumed six watts of energy per candlepower. This consumption was soon reduced to three watts per candle, where it remained for many years and seemed to baffle further reduction, but after years of scientific experimentation this was reduced to 1½ watts per candle, and now there is the tungsten lamp which consumes only one watt per candle power, still further improvement is promised in a lamp which is to consume not over one-half a watt per candlepower.

While all of the matters thus far discussed relate to improvements which have taken place in the physical apparatus of the property, one must not fail to give due credit for the development of the electric-lighting industry, and for the reduction in the cost of light, heat and power, to the scientific management of electric-lighting properties. These have been specialized to a remarkable degree and carried on with most satisfactory results for many years, in spite of the fact that the term "efficiency engineer" is just becoming known to the public. The improvements in electric-lighting properties have been due fully as much to the trained engineer who operates the property as to the engineer who plans it or who designs the apparatus used in it. It is the operating engineer who in many cases has pointed out opportunities for betterment and has suggested to the designing engineer where economies and improvements could be made in the physical apparatus. It is the operating engineer who by careful study of men, machinery and methods has brought about economies in the production of electricity which have resulted in reduced costs. He has instructed his men in their particular duties and has educated them so that they have become experts in their lines.

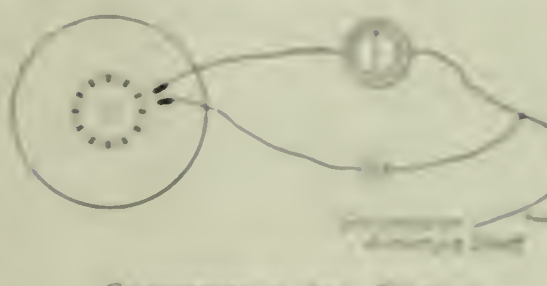
The operating engineer has not only brought about a great reduction in the cost of electrical energy itself, but as the result of a scientific investigation of the customer's needs he has effected, through the use of suitable electrical apparatus, what is in reality a still further reduction in the cost of light and power to the consumer.

The wonderful advance which has taken place in the last twenty years in the electric-lighting industry has been due to the combined efforts of the operating engineer and the designing engineer. It has been a gradual and a steady evolution and is still going on. The industry itself has not reaped all the benefits, for while the returns on electric-lighting investments have been sure they have not been as large as the dividends which the public has received in the reduced cost of electric light and power. Twenty years ago electric lights were high-priced luxuries, today they are inexpensive necessities.

LETTERS

Locating a Grounded Armature Coil

On page 420 of the March 14 issue, Mr. Davies describes a method of testing for the location of grounds in direct-current armature windings which is a good one. However, I think the method I have been using is simpler and easier of application. We have a good deal of this kind of trouble, caused by salt air attacking the copper and insulation, and the test has always been satisfactory. A millivoltmeter or galvanometer, a few cells of primary battery and a few short pieces of wire are all you need. Raise all brushes from the commutator and clean it thoroughly. Connect one terminal of the battery and one terminal of the galvanometer or millivoltmeter together and also to the armature shaft, as indicated



Connections for Testing

in the diagram. Then touch the two free terminals to one commutator bar and note the deflection of the instrument. If there is no deflection, one of the coils connected to that bar is dead grounded and that practically short-circuits the instrument and thereby prevents deflection. If there is a deflection, try another bar and note the deflection; if it is greater than the first one, you are moving away from the grounded coil. Successive tests will finally locate a bar where the deflection is smallest or where there is none; that bar will be connected to the grounded coil and by taking out the leads from the commutator bar and testing them separately the grounded coil will be easily identified.

A. J. [illegible]

U. S. S. "Michigan."

Smoothing Roughened Collector Rings

Cast-iron collector rings on revolving-field alternators are very hard to smooth after becoming rough from arcing. The "flowers" that have been raised are chilled and cannot be cut with a file. The best way I have found to deal with such cases is to grind a piece of an old emery wheel to the shape of the collector-ring brush, put it in one of the brush holders and run the machine, applying a little oil to the collector ring. It works like magic.

C. L. [illegible]

Dubuque, Ia.

lel, with partial success; closer attention was then given to the electrical part of the unit. It was found that either engine could be operated in parallel with the turbines, provided the field current of the engine-driven unit was greatly decreased, causing the output of the engine-driven unit to have almost unity power factor while the turbine unit would have a very low power factor, as it was then required to furnish practically all of the wattless component of the line current in addition to its load, but the two engine-driven units would operate in parallel with each other but little better than before. The supposition was that the field magnets of the engine-driven units were too close to the saturation point at any power factor much below unity, which would cause poor operation in parallel, as the reaction of the synchronizing current upon a field magnet is much less effective when the magnet is highly saturated. This impression was strengthened by the fact that on rare occasions the machines would run together for hours at a time at slightly reduced voltage, while a slight increase in field current would result in such heavy surges of cross currents that the machines would have to be separated immediately.

It was suspected for some time that the relative positions of the crank pins at the instant of synchronizing made a perceptible difference in the action of the generators, and considerable ingenuity was expended upon an electrical attachment to the engine shafts to indicate, through contact-making devices, when the cranks were in certain relative positions, but a large number of experiments indicated, so far as could be determined, that the relative positions of the crank pins made no difference whatever. When the power factor was favorable, 90 per cent. or higher, the generators would operate satisfactorily with the crank pins in any relative position, and when the power factor was much below 90 per cent. there was no position of crank pins with which they could be made to remain in parallel.

This, which at first appeared to be almost impossible to remedy, proved to be the simplest condition of all. It was reasoned that anything that would operate to maintain the necessary voltage without increasing the field current would assist in maintaining synchronism, and investigation developed that while the engine-driven alternators were rated at 78.5 revolutions per minute, they were running at about 77 revolutions per minute, or about 2 per cent. below speed. When the engine governors had been weighted down until the generators ran at 79 revolutions per minute, they operated in parallel perfectly under all changes in load and power factor. This required about 25 per cent. less field current and, incidentally, the increased speed and consequent higher frequency resulted in a much improved power factor on the entire system, which, of course, reduced the line losses and gave better voltage at remote points in the system.

It will be evident that no one item in the foregoing enumeration can be considered the reason that the alternators would not operate in parallel; correction of all of the deficiencies was necessary to obtain the result desired.

Improvements in Electric Lighting Properties*

By William H. Blood, Jr.

At the present time, when so much is being said about "efficiency" and "scientific management," it may be well to consider what the application of science to the electric-lighting industry has accomplished and to what extent the public has been benefited thereby.

In 1888, the writer tested the largest dynamo that the Institute of Technology possessed, and found the highest ratio of electrical output to mechanical input to be about 70 per cent. Today, machines of this size operate at about 85 per cent. efficiency, while larger units give efficiencies of 95 or even as high as 97 per cent. Assuming this improvement in efficiency to amount to an average of 25 per cent., it would mean that this percentage of the fuel which would have been burned, had there been no improvement in electrical efficiency since the year 1888, is now being saved.

If this figure is applied to the industry as a whole, basing the estimate upon figures given in the census reports on the cost of fuel used by the electric-light and railway plants in the United States, it shows that electrical engineers have brought about the conservation for future generations of approximately $12,000,000 worth of coal per year, and this solely on account of a single item—improvement in the efficiency of electric generators.

This improvement has been accomplished partly through an increase in the size of the units. The first commercial electric-light plant in Boston, built in 1886, contained six machines having an aggregate capacity of about 230 horsepower, two of them being of 15 horsepower each and the remaining four of 50 horsepower each. In 1888 the largest electric generators were of 100 horsepower, and they were regarded as monsters. Today, 15,000-horsepower machines are common and even units of 25,000 horsepower are about to be installed. The 25,000-horsepower generators, besides being more efficient, are much more reliable and are little, if any, more complicated than the older and smaller machines.

*From a paper delivered before the Technology Congress, at Boston, April 11, 1911.

One of the early electric-power plants with which the writer had some connection, contained twenty dynamos of 100 horsepower capacity each, giving a total capacity of 2000 horsepower, and the floor space required for the entire plant, including boilers and engines, was 9000 square feet, which is equivalent to 4.5 square feet per horsepower of capacity. This same company is today building a new station which is to have an ultimate capacity of 140,000 horsepower and which will require but slightly in excess of one-half a square foot per horsepower. The first plant represented an investment of approximately $225 per horsepower, while the new installation will cost about $45 per horsepower. Had there been no improvement made along this line, and had the company been obliged to increase its capital account on the basis of $225 per horsepower up to its present capacity, it would have required an additional investment of some $12,500,000, which would have entailed additional annual interest charges of $750,000.

A still further improvement in power-plant design has been the adoption of steam turbines. These, besides requiring much less room, use higher steam pressures and higher vacuums, and are, consequently, more efficient.

There has also been a great development in the boilers used in power stations. Instead of units of 100 to 125 horsepower, units of 600 horsepower are now in general use and boilers up to 2000 horsepower have been built. In the old tubular boilers 80 to 100 pounds was the common pressure used; this was later increased to 125 pounds, then to 150 pounds, and finally in the water-tube boilers of today 200 is commonly used. Improvements in superheaters, combustion chambers, automatic stoking devices, condensers, ash- and coal-handling machinery, apparatus for analyzing flue gases and other miscellaneous devices have all had their effect in cheapening the process of converting the heat units of coal into steam.

Turning again to the electrical equipment, the modern switchboard, although somewhat elaborate with its remote-control switches and automatic regulating and protecting devices, is simple of manipulation and arranged to give the plant the greatest flexibility of operation. With the increase in size of the units and the development of the modern switchboard, has come a decrease in the number of operators needed, so that today in the dynamo room of a 5000-horsepower plant there would be required only two or three men on a shift, whereas two decades ago eight or ten men would have been required.

In the early days of power-plant operation it required, as a rule, ten or more pounds of coal to produce one kilo-

This matter of securing the position "higher up" is getting so important that it has given rise to all these articles and if a fellow cannot find a helping hand if he makes any effort to "get there," it will certainly not be the fault of the writer of those editorials on the first page.

J. E. POCHÉ.

New Orleans, La.

In a recent issue, Oscar J. Richmond suggested that ideas be given upon the subject of how to proceed to secure a better position, assuming that one is properly qualified for it.

One's early training should prepare him to speak and write intelligently of the things he knows and to be at his ease among the cultured. When he endeavors to secure a higher position he needs to be able to show his prospective employer just why it will be advantageous to secure his services, just as the salesman must show the buyer why it will be to his advantage to buy the particular article that the salesman is offering. General, coupled with technical, education is necessary for this, and the more education an engineer can obtain the better it will be for him.

At all times one should take pains to work up as wide a reputation as possible of being a high-grade man so that when a man is needed for a desirable position in the neighborhood, he will be among the first to be thought of. One should be a mixer both in the associations of his fellow craftsmen and in a general social way. He should, as far as possible, cultivate the acquaintance of employers, and in this his personal appearance will count greatly. He should dress as well as the circumstances and his means will permit and remember that he may lose much more in opportunities for advancement by going poorly dressed than he saves in clothes. The commonly accepted badges of his profession, dirty hands, overalls, etc., should be discarded whenever his duties will permit, while at work he should be as neat personally as possible. The better class of employer takes note of such things and prefers employees that make a creditable showing, both on duty and about the streets and other public places.

One should avoid talking shop and should avoid appearing big-headed but, on the other hand, should make use of his opportunities of showing that he knows his business and knows it well. He should not claim to know it all, but he should let his conversation and actions show that he does know a great deal. Whenever occasion offers he should help his fellow craftsmen and not be afraid that the ideas he thus gives away will help another to get the position he himself desires. If one has the reputation of being a high-grade man among his fellow craftsmen, employers are sure to learn of it and it will be greatly to his benefit. Taking part in discussions in association meetings and writing for the technical journals will assist in working up the desired favorable reputation and will give one greater confidence in his own ability.

It often happens that one is so isolated by the place and conditions of his occupation that the foregoing suggestions are of little help and in such cases the following will more particularly apply.

In many sections of the country there are employment agencies that make a specialty of technical and professional positions and if such an agency is available it will often prove the easiest and best means of securing the desired result. Employers frequently advertise for high-grade men and advertisements for help in the desired line should be watched for and replied to. Replies should be made promptly and whenever possible in person. Take a day off and spend a little money for railroad fare if necessary. The trip will do you good and, though you may be too late to secure the position, it will extend your acquaintance both among employers and members of your own craft, and if a good impression is left with the employer he may call on you when next in need of a man, or recommend you to another. Great pains should be taken to leave a good impression. The clothes should be good but not showy, and the manner natural. No attempt should be made to show off. All questions should be answered carefully and truthfully. If a question be asked about some subject one does not understand he should be frank and admit it. Attempting to conceal is usually the surest way to get into trouble. Besides, no one is expected to know everything and have it all on his tongue's end. The employer should be allowed to do most of the talking. He knows the points he wishes to bring out. Many applicants make the mistake of trying to teach the employer, imagining that they are displaying their knowledge to advantage. The writer once heard an employer tell an applicant that he was looking for someone to do his work and not to teach others how it should be done.

When advertisements cannot be answered in person it is often wise to telephone or to telegraph. Telephoning is best where feasible as it gives the employer opportunity to learn more of the applicant. Lastly, the advertisement may be answered by letter. The letter should be carefully worded and carefully written. As much information as possible that bears directly on the suitableness of the applicant for the position should be given and copies of letters of recommendation should be inclosed. The original letters of recommendation should not be sent as they may be called for if desired and the employer may wish to file the letters with the application. References should also be given, as an indorsement that has not passed through the hands of the applicant is often desired and is of more value. Willingness to give references also shows greater confidence in one's own ability. Every effort should be made to make it easy for the employer to decide at once and to let the applicant know of his decision. Advertisements for help usually secure many replies and the ones that contain the information that the employer desires receive the attention first.

Advertising for a position is often the first means resorted to. The first thing to be considered is the medium to be employed. Care should be exercised to use mediums that reach the greatest number of the class of employers desired. Often, one's own journals are not read to any great extent by the employers he wishes to reach. A manufacturer may employ a number of steam engineers and yet seldom look into a steam-engineering journal. Often, several mediums circulating among different classes should be used.

The proper medium or mediums having been selected, the wording of the advertisement should receive careful attention. One should not be stingy of space but should say enough in the advertisement to convince the man looking for help that the advertiser is the person desired. Bragging should be avoided but at the same time one should show that he has confidence in himself. The employer will often find many advertisements for such positions as he has to fill and the advertiser that appears most nearly to meet his requirements will be the first to be considered. Advertisements should be repeated and varied. Vacancies are usually quickly filled but may occur at any time. One may occur soon after an advertisement for such a position has appeared but employers do not read such advertisements unless in need of help and when needing help will not look through many back numbers. Even if the advertisement is repeated a number of times and in several journals it is still an economical way of securing a position.

Traveling salesmen and supply houses often are instrumental in placing men and their friendship should be cultivated.

Finally, in looking for a new position, one should always show consideration for his present employers. A good and safe rule is always to leave a place so that one can go back again. Never try to climb up by pulling another down. It is more honorable to stay down than to climb at the expense of someone else. On the other hand, one can often help himself by helping another and make his position more secure by assisting others to climb with him.

G. T. [illegible]

[illegible]

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Abbreviations and Volatile Matter

In Power, December 27, 1910, under the title of "Coal Characteristics," what is meant by the letters after the name of the coals, such as R. O. M., N. P. & S.; also, volatile matter?

F. S. H.

The abbreviation R. O. M. signifies run-of-mine; N. P. & S. means nut, pea and slack. The volatile matter is the hydrocarbon, etc., distilled from the coal at a red heat as distinguished from the solid carbon.

Steam Bound Pump

If a pump frequently became steam-bound, how could it be remedied without reducing the temperature of the water?

A. R.

The head of water in the receiver is not sufficient to lift the suction valves and let the water run into the pump cylinder. This may be because the valve springs are too stiff or because the receiver is not high enough above the pump.

The tension in the springs may be reduced or the vertical distance between the water level in the receiver and the pump increased.

Installing Oil Burner

Please give little information on installing oil burners as to how should the furnace, combustion chamber, bridgewall and general brickwork be arranged to get the best results.

E. W. E.

The grates and bridgewall should be removed from the furnace and the bottom, side and end walls lined with firebrick. The burners should discharge about midway between the bottom of the boiler and the floor of the furnace. No more air should be admitted than is necessary for the smokeless burning of the oil.

Power of Falling Water

What will be the amount of water necessary to run a 50-horsepower water turbine set vertically under a head of 20 feet, and if set horizontally with the same head?

J. O. D.

To develop 50 horsepower requires the expenditure of $50 \times 33{,}000 = 1{,}650{,}000$ foot-pounds of energy per minute. One pound of water falling 20 feet will have 20 foot-pounds of energy and to develop 50 horsepower the water required per minute will be

$$\frac{1{,}650{,}000}{20} = 82{,}500 \textit{ pounds}$$

At an efficiency of waterwheel of 75 per cent. the actual water required per minute would be

$$\frac{82{,}500}{0.75} = 110{,}000 \textit{ pounds}$$

or approximately 18,000 cubic feet per minute. It will make no difference whether the wheel is set horizontally or vertically if the head and efficiency are the same.

Unloading Boilers

We are about to install new boilers, and as I will have charge I would like to have a little information in regards to the unloading, from the cars. The track is a short spur and it is so arranged that we can drive up alongside of the car. But my intentions are to jack up the boiler high enough so that we can push the car out from under it and then run the wagon under the boiler and let it down on the wagon. If you have a better plan than this, I would like to hear from you. The boilers are 72x18 inches and no dome. As this is the first time I ever had a job of this kind, I would like to do it the best and safest way. What should be the distance between the belly of the boiler and the bridgewall?

F. A. B.

The usual method is to place the wagon by the side of the car and roll the boiler from the car to the wagon on skids. The distance from the bottom of the boiler to the top of the bridgewall should be 10 inches.

Rebounding Dashpot Plunger

What causes a dashpot plunger to rebound after it makes the drop?

W. F. E.

The plunger rebounds because the air valve is open too little and allows more air to be caught in the cushion chamber than is necessary for the proper seating of the plunger.

Efficiency of Injector

What is the efficiency of an injector as a boiler feeder?

E. O. I.

Considered as a pump alone the efficiency is low, but as pump and feed-water heater the efficiency is nearly 100 per cent., as all of the heat not lost by radiation is returned to the boiler.

Lap on Duplex Pump Valves

Why do not duplex pump valves have lap?

L. D. P.

The pump must take steam full stroke, which renders lap inadmissible, as with lap cutoff would occur before the end of the stroke.

Compound-wound Machine with Open Shunt Field Circuit

What effect would the breaking of the shunt field circuit have on a compound-wound dynamo; what effect on a motor?

S. G. R.

The dynamo voltage would be considerably reduced and would become unstable, increasing with an increase of load and decreasing with a decrease of load. The motor would probably tend to run away; it would speed up until its torque just balanced the "pull" of the load, unless it went to pieces before that speed was reached and unless the torque of the load exceeded the torque of the motor with series field excitation alone; in the latter case, which is an improbable one, the speed would decrease until the motor torque balanced the load torque.

Candle Power of an Incandescent Lamp

Can the candlepower of an incandescent lamp be calculated from the watts it takes?

L. B. S.

Not unless you know the "characteristic" of the lamp filament; that is, the relation between watts per candlepower, volts and amperes at different voltages, which is a very uncertain one. A carbon lamp taking 3.1 watts per candle at rated voltage will take 4.7 watts per candle and only 80 per cent. of the total normal watts at 90 per cent. of the rated voltage. The candlepower at this voltage, therefore, would be

$$\frac{3.1 \times 0.8}{4.7} = 0.53$$

(53 per cent.) of the rated candlepower.

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Contents

The Poetry of the Fireroom

In "Heat a Mode of Motion," Tyndall calls up a picture of the regeneration in a hot box of the radiant energy of an ancient sunshine and of the failure of the man who is trying to cool it off to grasp the real significance of the homely phenomenon.

How many men who are shoveling coal into a furnace realize that they are burning the verdure of a by-gone age compacted by centuries of storage and pressure into the mineral form of coal?

How many realize that in the process of combustion going on under their charge the carbon separated from its oxygen by the subtle action of the sunlight and built into the structure of a forgotten forest is satisfying its long deprived affinity for oxygen; that it is the velocity acquired by these minute bodies rushing together under the force of their mutual attraction and acquiring velocity as does a body falling to the earth impelled by the force which it and the earth exert upon each other, which they see and feel and recognize as heat? That the velocity acquired by the molecules of the gas is communicated to the molecules of steel which compose the heating surfaces and, imparted from one to another of these, is communicated to the molecules of the water until the velocity acquired by them causes them to fly off like the stone from a sling shot and by their impact produce the pressure which moves the engine piston and drives the mill?

To the man who has read Faraday's "Chemistry of a Candle," to whom a coal pile is not a heap of grimy stuff to be shoveled but a heritage from the ages, full of the energy from that source of all terrestrial power, so full that the energy in it would project it to the height of between two and three miles, who understands the processes of combustion and is interested in carrying them to perfection, the life in a boiler room rises far above the menial and becomes full of meaning and of interest.

The engine room, with its finely designed and highly finished machinery, with its indicator and valve setting and air of applied science, has too long been the center of interest and of effort for the engineer. There is infinitely more chance for applied science in the boiler room. A careless fireman, an illy proportioned furnace, can waste more coal than the most elaborate engine can save. There is more chance for the application of highly specialized knowledge and training in the design and setting of boilers, in the selection and burning of coal, in the treatment and heating of the feed water, than there is in all the processes over which the man in the engine room has any control. Chemistry, physics, mechanics and accounting all have here the wider field and the better opportunity, and managers and owners are commencing to recognize this and to place in responsible charge of boiler-room operations not mere laborers, as has been too often the case, but men who are qualified by education and training to direct the burning of the hundreds of dollars' worth of coal which is used there daily. It is dirty work but it earns clean money and is full of training and opportunity. In a large station near New York, provision is being made for running the boiler room from a bridge or gallery where the trained attendant will have at hand the readings of pressure gages, water meters, CO recorders, flue-gas thermometers, feed-water temperatures and everything that bears upon the continuous and economical operation of the boiler plant, with a laboratory for coal, ash and feed-water analyses and the verification of the CO_2 recording apparatus close at hand.

Only recently the head fireman of a large textile mill was transferred to a new and larger mill of the same company as engineer-in-charge of the entire power plant.

The day may not be so far off when to be the head fireman of a large boiler plant will come to be "some pumpkins."

Mr. Parsons Approves the Initial Velocity Stage

We have several times called attention to the present tendency on the part of steam-turbine manufacturers to use a compounded velocity stage for the initial expansion. The very considerable fall in pressure and temperature before the steam enters the casing relieves the pressure upon the stuffing box and avoids excessive temperature changes, while in turbines of the Parsons or reaction type it avoids the multiplicity of short blades used for the stages which it replaces. It is gratifying to notice that Mr. Parsons himself has placed the seal of his approval upon the practice. In a lecture delivered recently at the Royal Institution, Mr. Parsons said that in the smaller class of land turbines, the high-pressure end of the reaction turbine has always been less satisfactory than the lower-pressure section. On account of the low blade speeds the number of rows required had been large, which had added to the length of the shaft, reducing its stiffness and increasing the allowable clearance. He did not, however, approve of the use of two or more of these velocity compounded stages before passing the steam to the reaction blading.

Advantages of Safety Appliances

Simplicity of design in power-plant equipment is undoubtedly wise engineering practice. Complicated machinery will, of course, give more trouble than that of simple design, and, likewise, the more machines or devices put in a plant the more chances there are for trouble to arise.

Many engineers put in no more apparatus than is absolutely necessary to operate the plant in an economical manner. In fact, some plants are so simple in equipment that they are nothing more than a small country isolated plant enlarged. Ordinary boilers, hand-fired furnaces, water columns and gage glasses, steam gages and safety valves, the necessary appliances for safety, and Corliss engines with the necessary pipes and fittings comprise the outfit.

An engineer can look over such a plant and congratulate himself on the design, on the absence of a hundred and one so called "frills" and especially so if he can operate more efficiently than other steam plants which contain more elaborate equipment.

There are, however, various apparatus that could well be installed, and, although they might not be called upon to perform their function for years, perhaps never, their presence gives a sense of security and if occasion does arise their worth in preventing a serious accident will prove a paying investment.

An engineer may debate as to the advisability of equipping his engines with a speed-limit safety device, and finally decide that one is not necessary. But a few months after the plant has been started up the governor gear becomes deranged, a flywheel goes to pieces and beside doing a lot of damage to the plant, kills the engineer on watch. Under such a circumstance the safety stop would have been a mighty good investment.

While this incident is cited as an example of what might happen it is at the same time a good illustration of what has happened.

Another engineer designs a steam plant along sound engineering lines. To him the matter of a nonreturn valve in the main steam line comes up. The matter is thought over and the decision arrived at is that the services of the valve would not be required once during the life of the plant. The decision is not a rash one; hundreds of steam plants have operated for years without such a valve, and were none the worse off. Nothing ever gave way, and the valve would have only been an additional first cost.

But, on the other hand, suppose that a nonreturn valve had been put in the line, and a steam pipe had burst or a valve or a blank flange fractured from water hammer or some other cause, the valve in the main steam line would stop the flow of steam and it is evident that the damage from escaping steam would be insignificant as compared to what would be done if the boilers emptied themselves, or valuable minutes were used in closing stop valves over the boilers by hand.

Using precaution is a good thing, and if one is to ere in the matter of safety devices it is better to ere on the side of safety.

A Friendly Suggestion

It would probably surprise most of our readers to know how many letters of inquiry concerning engineering matters we answer by mail each week. Nothing gives us more pleasure than to help a reader over a rough spot, however, and we do not begrudge the huge volume of correspondence involved; but we wish to offer one suggestion to any and all who may desire information: Before asking us for it, see if you cannot find it in some back number of the paper; if you can, you will not need to ask us for it. If you are unable to find in your back numbers what you want to know, write and we will gladly answer your letter—this is not a kick, merely a suggestion inspired by the fact that within two weeks we have answered by mail nine requests for information that had been printed in POWER within a year—some of it within a month.

Getting the Full Benefit

It is the common experience of most readers of engineering papers that upon looking through an old number of a paper one is likely to find an article that is of much interest and value and that the reader does not remember having seen at the time when that number of the paper was received. This experience proves conclusively that the man who has it is not getting the full benefit of the fund of material presented by his periodicals.

The remedy is simple: A card index. If every reader of POWER, for example, would preserve his copies and keep a card index of all subjects discussed in them—not merely those subjects which interest him at the moment of publication—he would have a "ready-reference" library in a few years that would be astonishing.

There is another method of making published information readily available; that is the scrap-book method. It entails the disadvantages, however, of not being able to classify an article under more than one head and of having to get an extra copy of almost every issue of the paper in order to paste clippings from both sides of a leaf. The card index is simpler, takes less time and is more general in scope and flexible in application.

The Fusibility of Ash

A great deal of emphasis has lately been placed by E. G. Bailey, M. E., of Boston, on the fusibility of ash. A coal having but a small percentage of ash the fusing point of which is below that obtaining in the lower strata of the fire will be a very troublesome and uneconomical fuel, for the ash will melt and run together, forming a plaster clinker which flows over the grates, shutting off the air supply, requiring the constant working of the fire, reducing the efficiency of the furnace by lack of continuity of operation and by restricting the supply of oxygen and involving a large percentage of carbon in the ashpit waste. On the other hand, a coal comparatively high in ash will work quite satisfactorily and reach its limit much less quickly if the nature of its ash is such that it will not melt at the ordinary furnace temperatures. Although the weight of ash produced in a given time is greater it remains in the form of powder and can easily be gotten rid of with a few passes of the fire tools or a movement or two of the grate. Mr. Bailey is able by determining the fusibility of its ash to estimate the real fuel value of a sample of coal and to predict its behavior much closer than by any analysis or determination of heat content.

Have you noticed that some managers will listen to a mud carrier? In the end they generally find that the mud soon turns to dust and blows away.

Conservation of water power means its use. Every drop that flows to the sea is just that much power lost forever.

Have you noticed that some men are always so busy that it is a wonder they can find time to sleep and eat?

Investors in water-power developments want to know what the Government will do with their property at the end of a limited franchise.

A man may have knowledge, but lacking energy will not amount to anything.

An engineer cannot get experience for nothing; it must be paid for.

Refrigeration Department

Principles and operation of ice making and refrigerating plant and machinery

With this issue we start a refrigerating department. Hitherto, we have published miscellaneous articles at odd intervals, but have decided that the subject is of enough importance to our readers to give it a definite location in the paper. From now on this department will appear every second issue. Contributions on the practical operation of refrigerating machinery and apparatus are especially solicited, and will be received as a token of the interest taken in the department.

The Specific Heat of Calcium Chloride Brine

By H. G. Fairview

The true specific heat of brine is often of great value in determining the performance of refrigerating machinery. It is a well known fact that the specific heat of water is not constant but varies with the temperature; and the use of steam tables, in which this variation is taken into account, for finding the "heat of the liquid" at any temperature is familiar to all engineers. The steam tables are calculated for pure water, the specific gravity of which is unity.

If a salt, such as calcium chloride, is added to the water the solution is known as brine, the specific heat of which varies not only with the temperature but also with the density; the denser the solution the less the specific heat. A dense solution is one containing a large amount of salt, that is, one having a high specific gravity. This variation with two quantities makes the task of preparing a comprehensive table of specific heats more complex because of the large number of brine densities that are in common use. So far as the writer knows there was not until quite recently any effort made to prepare such a table.

While doing some experimental work with a refrigerating plant a little more than a year since, it was necessary to know the specific heat of the brine accurately in order to make a heat balance for the system. A careful search failed to reveal anything more extensive than the well known tables of Landolt and Börnstein, giving the specific heat of various brine solutions at from 30 to 64 degrees Fahrenheit, but without any statement as to the variation with the temperature. All other available tables gave the specific heat at about the same temperature, and moreover the values did not show good agreement besides being for temperatures much above that of the test.

The only apparatus available at the time for finding the specific heat was a Parr coal calorimeter. The determinations were made with this, using standard benzoic acid of known heating value as the source of heat. At that time plans were made to go into the work more fully, and to use Dewar flasks instead of the calorimeter in order to reduce the radiation loss, and an electric heating coil instead of the benzoic acid. The Dewar flasks were purchased, but before the work was begun the Bureau of Standards published a bulletin on "The Specific Heat of Some Calcium Chloride Solutions Between − 35 degrees Centigrade and + 20 degrees Centigrade," giving the desired information in detail. The work was very carefully done by an electrical method, with all possible refinements, and the values may be taken as correct.

The results are presented both in tabular and graphical form for the various solutions. And further to make the results apply to all possible densities the authors have deduced the following empirical formula which represents their results to within 0.1 per cent.

$$D = 2.8821 - 3.0272\,S + 1.7794\,S^2$$

D = Density at 20 degrees Centigrade or 68 degrees Fahrenheit;

S = Specific heat at 0 degrees Centigrade or 32 degrees Fahrenheit.

For each degree Centigrade change in temperature the specific heat changes by an amount varying from 0.0006 to 0.0009, the usual value being between 0.0006 and 0.0007. In all cases the specific heat decreases with the temperature; the correction value 0.0009 applies only to brine of density 1.200 at temperatures below − 10 degrees Centigrade.

It is interesting to compare the results given by this equation with that obtained with the Parr calorimeter. The mean of two calorimeter determinations for brine of density 1.244 gave the value of the specific heat as 0.6944. Applying the formula to the same solution and solving:

Sp. Ht. at 0° C. = 0.7068

Making the proper temperature correction to change to 0 degrees Fahrenheit,

Sp. Ht. at − 17.7° C. = 0.6949

The difference between the two results is 0.0005, a percentage difference of 0.07 per cent. This is a remarkable agreement when one considers the practical difficulties of making such determinations at low temperatures. The equation gives equally as good results at higher temperatures. From Landolt and Börnstein's tables for a density of 1.231 at 60 degrees Fahrenheit, the specific heat is 0.700. Using the above equation the result is

Sp. Ht. at 0° C. = 0.6850

Applying the temperature correction,

Sp. Ht. at 60° F. = 0.6968

It is well at this point to call attention to the fact that the Bureau of Standards' values are slightly lower than Landolt and Börnstein's and differ considerably from some commercial tables.

The above formula was deduced for chemically pure calcium chloride solutions, but the experimenters found that the specific heats of various commercial solutions differed from that of the chemically pure by less than 0.3 per cent, being in some cases higher and in others lower; so that for practical purposes the formula may be safely used, and may be expected to give more reliable results than a direct determination because of the difficulty of making the latter at low temperatures. The formula is convenient, as it needs to be solved only once for each density.

In applying the formula the following points should be kept in mind:

First: Determine the density at or near 20 degrees Centigrade (68 degrees Fahrenheit).

Second: The equation gives the specific heat at 0 degrees Centigrade (32 degrees Fahrenheit).

Third: That this result must be reduced to the desired temperature conditions as before noted.

The importance of determining the density at the proper temperature is shown by the following table, showing the variation of density with the temperature:

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Problem in Refrigeration

By F. E. Matthews

How much refrigeration will be produced by the circulation of 50,000 *cubic feet of brine per month, the average temperature going out being* 28 *degrees Fahrenheit and that of the return* 32 *degrees?*

The amount of cooling that a given quantity of brine will do depends not only upon the number of degrees rise in temperature, but upon the density and kind of brine. As the problem does not state whether the brine used is calcium or salt or what its density is, it may be well to show how the problem is solved in the general case and illustrate by taking a single example based on assumed conditions.

The most important element in the selection of the kind of brine to use is the temperature to be produced, which fixes the temperatures at which the brine must be circulated. Saturated salt brine, by which is meant brine so strong that it will dissolve no more salt, freezes at about 5 degrees Fahrenheit below zero and would be safe for brine-tank temperatures above zero. Salt brine of lower densities freezes at correspondingly higher temperatures, the limit being reached when the amount of salt is reduced to nothing in which case the brine becomes water and freezes at 32 degrees Fahrenheit.

Saturated calcium brine freezes at about 55 degrees Fahrenheit below zero and according to its densities is adapted to brine temperatures from 40 degrees below zero up. The specific heat of either salt or calcium brine upon which depend their refrigerating capacities per pound per degree rise in temperature, decreases as the strength increases.

The refrigerating capacity of water per pound per degree rise in temperature is one British thermal unit. As salt or calcium chloride is added to the water this value decreases until its value at saturation (maximum strength) is only 0.77 B.t.u. In the latter case, about 30 per cent. more brine must be circulated, to accomplish a given amount of cooling for a given rise in brine temperature, than would be necessary were the desired temperatures sufficiently high to allow water to be employed as a medium for conveying heat, instead of brine. Tables showing the properties of salt brine and calcium brine are published in almost every handbook on mechanical refrigeration as well as in many ice-machine catalogs.

The unit by which cooling effects are measured is the ton of refrigeration. This is equal to the amount of cooling produced by the melting of one ton (2000 pounds) of ice having a latent heat of fusion of 144 B.t.u. per pound. Cooling at the rate of one ton per day would amount to the extraction at a uniform rate of

$$2000 \times 144 = 288{,}000 \ B.t.u.$$

per 24 hours;

$$288{,}000 \div 24 = 120{,}000 \ B.t.u.$$

per hour or

$$288{,}000 \div (24 \times 60) = 200 \ B.t.u.$$

per minute.

The amount of refrigeration, expressed in tons T per 24 hours, produced by a rise in temperature from t_1 to t_2 of a certain number of pounds p of brine circulated per minute and having a specific heat s, would be,

$$T = \frac{S\,(t_1 - t_2) \times p}{200} \qquad (1)$$

If p represents the number of pounds of brine circulated per hour, or per 24 hours, the expression would be the same except the constant 200 would be replaced by 12,000 and 288,000 respectively.

The circulation of 50,000 cubic feet of brine per month is equivalent to

$$\frac{50{,}000}{30 \times 24 \times 60} = 1.157 \ cubic\ feet$$

per minute. Assuming that it has the specific gravity commonly employed of 1.2, its weight per cubic foot will be

$$62.5 \times 1.2 = 75 \ pounds$$

or

$$75 \times 1.157 = 86.775 \ pounds$$

will be the amount circulated per minute under the given conditions. The rise in temperature as given in the original problem was from 28 to 32 degrees Fahrenheit and the specific heat of brine having a specific gravity of 1.2 is 0.7. Substituting these values in formula (1)

$$T = \frac{0.7\,(32 - 28) \times 86.775}{200} =$$

$$\frac{242.97}{200} = 1.2148 \ tons$$

A rough rule for calculating the number of tons of cooling effect produced by brine is to allow 25 heat gallons per minute per ton. Apply this rule to the foregoing case as follows: Since 1 cubic foot equals 7.48 gallons, 1.157 cubic feet equals 8.654 gallons and the rise in temperature is 4 degrees Fahrenheit. Hence,

$$8.654 \times 4 = 34.617 \ heat\ gallons$$

which is equivalent to

$$\frac{34.617}{25} = 1.38 \ tons$$

an amount somewhat larger than that given by the regular formula.

The percentage of saturation or the specific gravity having been determined, a table, giving the properties of the kind of brine employed, may be referred to and the specfic heat, corresponding to that density, found. Also the weight of the brine per gallon may be found and from this may be calculated the weight of brine circulated per minute. These quantities should then be substituted in formula (1) and the result will be the required cooling effect expressed in tons per 24 hours.

This approximate rule is intended to apply roughly to brines of the higher densities and, since it does not take into consideration possible variations in the value of the specific heat of the brine, it cannot be expected to apply accurately to brines of all densities. For example, according to formula (1) the amount of refrigeration produced by the circulation of 200 pounds of water per minute with a rise in temperature of one degree Fahrenheit would be

$$T = \frac{1 \times 200 \times 1}{200} = 1 \ ton$$

According to the rule, which ignores the specific heat of water, which is unity, the cooling effect would be, since 200 pounds of water is equivalent to 24 gallons,

$$\frac{24}{25} = 0.96 \ ton$$

For accurate determinations of the cooling effect the density of the brine should be determined by either a salonometer or some other form of hydrometer that will allow either the percentage of saturation or the specific gravity of the brine to be determined. In taking such hydrometer readings care should be taken to bring the temperature of the brine to that at which the instrument is calibrated. This method is less likely to lead to error than that of applying a correction factor for reducing the readings taken at other temperatures to what they would be if taken at the standard temperature.

Device for Charging an Absorption Ice Machine

By T. H. De Saussaure

It is often difficult to make a pump take suction from a drum of aqua ammonia when it is desired to add to the charge of an absorption ice machine while it is in operation. This is particularly true when the ammonia in the drum is warm, as the gas given off destroys the vacuum in the suction pipe, and the pump will not lift the ammonia.

Having a machine which required constant additions to the charge, I devised the following arrangement, which makes the operation a very simple and sure one.

I first built a substantial table large enough and strong enough to sustain the weight of a drum of ammonia, and placed upon the top of this table four friction rollers, as shown in Fig. 1. The rollers are each made of oak, 8 inches in diameter, and have a piece of 1-inch round iron through the center for the axle. When mounted on these rollers the drum is on a higher level than the pump, and can be easily rolled over until the bung is on the under side.

I then took a piece of 3½-inch wrought-iron shafting, 4 inches long, and turned and threaded it so that it could be screwed into the bung hole of the drum. Through this plug I made an opening for a suction pipe and another for an air pipe, Fig. 2. The air pipe is made of ⅛-inch wrought-iron pipe and is of such length that it will reach to within 1 inch of the side of the drum diametrically opposite the bung plug when the latter is screwed to a joint in the bung. Both the suction-pipe connection and that of the air pipe have valves on them, placed near the plug.

When it is necessary to add to the charge of ammonia in the machine the fresh drum is placed on the table and the new plug, with both air and suction

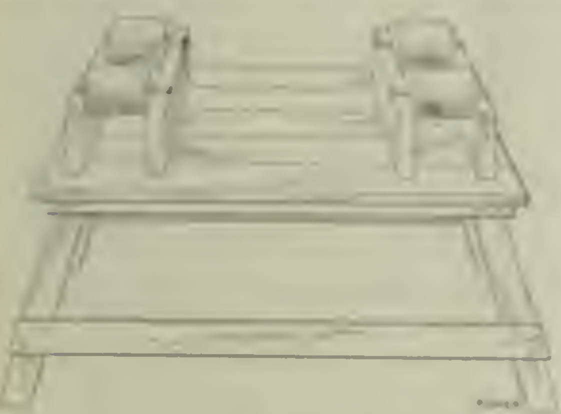


FIG. 1. BENCH FOR HOLDING AMMONIA DRUM

valves shut, is used in place of the one usually sent. The drum is then turned on the friction rollers until the bung is on the bottom. Connection is then made between the suction opening on the bung plug and that of the ammonia-circulating pump, and between the air pipe on the bung plug and the discharge opening of an ordinary plumbers' force pump. About five pounds of air pressure is pumped into the drum with the force pump; then the valve on the suction pipe is opened and the pump takes suction immediately.

FIG. 2. ARRANGEMENT OF PIPING TO PUMP

I have never had it fail in several years' use. It is necessary to keep a slight pressure in the drum so that the air may take the place of the ammonia pumped out.

The objection might be raised that there is danger of getting a quantity of air into the machine after the ammonia is all pumped from the drum; but if the ear is held against the head of the drum while the pumping is being done, one can detect the instant when the last drop of liquid is pumped out and the suction valve can be shut immediately.

The device has this advantage also—one can get the last drop of ammonia out of the drum and into the machine without any waste at all.

LETTERS

Fitting a Gasket on Compressor

Gaskets for the head of the ammonia cylinder of a vertical ice machine often cause trouble when not put on properly. The gasket frequently blows out into the water jacket or into the cylinder, specially where a pressure of 160 to 180 pounds or perhaps higher is carried. In nine out of ten cases the gasket gives out on the discharge side.

When a gasket is put on as illustrated, it will hold if the surfaces of the cylinder flange and the head are smooth. The old gasket should be scraped off on both surfaces, and to remove the grease use a clean cotton or linen rag (no waste) moistened with coal oil. Then take another clean rag and wipe off the coal oil.

The best rubber available should be used and it should not be thicker than

GASKET FOR AMMONIA CYLINDER

1/10 inch. The gasket should be cut accurately and the holes must fit snugly over the studs. The edges of the gasket where it is cut out for the suction and discharge should lap a little over the openings. No graphite or oil should be used on the gasket or metal surfaces, so that the gasket will not slip when tightened. It is very important to see that the nuts are tightened evenly. They should be tightened up with the fingers first and then with the wrench, starting with one nut and then following up on the nut diametrically opposite. It is a good plan for two men to do the tightening on the first six nuts. Then one wrench should be used by the two men to complete the job, starting on one nut and going all the way around.

Once I had a machine on which no gasket would hold tight. It was always blown out into the cylinder, no matter how carefully it was put on. A small groove was cut around the discharge opening, as indicated in the drawing, which proved to be a success. If a gasket blows out into the cylinder the defect may be detected by a sharp blowing noise, a hot suction pipe and an unusually high back pressure.

When the head of an ammonia cylinder, where no graphite was used, has to be taken off and a chain fall will not do the trick, loosen the nut at the crosshead and screw the rod out about three or four turns; then turn the engine over by means of the starting bar and the head will be forced off.

WILLIAM L. KEIL.

Philadelphia, Penn.

Connecting Ammonia Compressor

In answer to H. S. Free in the March 21 issue, I would advise the following:

In the first place, he does not state the combined capacity of both condensers, which would assist in explaining what is best to do.

First of all, a 2-inch pipe for a discharge on a 50-ton machine is too small; it should be at least 3 inches. The 25-ton machine should have a 2½-inch discharge pipe. The total area of these two pipes would be over 12 square inches, so it is plain that all the gas from the two compressors cannot pass through the one 2-inch three-way valve. It is ridiculous to attempt such a thing. It would be advisable to connect both condensers with a bypass so that either or both combined could be used for either compressor. But by all means increase the size of the discharge pipe from each compressor to the condenser and make a 2½-inch bypass at a convenient place, with as few elbows as possible. The three-way valve would do in the bypass if your employer will not allow the expense of a larger one.

WILLIAM NOTTBERG.

Kansas City, Mo.

A recent issue of the *Brass World* contained a simple method for removing rust from surfaces that were afterward to be electroplated, but the method might be applied equally well to other rusty surfaces. It consists in dipping the articles first into a strong, hot potash bath for about half an hour, and then immersing in a cold muriatic-acid pickling solution, composed of two parts of water to one of acid. This removed the rust in a few minutes, leaving the metal apparently attacked but very little. The previous soaking in the strong, hot potash solution is responsible for this rapid pickling, as it was proved that without the previous dipping 40 minutes were required by the acid bath, against four minutes when previously treated in the potash bath. Apparently a chemical reaction is set up, changing the character of the rust, softening it and making it readily soluble. The appearance of the rust as it comes from the potash bath is swollen or fine.

Handling Coal in a Modern Boiler Room

Probably no two boiler rooms in modern buildings present quite the same problems for solution. Conditions of location, space and requirements are such widely varying factors that the engineer is constantly called upon to devise new methods of adapting modern devices to suit his precise needs and yield the highest efficiency.

An ideal system would enable the coal to be dropped into the bunkers direct from the car or lighter, and fed to the grates without rehandling. This is manifestly impossible in any modern city building—or indeed in any but a few boiler rooms enjoying an exceptionally favorable situation.

An interesting solution of a-coal-handling problem is found in the new Fifth Avenue building at the corner of Twenty-third street and Broadway in New York City.

Fig. 2. Hoist Picking Up Ash Can

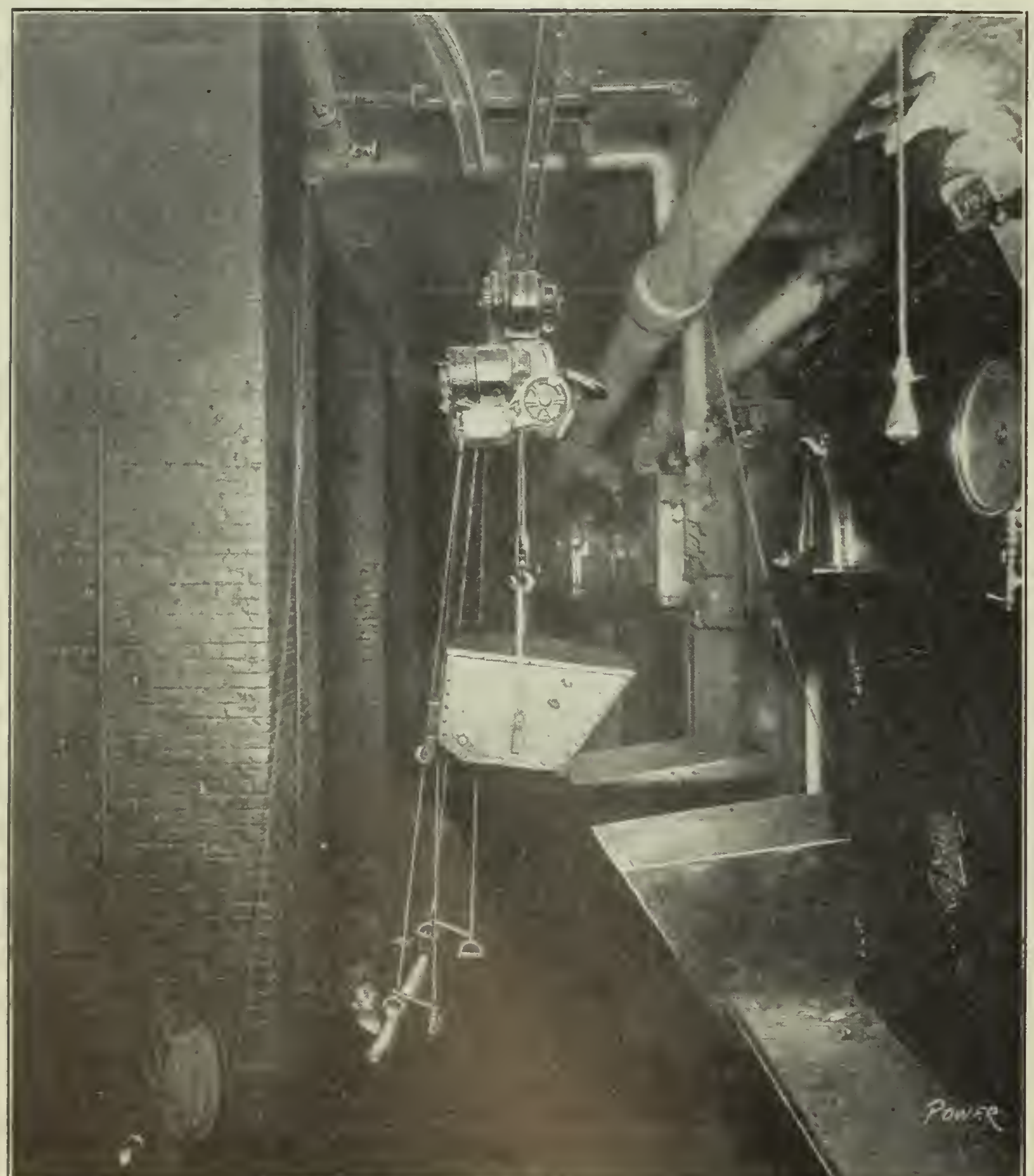


Fig. 1. Yale & Towne Hoist and 600-pound Coal Bucket

The boiler room is located three stories below the street level and the coal supply is carried in bunkers, which are as favorably located in relation to the boiler room as the general conditions will permit.

There are 2000 horsepower of Heine boilers, equipped with automatic stokers. The transfer of the coal from the bunkers to the hoppers of the stokers is effected in this instance in iron buckets holding about 600 pounds. These buckets are hung from the hook of a Yale & Towne electric hoist, which in its turn is built into a trolley running on an overhead track leading from the bunkers to the hoppers of the various stokers.

In operation, the buckets are lowered to a point opposite the mouth of the bunker chute to permit the coal to flow into them by gravity from the bunkers. A pull on the switch then starts the electric hoist and the bucket is lifted high enough to enable it to start on its journey to the hoppers of the stokers.

This journey, accomplished by means of a smaller motor (attached to the trolley) which is geared to and drives the trolley wheels, is made in a few seconds, and the coal is then dumped into the hoppers of the stokers.

A switch in the overhead track enables the hoist to be run to a point where it can pick up the ash cans.

The whole electrical installation is under the control of the operator. The hoist will raise or lower the bucket by fractions of an inch, if necessary, and the load is automatically held at all times. The control of the trolley motor is also quite as complete, and the load may be advanced or withdrawn at will.

The hoisting problem in this case is not in itself particularly difficult, but the conditions under which the hoist operates are severe. The temperature at the top of the boiler room probably averages 135 degrees and a considerable amount of dust and fine particles of coal is naturally present. Up to the present writing the hoist has continued to perform its work satisfactorily, and no diminution in efficiency has been apparent.

It is reported that the New York, New Haven & Hartford railroad is equipping a number of its locomotives with oil burners. Oil has been used successfully and with considerable saving by a number of railroads in the Southwest, but the relatively high cost of this kind of fuel in the central Atlantic and New England States has been largely responsible for its limited use. Undoubtedly the locomotive, where, due to the excessive draft, a large percentage of the coal goes up the stack, furnishes an attractive field for the application of oil fuel.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

The Thomas Electric Gas Meter

Some time since Prof. Carl C. Thomas, now of Madison, Wis., made, at Schenectady and later at Sibley College, some experiments upon the specific heat of superheated steam, the results of which were given in a paper presented by him

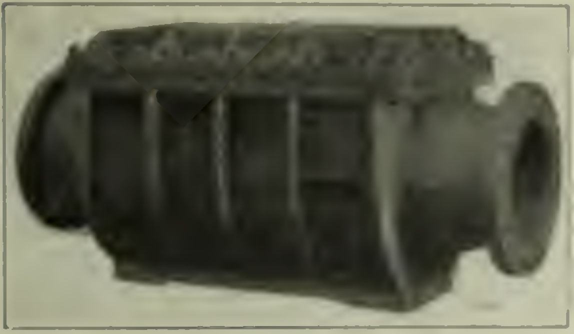


FIG. 1. CASING FOR THOMAS METER

to the American Society of Mechanical Engineers in 1907 and published in Volume XXIX of the *Transactions*. The method was to pass steam, known to be dry, through an electric heater, and to note the amount of current necessary to raise its temperature an observed amount. The weight of steam treated was determined by condensing and weighing it. Reducing the electrical energy to its equivalent in heat units, and knowing the weight of steam heated and the number of degrees its temperature was raised, it was a simple matter to compute the amount of heat necessary to raise one pound one degree on an average for the observed range.

Later Professor Thomas reversed the process and produced a meter for gases which was described in a paper presented by him to the Mechanical Engineers in 1909 and published in Volume XXXI of the *Transactions*. If the specific heat of a gas is known, the weight passing through the device can be determined by measuring the electricity necessary to heat it a given amount; that is, by ascertaining the increase in temperature produced by a known amount of energy. Reducing the measured current to its heat

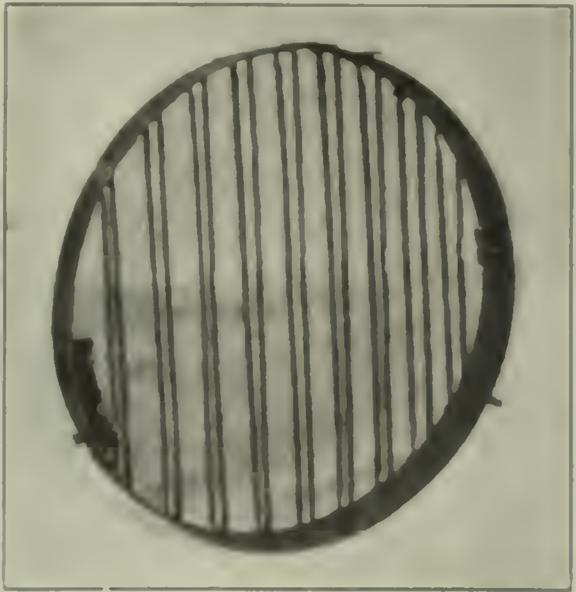


FIG. 3. SCREEN OF RESISTANCE WIRE FORMING THERMOMETER

equivalent gives the B.t.u. expended and knowing the number of B.t.u. necessary to raise one pound of the substance one degree the determination of the number of pounds necessary to absorb the observed amount of heat when heated through the observed range is a matter only of simple division. In the commercial form of the meter this process is automatically carried out in such a manner that the record, either indicating, graphically recording, or integrating, reads directly in "standard cubic feet" of gas per unit of time.

In the latest form of the meter a constant temperature rise of about two degrees Fahrenheit is preserved, and the regulating mechanism necessary to effect this as well as the perfection of recording mechanism brought it within the field of the Cutler-Hammer Manufacturing

FIG. 4. HEATER LOCATED IN METER CASING SHOWN IN FIG. 2

Company, of Milwaukee, which is putting it upon the market.

The meter proper, as they make it, is shown in perspective in Fig. 1 and diagrammatically in Fig. 2. A meter having a 10-inch outlet will take care of 750,000 cubic feet per hour.

The thermometer consists of a continuous length of very fine nickel wire, the electrical resistance of which varies considerably with its temperature. This is carried back and forth in parallel lines across a circular frame as shown in Fig. 3, and bound by silk threads crossing it at right angles. One of these thermometers is placed at the inlet and another at the outlet end of the meter. Between them is placed a heater, shown diagrammatically in Fig. 2 and in perspective in Fig. 4. This is simply a resistance coil wound upon a [illegible] frame so that all the gas passes over a heated wire. The thermometers form the two sides of a Wheatstone bridge and the current is regulated so as to maintain a constant temperature difference between them in the manner shown diagrammatically in Fig. 5. The controller is, in effect, a galvanometer and Wheatstone bridge combined. The movable member is caused to swing to the left or right

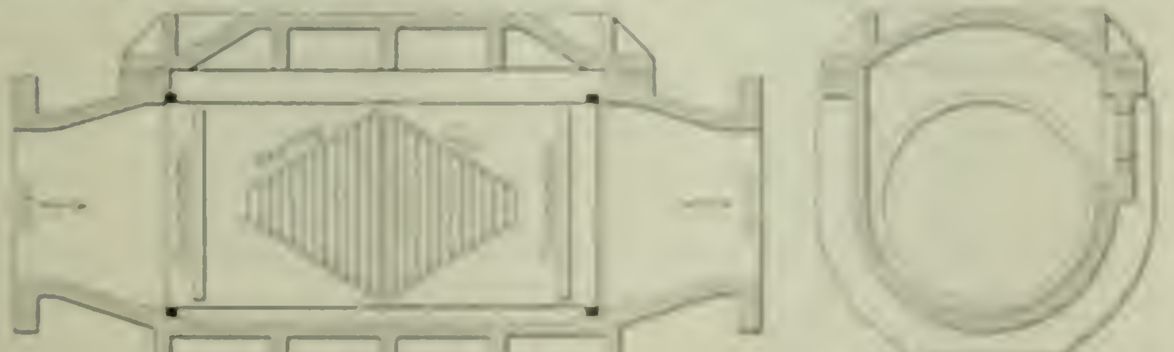
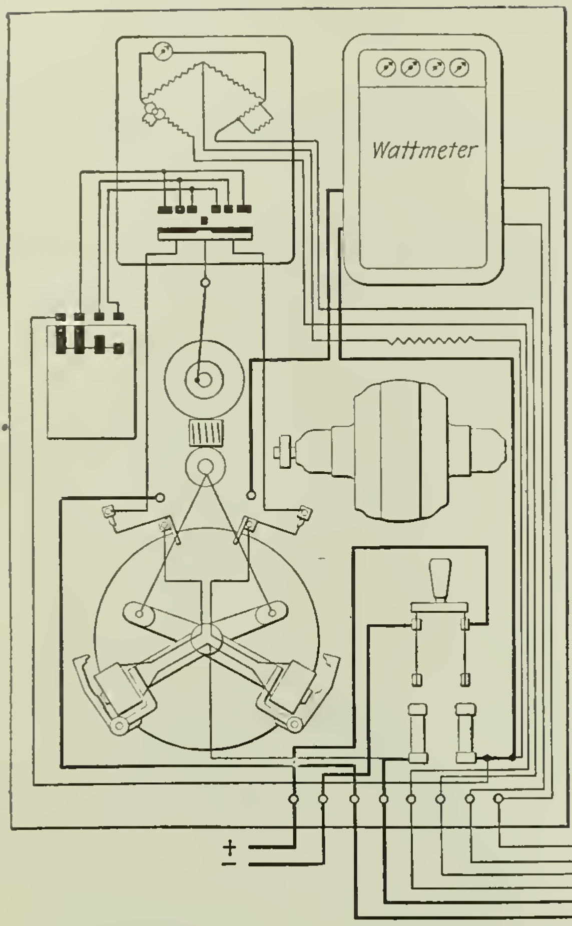


FIG. 2. SECTIONS OF METER CASING, SHOWING POSITIONS OF HEATER AND THERMOMETERS



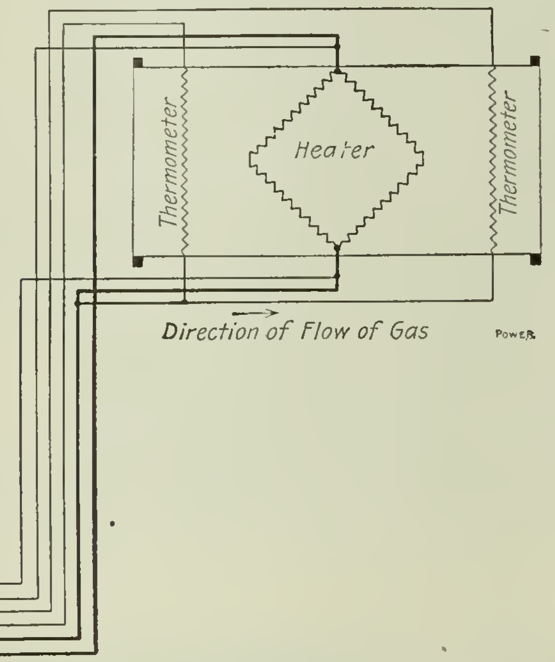


FIG. 5. DIAGRAM OF ELECTRICAL CONNECTIONS OF THOMAS METER

of a fixed position according as the difference in resistance of the thermometers is greater or less than that corresponding to the desired temperature difference of two degrees between the inlet and outlet of the meter. The motor (1/8 horsepower) operates continuously, and by means of a crank causes a bar to move up and down, clamping the needle at the top of the stroke. It also drives, at a slow but constant speed, a contact drum and two eccentrics which give the rheostat pawls a reciprocating motion through a small arc along the edge of a toothed wheel on the rheostat shaft. On the drum are three segments of different lengths corresponding to one, two and three teeth on the wheel. If the needle is clamped in position on the right of the zero position the solenoid on the pawl which will turn the rheostat in the direction to increase the heater energy is energized and holds the pawl up long enough to move the wheel one step and it will continue to do this until by successive strokes the rheostat has been turned enough to restore the desired temperature difference and thus balance the system. A very slight fall of temperature in the gas will cause it to do this. When the temperature difference is restored the needle returns to zero, makes no contact when it is clamped and the rheostat remains stationary. If the temperature difference increases above two degrees the needle swings to the left of the zero mark and the same process works to reduce the current. The wattmeter in the upper right-hand corner shows the energy which has been used to heat the gas, which is proportional to the amount flowing, so that the wattmeter may be made to read in any units. A graphical wattmeter may also be used to show the variation in gas flow. The appearance of the board carrying the regulating and recording mechanism is shown in Fig. 6. It need not necessarily be located near the meter but may be in the manager's office or at any convenient point.

When the physical condition of the substance measured does not change by reason of the heating, as by the drying out of moisture, and when the specific heat is known the meter would seem to promise a solution of the difficult problem of measuring gas and air in large quantities with considerable accuracy. When the material contains moisture it is suggested that a drier consisting of a steam coil be used just before the meter. With regard to measuring saturated steam the uncertainty of complete dryness and the serious effect of the absorption of heat in evaporation, may complicate its use as a steam meter, for which indeed, we do not know that it is intended. Superheated steam can, however, be successfully measured by a meter of the kind described. For a stable substance like natural gas with a practically constant specific heat it has been doing excellent work for some time. For artificial gas and other products occasional analyses will enable the specific heat to be determined with sufficient accuracy for commercial purposes.

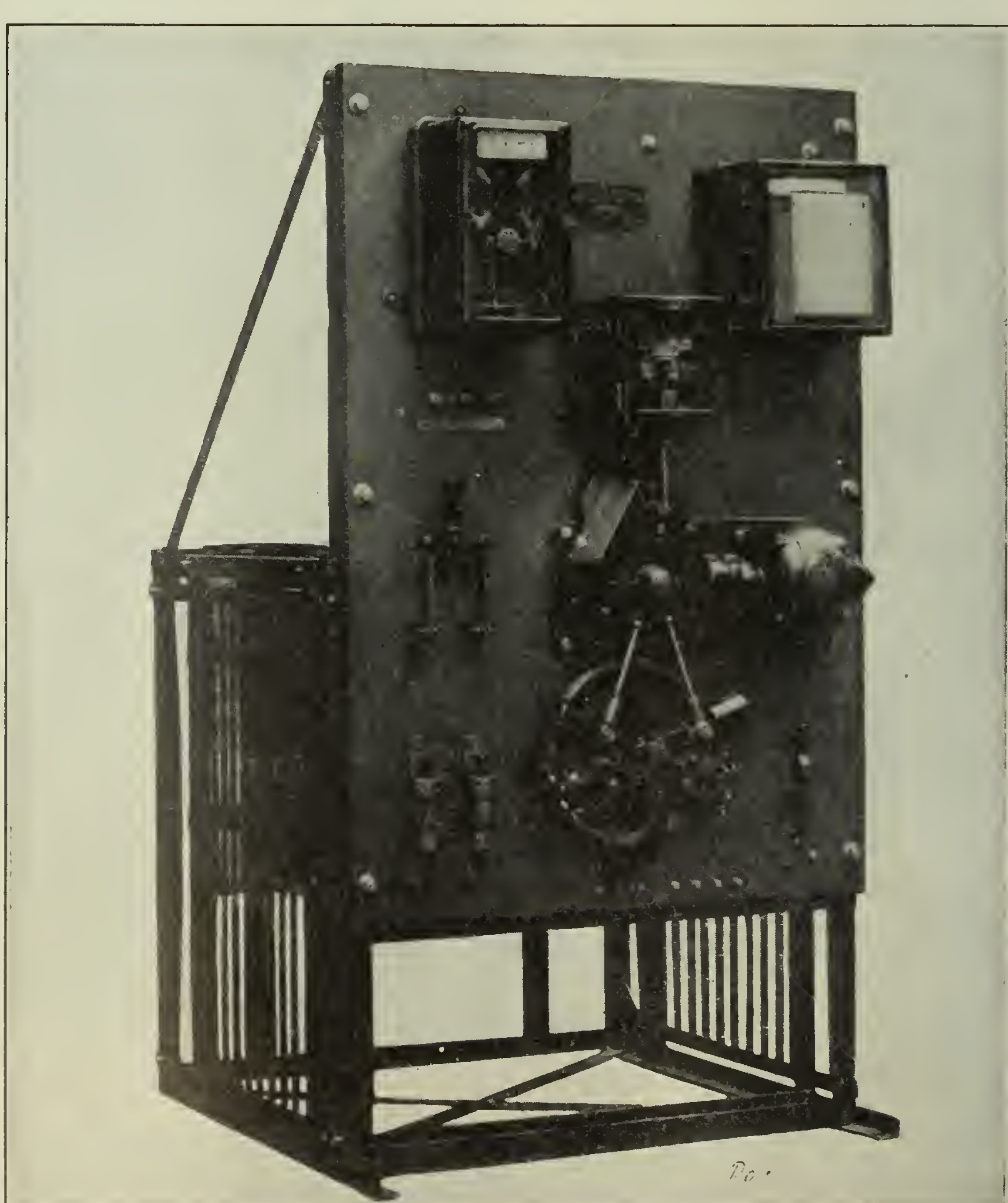


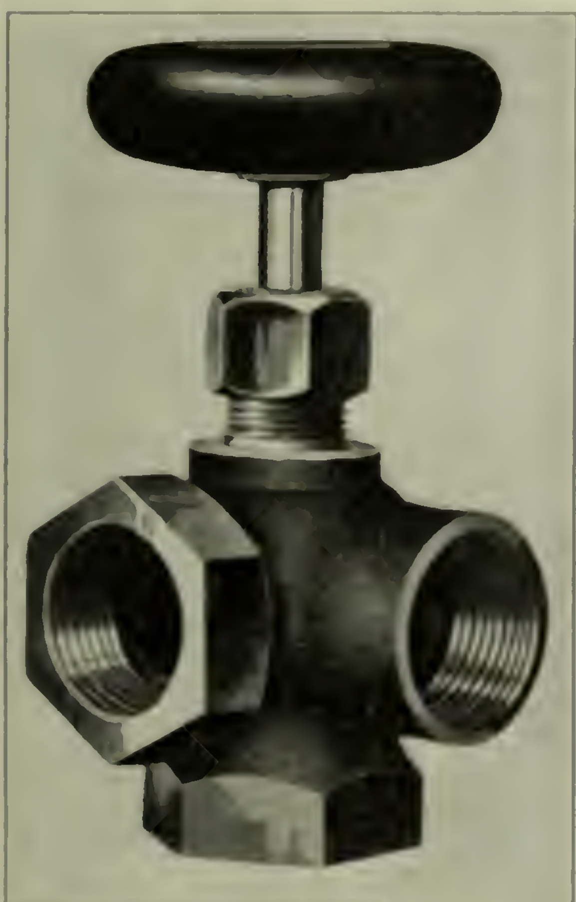
FIG. 6. SWITCHBOARD AND RECORDING INSTRUMENTS FOR THOMAS METER

Detroit Three Way Valve

The accompanying illustration shows the Detroit quick-opening three-way valve, which is used on water-cooled gas and gasolene engines to turn the necessary amount of water into the water-cooled muffler or exhaust, after it has passed through the water jacket on the cylinder, and has turned the rest of the water to waste.

This valve permits any quantity of water to be diverted into the muffler by a slight turn of the indexed valve handle. All the rest of the water goes to waste without any further regulation.

The valve consists of a globular body with three openings, one at the base through which the water enters and two



Detroit Three-way Valve

at the sides, at right angles to each other. The shell is so arranged that all of the water coming up through the opening in the base can be turned through either one of the side openings or it can be graduated to divert any required volume of water through either of the openings and turn the rest through the other hole. The handle is indexed and shows what proportion of water is wasted.

The valve is manufactured by the Detroit Lubricator Company, Trumbull avenue, Detroit, Mich.

The blowing off of a cylinder head at the works of the Hope Webbing Company at Pawtucket, R. I., on the afternoon of April 15, caused two men to be painfully, if not seriously, scalded. The peculiar feature about the accident is that the steam was shut off at the time.

Fatal Tube Blowout in Winsted, Conn.

By George L. Strait

A fatal accident occurred at the woodworking plant of J. H. Rowe in Winsted, Conn., on Saturday, April 15. The owner, Mr. Rowe, sustained severe injuries and lived only a few hours. The cause of the accident was a defective tube. The boiler is of the locomotive type, having sixty 3-inch tubes, and is used for heating the shop and dry kiln, and carried from 40 to 50 pounds gage pressure. It has been in the Rowe plant for 18 years and was an old boiler when installed. Upon examination it was found that four tubes in the bottom row and two in the second row from the bottom were stopped with pine plugs which had been driven in with no rod running through the tubes to hold them in place. The stem on the handhole plate was badly corroded and looked as if it had not been taken out in years. The safety valve was of the ball and lever type, and an effort to raise it showed that it was stuck fast. I learned from an employee at the plant that the boiler had never been cleaned to his knowledge since being installed.

It is the writer's impression that there was from 6 to 8 inches of mud in the bottom as this could be seen from the place where the defective tube burst. The ends of all the tubes in the two bottom rows were corroded so that they could easily be broken off with a hammer. From all reports the boiler had never been inspected.

Mr. Rowe was fixing up the fire for the night when the accident occurred. The door in front of the boiler room was closed so that he could not escape that way on account of the steam and hot water; he finally got out through a window and his cries attracted a passerby who came to his assistance.

This is another case of negligence on the part of owners and operators of steam plants. The laws of Connecticut are very lax in this respect; there is no law requiring experienced men to be employed in caring for steam plants, although there is a bill before the present house of representatives which, if passed, will in a measure remedy this deficiency.

A 110-foot steel smokestack in course of construction at the factory of the Keyes Products Company at Mansville, Conn., collapsed on Saturday, April 15, as the third section was being raised into position. The tackling appears to have slipped in some manner, allowing a piece of steel weighing several tons to fall and crash through the roof of the mill building below. Fortunately no one was hurt although several workmen had narrow escapes.

SOCIETY NOTES

At the last meeting of the executive committee of the Institute of Operating Engineers, Hubert E. Collins was elected secretary in place of M. W. Rice, resigned. W. P. F. Hill was elected treasurer in place of Adam Harkness, whose term had expired.

J. B. Linbrey, secretary of the Practical Refrigerating Engineers Association, with headquarters in Shreveport, La., reports that the growth of the association since its organization last December has been phenomenal and has far exceeded the most sanguine expectations. The association is composed of white refrigerating engineers of good moral character, who have had one or more years' experience in operating ice and refrigerating plants.

Several important papers on "Patents" will be presented at the New York meeting of the American Society of Mechanical Engineers, 29 West Thirty-ninth street, on Tuesday, May 9. The subject will be discussed by E. W. Marshall, D. Howard Haywood, Edwin J. Prindle, all of New York. The purpose of this meeting is to outline to the engineer and manufacturer the fundamental principles of the patent law, the position and qualifications of a patent expert and the industrial development for the purpose of establishing a patent monopoly.

PERSONAL

Frank B. Davenport, who has been employed by the G. B. Markle Company in the mechanical department to design a new breaker at Hazleton, Penn., resigned recently to open a consulting engineer's office in Wilkes-Barre, Penn.

BOOKS RECEIVED

The Engineering Index Annual for 1910. The Engineering Magazine, New York. Cloth, 490 pages, 6 x 9½ inches. Price, $2.

Scientific Management and Railroads. By Louis D. Brandeis. The Engineering Magazine, New York. Cloth, 92 pages, 6 x 9½ inches; indexed. Price, $1.

Chemistry for Engineers. By Edward Hart. The Chemical Publishing Company, Easton, Penn. Cloth, 214 pages, 5x8 inches; 78 illustrations; indexed. Price, $3.

Practical Mathematics and Geometry for Technical Students. By Edward L. Bates. D. Van Nostrand Company, New York. Cloth, 348 pages, 6x7½ inches; 391 illustrations; tables; indexed. Price, $1.25.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

The other day the Chief Engineer of an electric light and power plant in Iowa wrote to the editor of POWER for some information on recording instruments.

"Would it pay," he asked, "to install a recording thermometer on the feed-water line, a recording pressure gage, a recording flue-temperature instrument, a CO_2 recorder, recording switchboard instruments, recording pressure gage on an exhaust-steam heating system, etc.? I am in favor of such instruments, but only want such as will warrant the investment and must be able to prove same to my company before they can be had.

"Would like to get opinions as to what instruments we need and don't need, and why."

To which the editor replied: "Whether the purchase and installation of the various recording instruments named in your letter will 'pay' depends entirely upon how much you wish to know about the conditions obtaining in your plant.

"Unless your plant is being operated under exceptionally good conditions, a CO_2 recorder will, if the records are intelligently read and appreciated, save its price in a very few weeks.

"The charts from recording instruments of all kinds make a daily history of the plant and are often used to show whether one set of men is doing as well as, or better, than another, and to excite a spirit of emulation which will put every man on his mettle to do as well as possible.

"In short, if you have any desire to keep your plant at or near the head of the list of uptodate plants, recording instruments are a necessity."

Here is the case of a man who didn't realize the value of reading and acting upon the ads in the paper.

If he had read them he wouldn't have needed to write the letter—he would have learned much more about recording instruments from the ads—and from the advertisers' own printed matter than our editor could tell him in a letter.

And this is a good example of just what we are trying to teach in our own weekly talks on this page.

There are many engineers who want who really need information on some kind of power-plant equipment or other, and it doesn't occur to them that they have a veritable encyclopedia of just that information coming to them every week in the Selling Section of POWER.

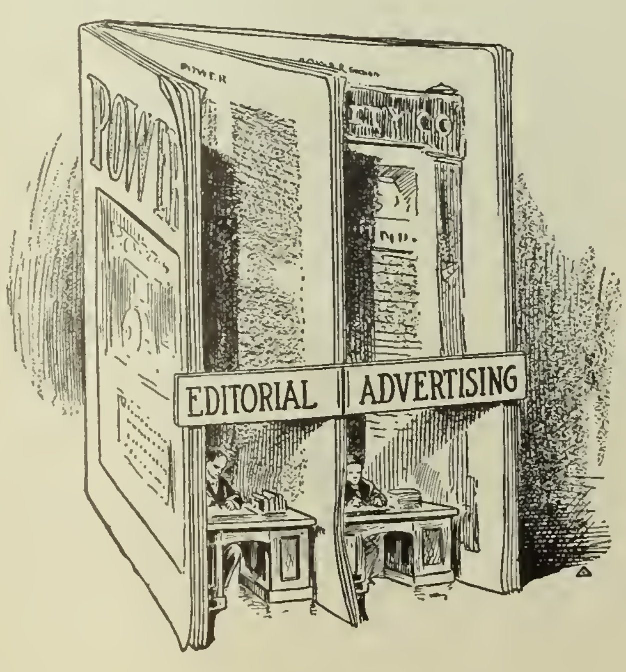
For of course the very best information possible on everything for the power plant is printed in the advertising pages.

The manufacturers rely on their ads to explain their products and all their features, advantages, savings, etc., to the readers—who are possible buyers.

What they cannot tell in the ads they put forth in booklets, catalogs and letters, which are sent to any reader on request.

Where else could you hope to get as complete details and information?

The engineer whose letter we have quoted is the right sort—he wants to know about any device that will help him get better results for his employers—he is worth every cent of his salary, for he's not content to stand still.



But—he will find that the grand parade of Progress doesn't stop with the reading pages of POWER. The reviewing stand is located in the advertising section and he—and all of you—want to book a seat in the front row where you can see all that's going on in the fast-moving march of the aforesaid procession.

The advertising pages are the heralds of Progress. Read them and heed them.

POWER

NEW YORK, MAY 9, 1911

AMBITION is, in all cases, the mainspring of the action which leads to success, and nothing worth while is ever accomplished without it.

There are instances of the peculiar fitness of some men for particular lines of work. The accomplishments of these men are often labeled the work of geniuses. But upon even superficial examination it is found that their achievements are the results of persistent effort.

Genius has been characterized by someone as nothing beyond a capacity for hard work.

In the everyday life of the engineer may be found almost numberless illustrations of this. Among the employees about the power plant of a large cotton mill in New England some years ago, there was an undersized and rather frail young man wheeling coal from the yard to the boiler room. Thinking little or nothing of the man except that to all appearances he was a misfit for the job, the chief engineer suggested that he try to get work in the weave shed as it was perhaps more suited to his physical strength.

Answering the suggestion the young man said: "I am well satisfied at present, although the work is near the limit of my strength, but I do not intend to be a coal passer all my life. I expect to be the chief engineer of this mill, or a bigger one, perhaps, so it will not hurt me to know how coal should be handled."

With the position of chief engineer as his goal the young man bent all of his energy to the task of fitting himself for it. Step by step he conquered each difficulty and when the chief who had advised the seeking of a lighter task resigned, this man with a definite aim in life was selected to take the place.

This is not an unusual story. It is only one from thousands which are never told.

Every change is rung upon the achievements of Watt, Corliss and Edison, while the more modest attainments of humbler workers are never mentioned. So, the worker grows into the habit of thinking that only great things are worth a struggle.

The coal passer chose a goal within the reach of men of average mental equipment and made that goal the chief object of his life. His was not an uncommon success because his aim was not unusually high, but it shows that with a fixed aim a man may compel opportunities by preparing for them.

There is nothing between any man and his goal, no obstacle to overcome, no barriers to be broken except himself. He alone sets the limits by which attainment is measured.

Not all men are possessed of a desire to stand so much above their fellows. Not every soldier can be a general or even a major, but each should cherish at least the ambition to be among the best of his class.

Municipal Pumping and Power Plant

By Warren O. Rogers

In this plant at Orange, N. J., alternating current is generated to drive induction motors coupled to direct-current arc machines. Two 3,000,000-gallon water works pumping engines with no atmospheric exhaust are installed. Both engines and pumps are run condensing without the aid of circulating pumps, the water being bypassed through the condensers from the suction pipe.

After several years of litigation, the city of Orange, N. J., has installed its own electric-lighting plant, which it is now operating. In 1908 a new pumping plant was built and enough boilers were installed to operate a city lighting plant; an engine room was also reserved between the boiler and pump rooms. The Public Service Corporation of New Jersey, however, was naturally opposed to the installation of a municipal plant as it would mean a loss of $28,500 per year to them, so they zealously fought the project.

They instituted proceedings against the city which delayed matters until February 13 of this year, when the current was cut off from the lines of the Public Service Corporation. With this event the price of $85 per lamp per year for 340 arc street lamps became a thing of the past.

The red-brick building housing the machinery is located on Chestnut street and as one turns the corner to enter the boiler room, the brick coal-storage house is seen. This building is divided into six compartments, each capable of holding 40 tons, or a total of 240 tons of coal. All fuel is carted to the storage house and is then loaded into a one-ton car that runs on an industrial railway. When run into the boiler room each car of coal is weighed on a Hunt platform scale.

Boilers

There are four Heine boilers, each of 225 horsepower capacity. They are set in one battery and each furnace is provided with a grate area of 52 square feet. Fig. 1 represents a view of the boilers and a partial view of the piping above them. Fig. 2 shows the piping arrangement more in detail. There is but one outlet from the steam drum of each boiler. To this outlet a tee connection is secured and an Ashton pop-spring safety valve is bolted to the top outlet. To the side outlet a stop valve is attached and to this valve a long-radius bend connects with the header which runs over the rear of the four boilers. At the central point of this header is a tee to which the main steam pipe, with a stop valve in the line close to the boiler header, connects. This line runs up over the economizer and through the wall between the boiler and engine rooms and dropping down, connects to a header in the engine

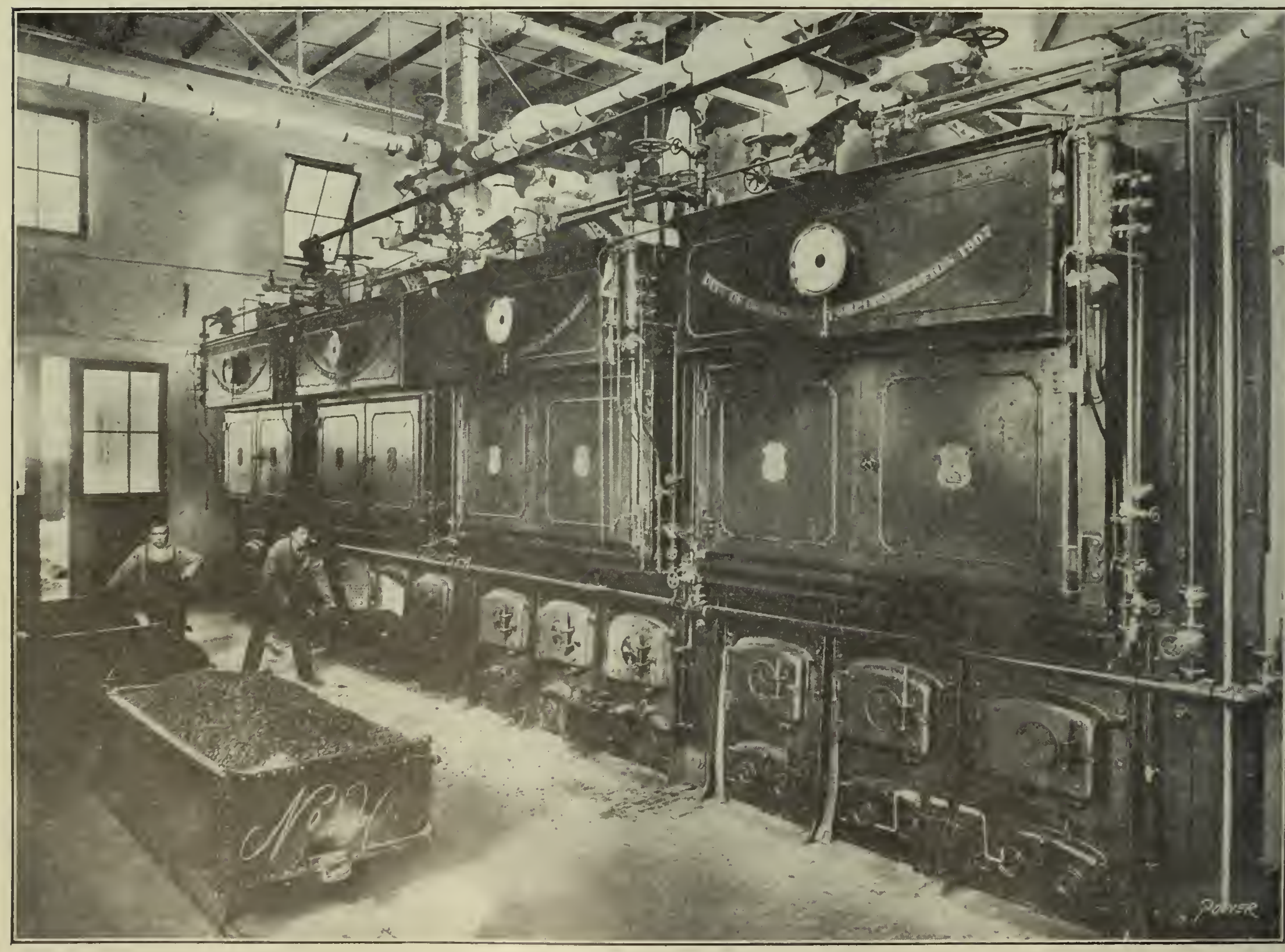


Fig. 1. Boiler Room of the Orange, N.J., Municipal Electric-light Plant

room. From this header the main feed pipes pass down through the engine-room floor and are run under the floor to the two large engines.

At the opposite end of the header a pipe is connected and runs across the end of the engine room with branches to the two pumps in the pump room.

The boilers are hand fired, and No. 1 buckwheat is burned. The average water evaporation for the last month was eight pounds per pound of coal. A steam pressure of 150 pounds per square inch is carried. Two boilers easily carry the night load. One boiler, if run to its capacity, would supply steam for operating the large service pump that is run continuously, but operating conditions make it more economical to run two boilers during the day than banking the fires under one and breaking the fire out for the night load. The two working boilers are, therefore, run light during the day and are ready for the night load when required, without the loss of fuel which the other method would entail.

Fig. 2. Piping Over the Boilers

Economizer

A Greene fuel economizer is located at the rear of the boilers. It contains 252 four-inch by 8-foot tubes. The feed water is passed through a feed-water heater and is heated by the steam from the exciter engine when it is running or by the steam from the boiler-feed pump, and the vacuum pump, the latter operating when the engines are running. As the economizer is designed for four boilers and as but two are used, the feed water is at present heated to but 170 degrees Fahrenheit.

A smoke flue reaches across the back end of the boiler on top and one end is connected with the smoke passage in the

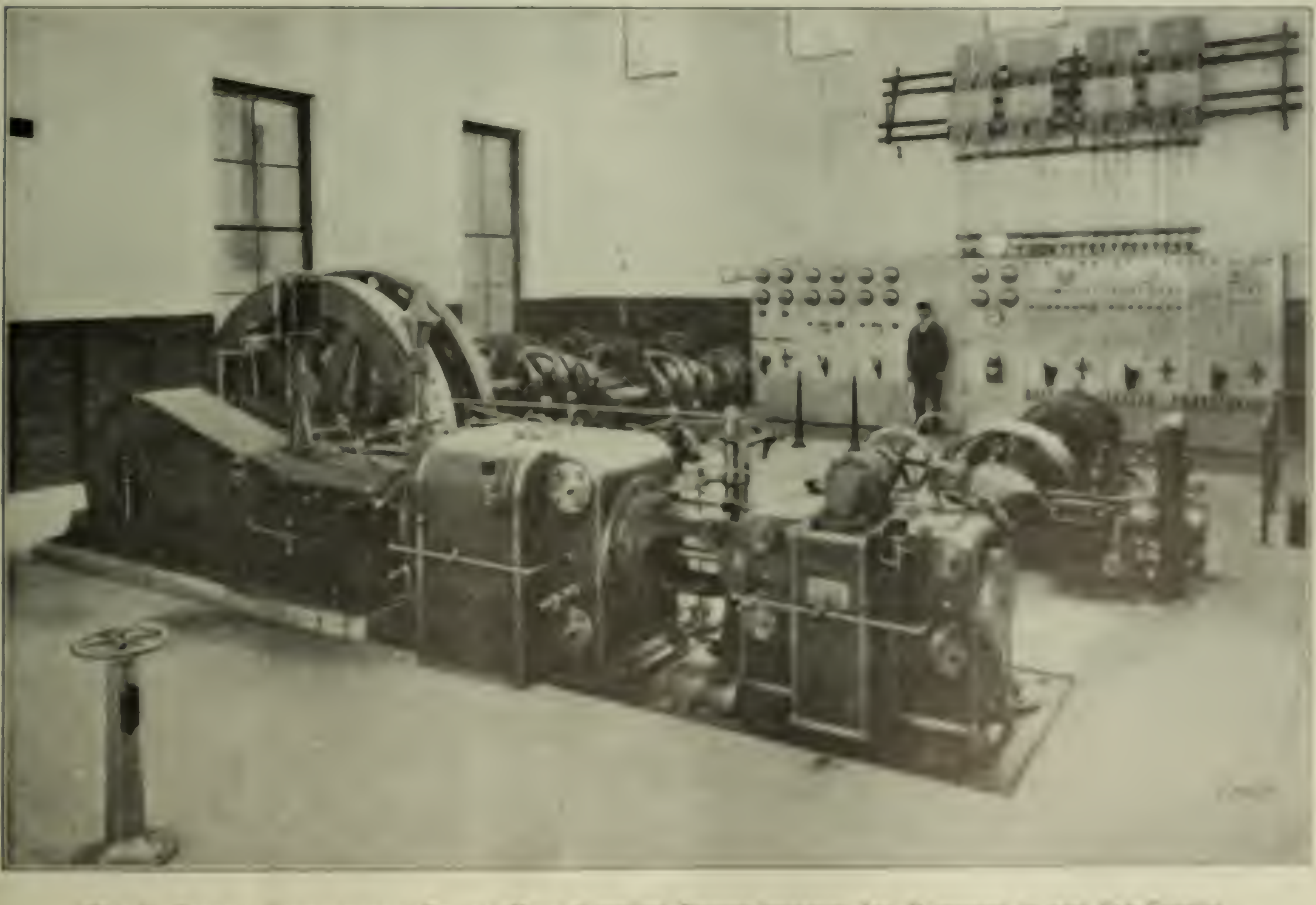


Fig. 3. Partial View of the Engine Room Showing Direct-current Arc Machines in the Far Corner

economizer. The other end is connected directly with a 175-foot Keeler radial-brick chimney, the base of which is 9 feet and the top 6 feet inside diameter.

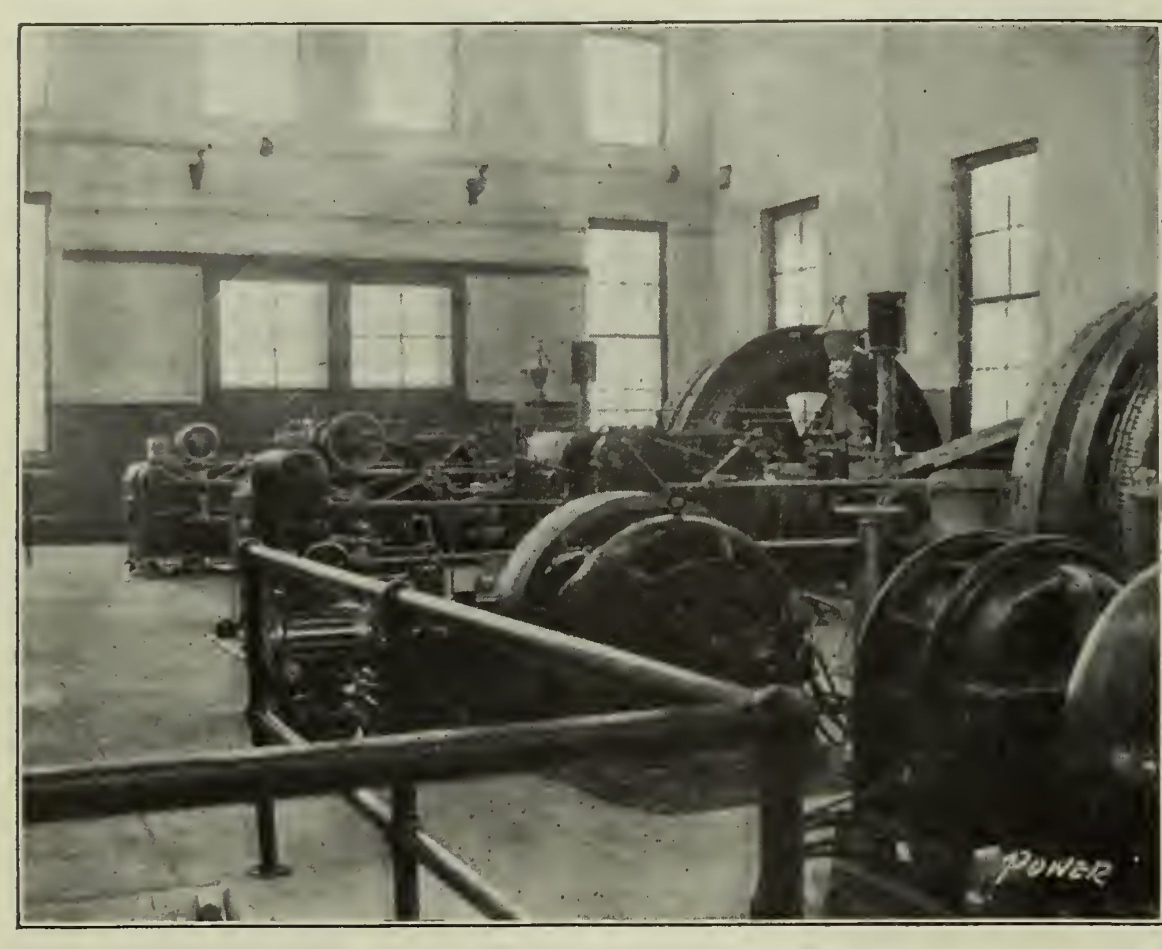


FIG. 4. ANOTHER VIEW OF THE ENGINE ROOM

Natural draft is used, although a Greene engine and fan-blowing set is installed in the blower room adjoining the base of the stack. Air-ducts running to the boiler setting have also been constructed.

ENGINE ROOM

Passing into the engine room, a view of which is shown in Figs. 3 and 4, one is confronted by two Hewes & Phillips' engines, 11 and 22x30-inch tandem-compound Corliss engines. Each runs at a speed of 150 revolutions; this high speed is practical, due to the new Franklin valve gear with which both engines are equipped. Each engine is direct coupled to a two-phase 250-kilovolt-ampere, 2200-volt Fort Wayne alternating-current generator. Contrary to general practice these machines do not deliver electrical energy outside of the building, but generate energy for three Fort Wayne induction motors which drive five arc machines. Two of these motors are of 120 horsepower capacity and are each coupled, by means of two flexible insulated couplings, to two Brush 9000-volt 4-ampere arc generators, which run at a speed of 700 revolutions per minute. The third motor is of 60 horsepower capacity and is coupled to one arc machine of the same capacity as the others. The grouping of these machines is shown in Fig. 3.

The coupling between the motor and generator shafts is shown in Fig. 5. It consists of a flange mounted on each shaft to be coupled together. Each flange has four arms which are made with a rim about 4 inches wide. Between the eight arms of the two coupling flanges are placed four pieces of round rubber. They are prevented from working out at the top of the arm by the overlap of the rim face and from working out at the side by flat plates which are secured to each arm of the coupling, by means of screws.

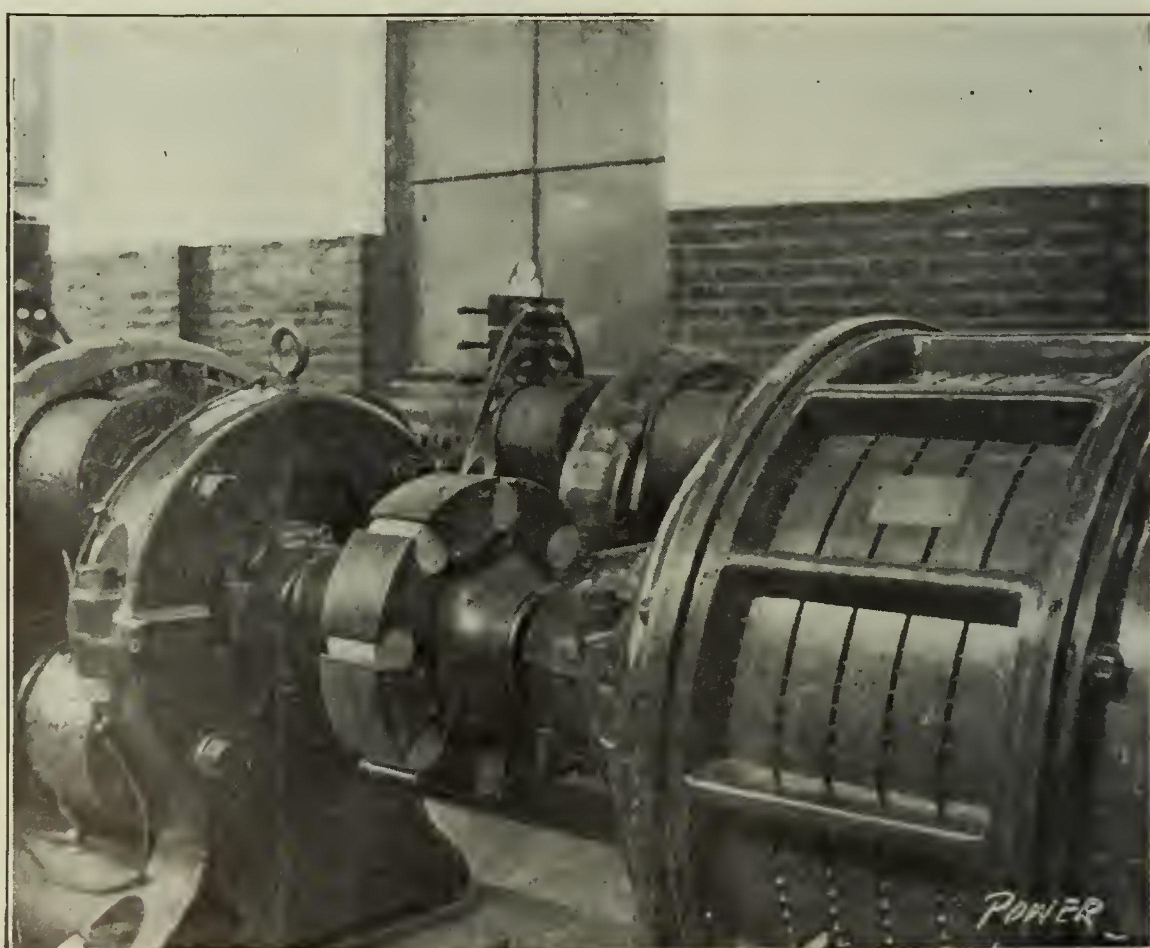


FIG. 5. METHOD OF COUPLING MOTOR AND GENERATOR TOGETHER

EXCITER UNITS

There are two exciter units. One consists of a 15-kilowatt, 125-volt direct-current Wood generator which is directly coupled to a Flemming automatic engine, running at 350 revolutions per minute. The other unit consists of one 25-kilowatt,

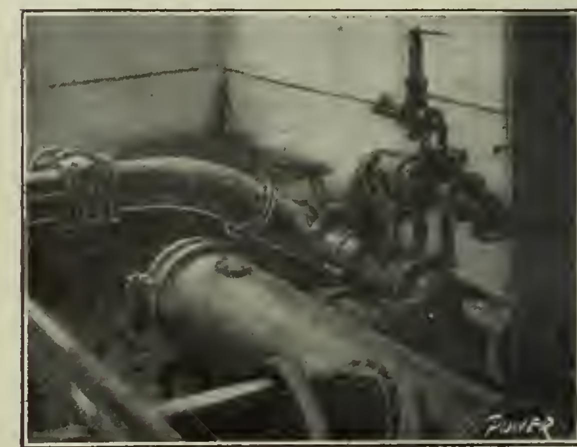


FIG. 7. RELIEF VALVE ON SUCTION PIPE OF PUMPS

125-volt direct-current Wood generator, directly coupled to a 40-horsepower induction motor, running at 900 revolutions per minute.

SWITCHBOARD

The switchboard is made up of seven panels of blue Vermont marble. Three are used for the plug switches of the arc-light circuits, two for the generators, one for the exciters and one is a spare panel for an extra generator unit, for which space is provided. The machine panels have the usual recording and indicating instruments, switches and other devices.

PUMPS

Beyond the engine room is the pump room, in which there are two Snow pumping engines, each of 3,000,000 gallons water capacity per 24 hours at 39 revolutions per minute. These pumps deliver city water to a 6,000,000-gallon storage reservoir against a 288-foot head.

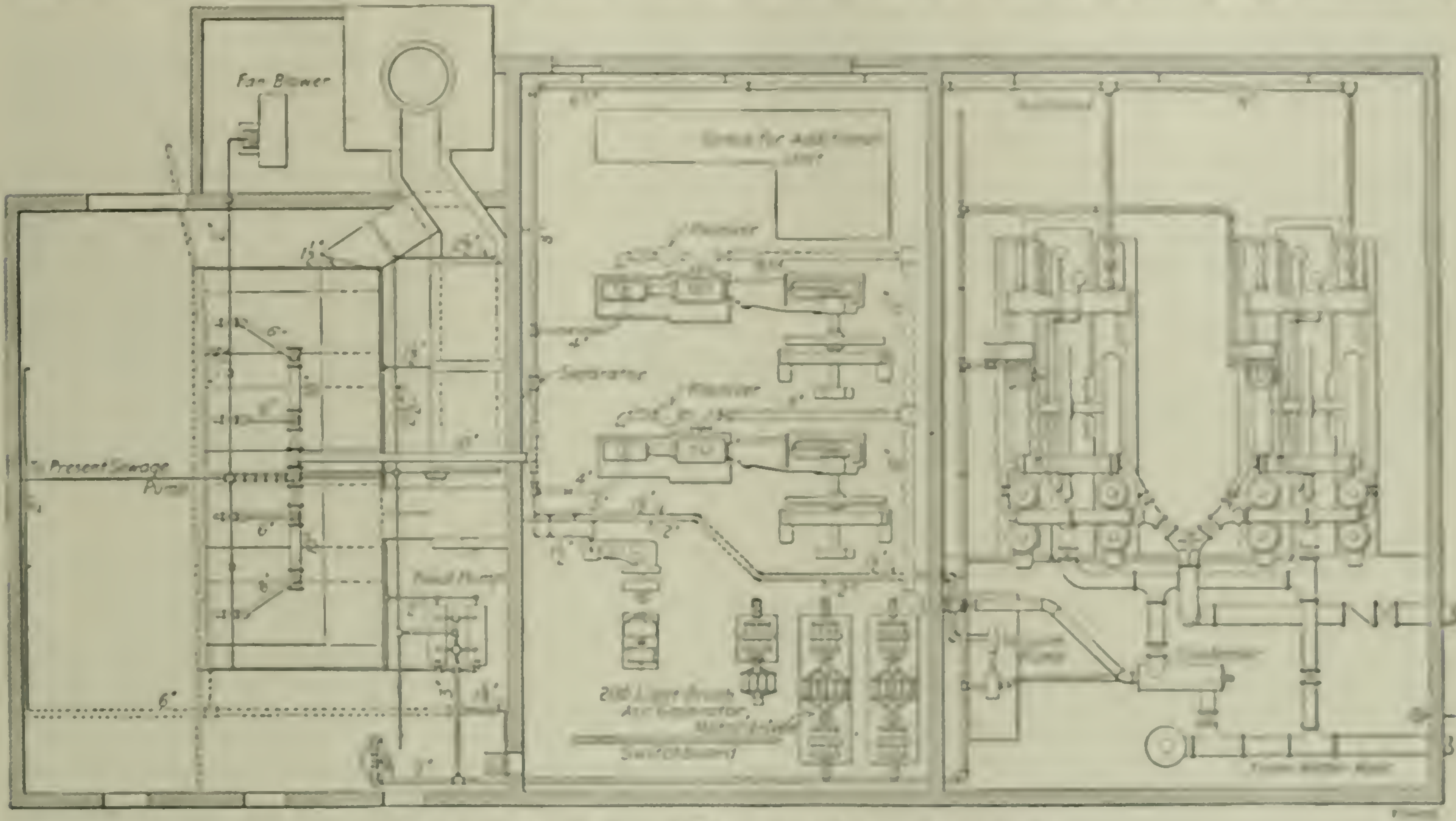


FIG. 8. PLAN VIEW OF BOILER, ENGINE AND PUMP ROOMS

But one pump operates at a time. Both pumps run condensing. In fact, they can run in no other way, as neither is fitted with an atmospheric exhaust pipe. Fig. 6 shows two views of the pumps.

At one time considerable trouble was

FIG. 6. VIEWS OF THE TWO LARGE PUMPING ENGINES

experienced by excessive pressure in the suction line of the pumps. This pressure would occur when the valve gear on the pumping engine failed to engage once or twice in succession, or when carelessly shutting down. As the pump takes the water from the suction pipe about as fast as it can flow by gravity, due to a 49-foot fall from the source of supply, the pressure was built up in excess of 90 pounds per square inch. To eliminate this dangerous condition, Chief Engineer Berg decided to put in a relief valve on the suction line. Accordingly a 7-inch Lombard relief valve was installed, as shown in Fig. 7. It is set to operate at 25 pounds pressure per square inch on the suction pipe and so the danger from a pressure greater than this is eliminated.

CONDENSERS

The principal generating units and the pumps are operated condensing, but the arrangement of the condenser differs from that found in most power plants. A Worthington surface condenser is placed on a stand made of pipes and is located in the basement of the pump room. No circulating pump is used, but a vacuum of [illegible] inches is easily maintained. The exhaust steam enters the condenser at one end and surrounds the tubes within the shell. The cooling water is drawn from the suction pipe of the large service pump and is passed through the tubes of the condenser, entering the suction pipe at the other end. The inches of vacuum are regulated by means of a valve in the bypass pipe leading to the condenser.

This novel method of supplying cooling water eliminates the first cost of a circulating pump and also the expense of its operation. As one of the pumping engines is always in operation, circulating water for the condenser is always available.

A similar arrangement is also carried out in working both of the large pumps. The condenser, however, is located above the water end of each pump, as shown in Fig. 6. In the case of the pumps, however, the exhaust steam passes through the condenser tubes. They are surrounded by the water and passing through the condenser, the condensing waters enter the discharge pipe of the pump and mix with the water which is pumped for domestic use. One would at first suppose that this arrangement would affect the temperature of the city water, but as the rise is but 4 degrees in the summer time, it is not objectionable. The condensed water from the pump surface condenser discharges the condensed water by gravity to a hotwell from which it is pumped to the boilers by one of the two Knowles 7½ and 5x6-inch outside packed feed pumps. They are both located at the rear of the boiler setting, as shown in Fig. 8, which is a plain view of the entire plant. Fig. 9 shows a side elevation of the power apparatus.

The condensation from the engine condenser is handled by a Burnham 8 and 12 by 12 vacuum pump, which is placed in the basement pit at the rear end of the pump room.

Another feature not found in most power plants is the Worthington recording liquid weigher. It is so connected that the water of condensation taken from the engine condenser can be automatically weighed and the steam consumption determined without preparation.

At present there are 374 arc lamps on the various circuits, as against 340 that were carried by the Public Service Corporation. There are also 145 incandescent lamps placed in series.

Owing to the short time this plant has been in operation no figures are available for comparison as to the cost of operating the street lights under the two systems. Later on, when figures for comparison are available, it will be possible to compare the costs under a municipally operated electric-lighting plant and a private central station.

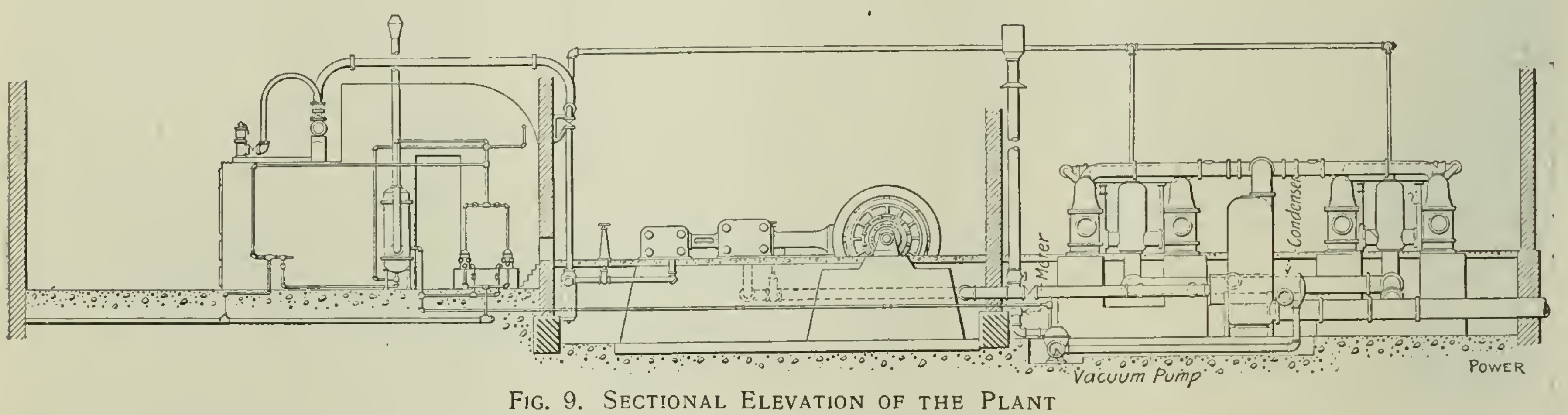


FIG. 9. SECTIONAL ELEVATION OF THE PLANT

High Boiler Efficiency with Oil Fuel

By Frank T. Clarke

A series of tests upon one of the boilers of the Redondo plant of the Pacific Light and Power Company, using crude oil as fuel and showing an average efficiency of 80.47 per cent.

When the Redondo plant of the Pacific Light and Power Company was built a few years ago it attracted considerable attention, owing to the fact that reciprocating engines were selected as prime movers instead of turbines. The main units are each of 5000 kilowatts capacity and are arranged on the panel system. Each panel consists of six oil-fired Babcock & Wilcox boilers supplying steam at 175 pounds and 100 degrees superheat to a double horizontal and vertical McIntosh & Seymour compound-condensing engine running at 100 revolutions per minute, the latter direct connected to a three-phase, 50-cycle, 18,000-volt generator.

In December, 1908, a paper was read before the American Society of Mechanical Engineers, giving the figures of a test upon this plant which showed an exceptionally high overall efficiency. But, as the figures represented the performance of the complete plant, it was impossible to separate the individual efficiencies of the boilers, engines and auxiliaries. However, the results of a test upon one of the boilers have now become available and, although this was made some time after the complete plant test referred to, it is reasonable to assume that the boiler efficiency had not changed appreciably. In view of this it would appear that the boilers were largely responsible for the very high plant efficiency.—EDITOR.

The object of the tests, the results of which are here shown, was to determine the efficiency, under average operating conditions, of the burners and furnaces. The seven tests covered by this report were all made with Hammel patent furnaces and burners, and it is believed that the results would justify the statement that these trials represent the highest economies ever obtained under similar conditions.

The boiler tested was of the Babcock & Wilcox type, of which there are eighteen in the plant, each containing 6042 square feet of effective heating surface and rated at 604 boiler horsepower. It was designed to carry steam at 200 pounds gage pressure, but is ordinarily operated at 185 pounds.

The superheaters, which were designed to give 100 degrees superheat at the nozzle, are also of the Babcock & Wilcox type, having two loops of tubes in two decks and approximating 960 square feet of superheating surface to each boiler.

There are three passes in the boiler, the products of combustion rising through the first pass, which is baffled along the lower row of tubes from the first flame plate to the bridgewall by fire tile. The gases then pass over and through the superheater to the second pass, and from there to the last pass, from which they escape to the uptake.

The furnace was of the Hammel type, having a separate tunnel for the air supply to each burner. The burners were also of the Hammel patent inside-mixer type, there being three to the furnace. These were arranged under an arch in the bridgewall, and the direction of the flame was toward the furnace front. Fig. 1 shows the arrangement of furnace and burners; while Fig. 2 is a view of the burner.

The feed water was measured by means of platform scales and tanks, and precautions were taken to detect any leakage.

The fuel oil was pumped from one of the three auxiliary storage tanks, adjacent to the boiler room, at a temperature of 80 degrees Fahrenheit, through a 3-inch quick-acting valve into a weighing tank, from which it flowed through a 4-inch suction pipe to a second pump located near the boiler under test. This pump discharged the oil directly into a Goubert oil heater, where its temperature was increased by the exhaust steam from the pump. From the heater it was discharged to the line leading to the burner. Between the oil pump and the heater there was a bypass which discharged to the reservoir tank. This gave the necessary circulation and allowed a means of pressure regulation.

Samples of the oil were obtained from a tap in the pump discharge between the boiler and the heater. The steam for atomizing purposes was taken from directly under the stop valve of the boiler; consequently, this contained the same degree of superheat as was shown by the thermometer at the boiler nozzle.

For obtaining flue-gas analysis a standard Orsat machine was used. The samples were collected every half hour from the center of the last pass.

The flue temperatures were taken by a Hohmann & Maurer thermometer, reading to 800 degrees Fahrenheit, this being placed between the two dampers at the center of the boiler breeching. Temperatures were taken of the steam at the boiler nozzle; of the oil at the discharge from the heater; of the feed water in the reservoir tank, and of the boiler room at a point about ten feet in front of the boiler and at an elevation above the floor of five feet.

The draft pressure was measured by means of three Ellison differential draft gages, one located at the boiler front, for the ashpit draft, and the other two mounted on the side of the boiler, one being piped to the furnace and the other directly inside the flue dampers. All draft gages were insulated from the boiler setting to prevent error due to heating. The precaution was taken to have the outlets of the draft pipes arranged at right angles to the direction of the flow to prevent inaccuracy due to the velocity. For taking the high temperatures at the different parts of the boiler a Bristol electric pyrometer, reading to 2500 degrees Fahrenheit, was used.

All scales and instruments were calibrated before and after the tests, and were found to be substantially correct.

The blowoff valves on both the boiler and the superheater were disconnected and the water-column outlets were at all times visible for inspection. Also, leakage from the feed-pump glands was collected and returned to the feed-water reservoir.

During all the tests the water level was maintained practically constant at a point four inches from the bottom of the gage glasses. To avoid error due to change of temperatures in the water columns and their connections, the glasses were not blown down at any time immediately prior to or during the tests.

All readings were taken at fifteen-minute intervals during the tests, and every hour the water and oil levels were brought to the same point and calculations made. Besides the power company's testing engineer, there were four men engaged in the tests: one fireman, one temperature reader, one water weigher and one oil weigher. In addition to this crew the company making the burner also had a man in each of these capacities who kept independent log sheets. At the conclusion of each test the logs were compared and they agreed in all cases. Smoke observations were taken every fifteen minutes, and during none of the trials was anything heavier than a light haze observed; this is particularly true of the maximum-capacity test.

The oil was sampled every fifteen minutes during each run, and, before taking a sample, precaution was taken to see that the sampling pipe was drained. The sample from each test was analyzed twice by the Los Angeles branch of the New York Testing Laboratories and the average results used.

CONDITION OF THE BOILER

Before starting the tests it was found necessary to rebuild the division wall

GENERAL DATA AND RESULTS OF TESTS

Test number	1	2	3	4	5	6	7	Average
Duration of test, hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Steam pressure, pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Steam temperature, degrees Fahrenheit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Superheat, degrees Fahrenheit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Temperature feed water, degrees Fahrenheit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Factor of evaporation, pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average water level, inches	4	4	4	4	4	4	4	4
Barometer, inches	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Temperature of boiler room, degrees Fahrenheit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Temperature of flue gases, degrees Fahrenheit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Draft in ashpit, inches	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Draft in furnace, inches	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Draft in final pass, inches	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Carbon dioxide, per cent	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oxygen, per cent	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Excess air, per cent	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Smoke	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Position of ashpit doors	Doors wide open throughout all tests							
Temperature in first pass above combustion, degrees Fahrenheit	1,100	[illegible]	1,100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Temperature at top of first pass, degrees Fahrenheit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Temperature at top of second pass, degrees Fahrenheit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Temperature at bottom of second pass, degrees Fahrenheit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Temperature at bottom of third pass, degrees Fahrenheit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total water actually evaporated, pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total water evaporated from and at 212 degrees Fahrenheit, pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Water per hour evaporated from and at 212 degrees Fahrenheit, pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Steam used by burners, pounds per hour	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Steam used by burners, per cent of total steam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Steam pressure to burners, pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oil pressure to burners, pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Temperature of oil to burner, degrees Fahrenheit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Kind of oil burned	[illegible]							
Specific gravity of oil at 60 degrees Fahrenheit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Specific gravity of oil, Baumé, at 60 degrees Fahrenheit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Moisture in oil, per cent	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Heat value of oil as fired, B.t.u.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Heat value of oil, corrected, B.t.u.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total oil as fired, pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total oil, corrected for moisture, pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oil per hour as fired, pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oil per hour, corrected, pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Water evaporated from and at 212 degrees Fahrenheit per square foot heating surface, pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Boiler horsepower, builders' rating, B.h.p.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Boiler horsepower developed, B.h.p.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Per cent builders' rating	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Water evaporated per pound of oil, from and at 212 degrees Fahrenheit: Oil as fired, pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Corrected for moisture, pounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Boiler efficiency, per cent	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

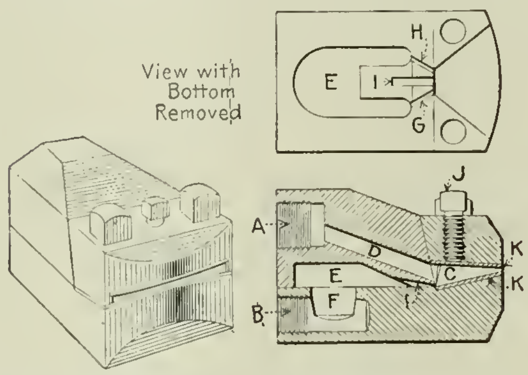
between the boiler under test and the one forming the other half of the battery. The boiler was cleaned about four days prior to starting the first test, and was in operation two days before the test was begun. The tubes were dusted off through the dusting doors, by means of a steam jet, every morning before starting a test. As the tests were to be, as far as practicable, representative of operating conditions it was considered that this cleaning was sufficient to fulfil the average conditions.

The setting was in extremely poor condition, and it was found advisable to stop up the worst cracks. During the tests there was quite a number of small air leaks in different parts of the setting which did not receive any attention.

Prior to making the tests herein recorded, an inspection was made of the tubes as a result of which four in the first row were replaced. At the conclusion of the tests the tubes were again inspected and they were all found to be in good condition; also, the furnace brickwork was given a careful inspection and there was no apparent injury.

Starting and Stopping Trials

All tests were started and stopped by a whistle signal. The boiler was operated at the load under which it was tested for a period of three to four hours before actual starting, and as the fires were maintained uniform the water level was practically constant at the time of starting and stopping. The water glasses were provided with washers at fixed points, and no trouble was experienced in having the water at these fixed levels at the start and finish. Therefore, it was found unnecessary to make any corrections for difference in levels.



A Orifice for Oil Supply Pipe
B Orifice for Steam Supply Pipe
C Mixing or Atomizing Chamber
D Oil Inlet Duct
E Equalizing Steam Chamber
F Steam Entrance
G, H, I Steam Ducts
J Set Screw Holding Plate
K Removable Steel Plates
X Bypass or Blowout Valve

Fig. 2. Hammel Burner

The boiler was at "standby" about four hours every night, but the four-hour period of service before the test was considered sufficient to heat the setting thoroughly and to eliminate the possibility of heat storage.

Results Of Tests

Fig. 3 shows graphically the efficiency referred to the boiler horsepower developed, while Fig. 4 shows the efficiency as plotted against the water evaporated from and at 212 degrees Fahrenheit per square foot of heating surface. In both curves it will be noted that the points at 33.6 and 64 per cent. above rating are somewhat below the curve. This is accounted for by the fact that at the point

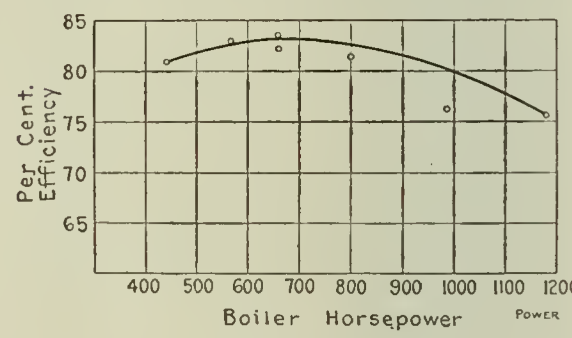


Fig. 3. Efficiencies at Various Horsepowers

of maximum capacity it was found that the ¼-inch pipe which the makers supplied with the burners was entirely too small for atomizing the oil at the higher loads, and to make the maximum-capa-

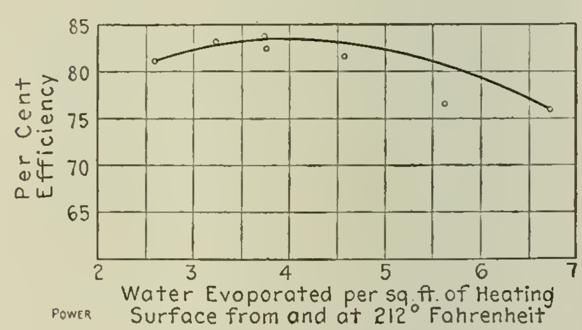


Fig. 4. Efficiency Referred to Evaporation per Square Foot of Heating Surface

city test ⅜-inch pipe was substituted. This is indicated by the drop in burner efficiency at those points. In order to get the maximum capacity it was also found necessary to increase the width of the tunnels and to provide a greater number of air openings through the grates.

It is regretted that the two tests mentioned were not repeated, but lack of time prevented and it is reasonably certain that had additional tests been made it would have shown these points very close to the curve.

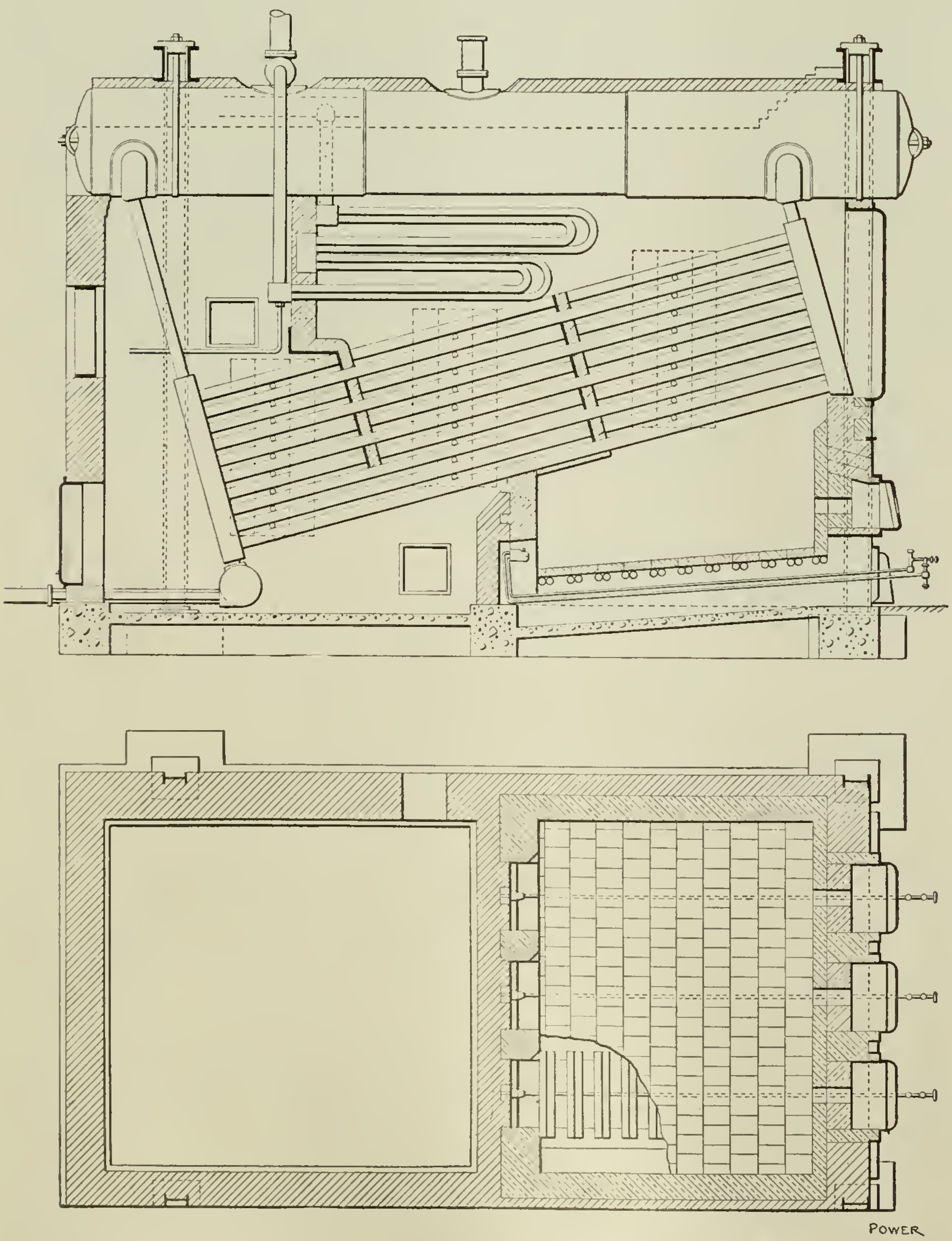


Fig. 1. Boiler Showing Arrangement of Furnace

Fig. 5 shows the efficiencies referred to the pounds of water evaporated per pound of oil, corrected for moisture, and in Fig. 6 is given a curve showing the relation between the percentage of carbon dioxide and the boiler horsepower.

Fig. 7 shows the relation between the boiler horsepower and the water evaporated per square foot of heating surface, from and at 212 degrees Fahrenheit.

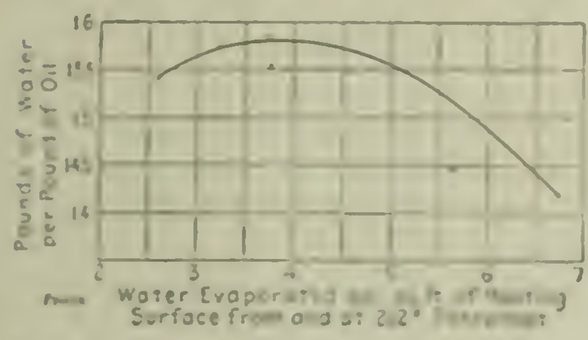


FIG. 5. EVAPORATION PER SQUARE FOOT OF HEATING SURFACE REFERRED TO EVAPORATION PER POUND OF OIL

CALCULATIONS

In calculating the factor of evaporation the specific heat of superheated steam was taken as 0.6 for the gage pressure obtained.

The amount of steam used by the burners was obtained by placing the burner in the water-weighing tank, with the connecting piping and fittings the same as were used during the tests. The average steam pressure for the different tests was then maintained on the burner line for a period of half an hour. The amount of condensation was then weighed and this was checked by figuring the amount of discharge by temperature readings. For additional accuracy several different trials were made at each point, and these all agreed within a very small per cent. In the burner-efficiency calculations there is a small discrepancy between the actual and the test conditions due to the difference between the pressure of the oil and of the water. Under operating conditions the steam in the burner head is retarded in its flow by the pressure due to the oil in the mixing chamber, while the tests made by the tank method gave a greater steam flow due to there being only a very slight water pressure.

It was also found that with heavy boiler loads the tubes directly exposed to the fire suffered much less than with the light loads. This is accounted for by the fact that on the heavy loads the distribution of heat throughout the boiler was much more uniform than with the light loads, which had a tendency to concentrate the heat in the front part of the boiler, due to the difference of draft.

CONCLUSIONS

In order to demonstrate what advantage a long furnace would have over a short one, a furnace was installed having a total length of eight feet, which was two feet shorter than the one installed by the boiler company at the time the boiler was erected. A test demonstrated clearly that far better results could be obtained with the long furnace, having a length of ten feet from the face of the bridgewall to the inside face of the boiler front, and it was at this point that the first six tests were made.

To obtain the maximum capacity it was found necessary to increase the width of the tunnels to give a slower air velocity through the grates, and to increase the number of openings through the grate. At that time the bridgewall was also moved back another six inches, which increased the cubical contents of the firebox about 10 cubic feet, and greatly assisted the combustion at high loads. It is also believed that the large firebox would greatly assist the combustion at the lower evaporative points. In all cases it was found that the best results were obtained by leaving the front dampers wide open, and controlling the admission of air entirely by the rear damper. By this means the velocity of the gases was kept at a minimum, which seems to be essential for the best combustion.

In several instances during preliminary trials the temperature of the oil in the reservoir tank was increased to 120 degrees Fahrenheit, and it was found that by so doing the efficiency of the boiler dropped considerably. This would indicate that for average conditions it is a great mistake to heat the oil to excessive temperatures except in cases where it is absolutely essential for handling. During the tests, with oil having a specific gravity of about 13, the temperature was maintained at 80 degrees Fahrenheit, which temperature gave the most satisfactory results. The excessive heating of the oil causes decomposition of the hydrocarbons.

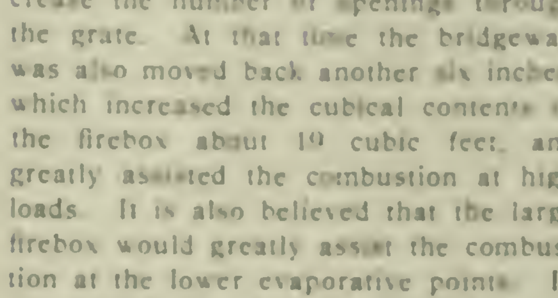


FIG. 6. RELATION BETWEEN CO_2 AND HORSEPOWER

It is believed that the efficiencies of all tests would have been materially improved had it been possible to obtain a steady oil pressure on the burners. The pump was not supplied with any sort of automatic-control device, and as a result it was impossible to keep the pressure from varying from five to fifteen pounds.

It was found that the better known burners could be divided into three classes: those using excessive amounts of steam for atomizing—over 3 per cent. of the total steam generated; those whose steam consumption is less than 1½ per cent., and the ones whose steam consumption lies between the two. In the first case the different pipes and burner openings are of large area and offer small resistance to the passage of dirt, with the result that these burners do not become obstructed and can be operated at a very low maintenance cost. This, however, is offset by the excessive steam used. In the second case the passages must be extremely small and the burner consequently becomes obstructed very readily, resulting in excessive maintenance costs, which more than equal the steam economy. It is obvious, therefore, that a burner fulfilling the requirements between the two extremes is best adapted for general use.

FIG. 7. RELATION BETWEEN HORSEPOWER AND EVAPORATION

It is to be regretted that sufficient data was not obtained from the analysis of the oil samples to permit the working up of a "heat balance," but it is believed that the information given will otherwise be found complete.

An Expert and a Strap Brake

"Yes," said Jones, "our superintendent at the Throwmtogether Engine Works was the engine man for you. He wouldn't let any engine out of the shops without taking cards running free and with all she could pull. You should have seen the slick rig he got up to load them. He fixed up a long wooden beam with a piece of belting and bolts (strap brake). Well, of course, he didn't get onto this rig first shot. Instead of letting the arm shove against the floor, he hooked it with it on the other side and had enough of the lads sit on it to hold it down. Anyway, this worked fine until one time the brake seized and threw a bunch of the men over the engine. Of course, you seen the sensitive engine men can get those fancy charts without him then."

An employee in a sawmill near Duluth, Minn., was killed in a peculiar manner. One of the balls of a steam-engine governor flew off and struck him on the head, causing instant death.

The Cooling of Circulating Water

By Edward F. Miller

A method of calculating the volume of air required to cool a given amount of circulating water passing through a cooling tower, and calculations showing that under certain conditions it is better to employ a moderate vacuum than a high one where a cooling tower is used.

Whenever possible, large power plants are located near a river or near tide water, in order to obtain an abundant supply of condensing water; in many cases, however, plants have to be located where there is either no supply or but a limited supply of water which can be used for condensing purposes. In such cases if the plant is to be run condensing, it becomes necessary to cool the condensing water after it has passed through the condensers so that it may be used over and over again. Some of the various devices for cooling the water are: Cooling towers, spray nozzles, cooling ponds, and spray nozzles combined with cooling ponds.

In every case, with the exception of the "cooling ponds," the greater part of the cooling is effected through the evaporation of a small part of the water circulated, each pound of water evaporated taking approximately one thousand heat units from the water left. This method of cooling by the rapid evaporation of a part of the liquid was known and made use of in India 2000 years ago.

According to Dalton's law, the weight of steam required to fill a certain volume at a given temperature is the same regardless of whether any air is present. The resulting pressure is the sum of the pressure exerted by the air and that exerted by the steam, considering that each occupied the same volume separately. The weight of moisture required to saturate one cubic foot of dry air, or that which will occupy one cubic foot, can be calculated from any reliable tables giving the properties of saturated steam.

The curved line (Fig. 1) was computed by taking from the steam tables values representing the reciprocal of the volumes of one pound of steam at the different temperatures. From this it is evident that at 66 degrees, 0.0010 pound is required to saturate a cubic foot of dry air and at 130 degrees, 0.0063 pound is required. If air at 66 degrees were 70 per cent. saturated, or had a relative humidity of 70, then the amount of moisture in a cubic foot of such air would be

$$0.7 \times 0.001 = 0.0007 \textit{ pound}$$

and if the air were saturated at 130 degrees the additional amount taken up would be

$$0.0063 - 0.0007 = 0.0056 \textit{ pound}$$

Cooling Towers

Probably cooling towers are used to a greater extent for cooling water than spray nozzles or cooling ponds, although spray nozzles are coming into frequent use now that engineers know more about them.

The amount of water surface in a cooling tower varies from 23 to 27 square feet per indicated horsepower, more surface being needed in a natural-draft tower than in a fan tower. The amount of air required depends to a large extent upon the humidity of the air entering the tower and upon the temperature of the water entering the tower. The air leaving the tower is usually saturated. It is not advisable to send an abnormal amount of air through a tower as the cost of the increased power required to run the fan and the greater shrinkage in the bulk of water due to evaporation may amount to more than the gain made by the increased vacuum on the engine.

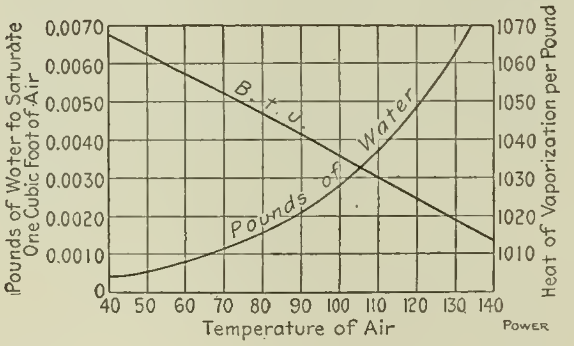


Fig. 1. Water Required to Saturate Air and Heat of Vaporization

The materials used inside of cooling towers for bringing as large a surface of cooling water as possible into contact with the air, without obstructing the free flow of air, are tiers of tile paper, galvanized-iron wire screens set nearly vertical, galvanized-iron troughs set horizontally and arranged so that the water flows from trough to trough as it descends, boards, brush or other material.

The amount of air to be supplied to a tower and the shrinkage of water due to evaporation, may be calculated with sufficient accuracy from the following equations:

$$W(Q_h - Q_c) = \frac{V_c}{0.736\,\frac{T_c}{P_c}} \times 0.24\,(T_h - T_c)$$

$$+ r\left(\frac{V_h}{\text{Specific volume of steam at the temperature of the air at top}} - \frac{V_c}{\text{Specific volume of steam at the temperature of the air at bottom}} \times \textit{relative humidity}\right)$$

where,

W = Weight of cooling water entering the condenser per pound of steam;

V_c = Cubic feet of cold air entering the tower per pound of steam condensed. This air may enter by natural draft or be forced in by a fan;

V_h = Absolute temperature of air leaving the tower; condensed and is equal to $\frac{V_c T_h}{T_c}$;

T_c = Absolute temperature of entering air;

T_h = Absolute temperature of air leaving the tower;

P_c = Absolute pressure of air entering the tower in inches of mercury;

Q_h = Heat contained in hot condensing water;

Q_c = Heat contained in cold condensing water;

r = Heat of evaporation corresponding to temperature at top of tower.

The first factor,

$$\frac{V_c}{0.736\,\frac{T_c}{P_c}} \times 0.24\,(T_h - T_c)$$

represents the heat given up directly to the air and the second part of the equation

$$r\left(\frac{V_h}{\text{Specific volume of steam at the temperature of the air at top}} - \frac{V_c}{\text{Specific volume of steam at the temperature of the air at bottom}} \times \textit{relative humidity}\right)$$

represents the heat given up by evaporation of some of the water. This expression divided by r represents the weight of water evaporated from the pond per pound of steam condensed; represent this by E.

If E is greater than one pound the excess must be supplied by makeup water. For a surface condenser E represents the makeup water.

If the excess pressure of the air entering the tower is measured by the difference of water level in a U-tube, P_c will equal the sum of the barometric reading and $\frac{0.0365}{0.491}$ times the difference in water level.

In nearly every case P_c varies so little from the reading of the barometer that the barometric hight in inches of mercury may be substituted for it.

Example:

A cooling tower receives water from a surface condenser at 122 degrees Fahren-

*From a paper presented at the Congress of Technology, at Boston, April 11, 1911.

heit; the water leaves the cooling tower at 90 degrees Fahrenheit; temperature of outside air 72 degrees, relative humidity 80 per cent.; temperature of condensed steam 95 degrees; vacuum in condenser 25 inches; barometer 29.7 inches. Engine of 500 horsepower and consumes 20 pounds of steam per horsepower-hour.

Find the amount of air needed per pound of steam condensed and the per cent. loss of cooling water due to evaporation.

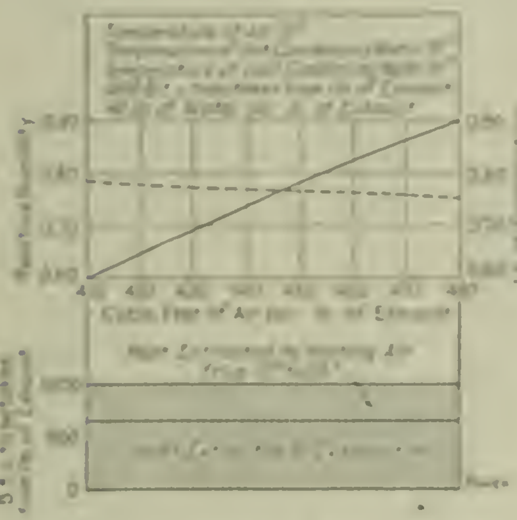


FIG. 2. CONDITIONS WITH 28-INCH VACUUM

$$W = \frac{1053.2 - 63.1}{90.0 - 58.1} = \frac{990.1}{31.9} = 31.8$$

Substituting in the foregoing formula

$$31.8(90 - 58.1) = \frac{V_e}{\frac{0.736 \times 513.3}{29.7}} \times 0.24(30)$$

$$+ 1025.2\left(\frac{V_e \, 481.6}{531.5 \times 149.7} - \frac{V_e}{813} \times 0.80\right)$$

$$990.1 = 0.902\, V_e + 1025.2$$

$$(0.00508\, V_e - 0.000981\, V_e) = 0.902\, V_e + 4.806\, V_e$$

whence

$$V_e = 173 \textit{ cubic feet}$$

$$E = (0.00508 - 0.000981)\, V_e = 0.815$$

$$\frac{0.815}{31.8} = 0.0256 \textit{ or } 2.56 \textit{ per cent.}$$

To illustrate more fully the use of the equation and to illustrate also the extra cost (at the cooling tower) of a high vacuum over a moderate vacuum two cases will be considered.

First: A condenser maintaining a 28-inch vacuum with hot condensing water at 95 degrees Fahrenheit, or 7 degrees below the temperature corresponding to the vacuum, cold condensing water at 70 degrees Fahrenheit, and exhaust steam containing 4 per cent. moisture. Forty pounds of circulating water are figured as the minimum needed to abstract the heat from a pound of the exhaust steam. Calling the relative humidity 90 per cent. and applying the foregoing formula:

$$40(95 - 70) = \frac{V_e}{0.736\frac{[illegible]}{29.92}} \times 0.24\,(95 - 70)$$

$$+ 1048.5\left(\frac{V_e \, 554.4}{434.8 \times 529.5} - \frac{V_e}{[illegible]} \times [illegible]\right)$$

$$1000 = 2.077\, V_e$$

whence,

$$V_e = 481 \textit{ cubic feet}$$

The evaporation from the tower per pound of steam condensed in the condenser is 0.748 pound and

$$1038.5 \times 0.748 = 776.8 \textit{ heat units}$$

carried off by the water evaporated; the balance, 223.2 B.t.u., is taken up in heating the air.

With 80 per cent. humidity, 455 cubic feet of air would be needed and 0.761 pound would be evaporated. Similar calculations for 70 and 60 per cent. of humidity give, respectively, 430.9 cubic feet of air and 0.772 pound of water evaporated and 410.7 cubic feet of air and 0.781 pound of water evaporated.

Second: Suppose that the vacuum to be carried is 26 inches with air at 70 degrees and hot condensing water at 119 degrees, or 7 degrees below the temperature corresponding to the vacuum. Cold water at 70 degrees and 4 per cent. moisture in the exhaust steam. The heat to be abstracted per pound of exhaust is 983 B.t.u. and 20.6 pounds of cooling water is the minimum required per pound of exhaust.

From calculations similar to the preceding it appears that the amounts of air needed and the evaporations are as follows:

Relative Humidity	Cubic Feet Air	Evaporation in Pounds
90	186.1	0.793
80	184.1	0.797
70	180.6	0.800
60	176.5	0.801

The amount of water evaporated per pound of steam condensed is about the same in each case.

In the first case the evaporation averaged 0.77 pound in 40 pounds of water sent into the tower, or 1.92 per cent.; in the second case about 0.80 pound in 21 pounds of water, or 3.81 per cent.

The results of the calculations are plotted in Figs. 2 and 3. It is evident from these that the amount of heat taken up in the heating of the air was about the same for any one case, regardless of the humidity.

PERCENTAGE OF ENGINE POWER REQUIRED BY COOLING-TOWER FAN AND BY THE EXTRA DISCHARGE HEAD ON THE CIRCULATING WATER DUE TO THE TOWER

Referring to the first case cited, with a relative humidity of eighty, 455 cubic feet of air were found to be needed. Suppose a disk fan is to be used and a dynamic head of 0.3 inch of water maintained at the fan. As the static head is zero the velocity head will be 0.3 inch. This corresponds at 70 degrees to a velocity of 2200 feet per minute. Suppose that the main engine uses 14 pounds of steam per horsepower per hour, then the steam per minute is 14 ÷ 60 and the cubic feet of air sent through the tower per pound of steam is $\frac{14}{60} \times 455$

The horsepower input to the fan is, for this case, if 30 per cent. is assumed as the fan efficiency:

$$\textit{Horsepower} = \frac{0.3 \times 5.2 \times \frac{14}{60} \times 455}{33{,}000 \times 0.30} = 0.0167, \textit{ or } 1.67 \textit{ per cent.}$$

of the engine power.

To this should be added the power due to pumping $\frac{14 \times 40}{60}$ pounds of cooling water per minute through an additional head of about 30 feet. This amounts to 0.00848 horsepower.

If the fan were driven by a small engine using 35 pounds of steam per horsepower-hour and the circulating apparatus were also steam driven, using 40 pounds per horsepower-hour, then the extra steam required by the cooling-tower outfit would be

$$0.0167 \times 35 + 0.00848 \times 40 = 0.923$$

and

$$\frac{0.923}{14} = 0.066, \textit{ or } 6.6 \textit{ per cent. additional}$$

A similar calculation for the second case with a 26-inch vacuum and 80 per cent. humidity, with the engine using 15 pounds of steam per horsepower-hour, gives:

Air per minute =

$$\frac{15}{60} \times 184$$

Horsepower to fan =

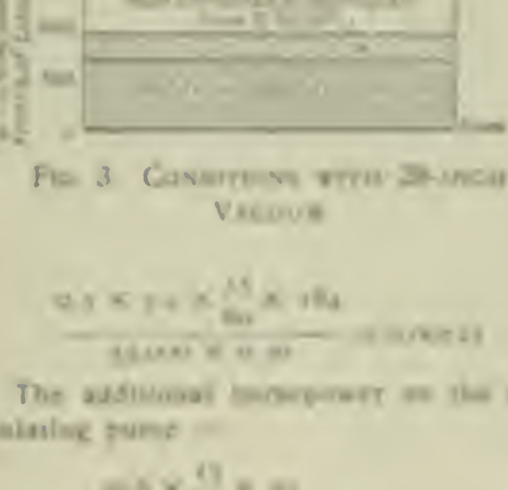


FIG. 3. CONDITIONS WITH 26-INCH VACUUM

$$\frac{0.3 \times 5.2 \times \frac{15}{60} \times 184}{33{,}000 \times 0.30} = 0.00724$$

The additional horsepower on the circulating pump =

$$\frac{20.6 \times \frac{15}{60} \times 30}{33{,}000} = 0.00468$$

If the fan engine and the circulating apparatus were steam driven, then using the same rate as before:

$$0.0072 \times 35 + 0.00468 = 0.443$$

and

$$\frac{0.443}{15} = 0.0295, \textit{ or about 3 per cent. additional}$$

If the cooling surface used in the tower offers much resistance to the free discharge of air from the fan through the tower, it may be necessary to run the fan at a higher velocity and this increases the work of driving.

Spray Nozzles

By spraying water into the air, cooling may be effected through the evaporation of a part of the water just as in the case of the cooling tower. The total exposed surface of the sprayed jet meets less air per pound than in the cooling tower, and on this account it is often advisable to spray 30 to 50 per cent. of the water a second time before sending it through the condenser.

Generally speaking, spray nozzles of the size known as 2 inches are the most economical. This size screws onto a 2-inch outlet, the opening in the nozzle tip being about 0.8 inch. As many nozzles should be provided as are needed to discharge the entire weight of condensing water under a pressure of not over 15 pounds gage at the nozzle.

The nozzles should be set from 8 to 10 feet apart if 2 inches; and a greater distance if over 2 inches. Where a number of nozzles are used, it is customary to have the water which is sprayed into the air fall back into an artificial pond one or two feet deep. Also, when a number of nozzles are in use the aspirator effect produced by the jets causes a current of air to flow along the surface of the pond from the edge toward the center and this current of air assists to some extent in the cooling.

In some few instances spray nozzles have been put along the edges of a narrow brook and the falling spray caught on board fences inclined 30 degrees with the ground and draining into the brook.

There are a few small plants where the cooling nozzles discharge onto the roof of the building. The extra head of water on the circulating pump makes this inadvisable, however.

Experiments on Schutte & Köerting nozzles of sizes known as 3, 2 and 1 inches have been carried on at the Massachusetts Institute of Technology since 1908; and at the present time two other types of nozzle are being tested. The nozzle under test is placed at the center of a flat roof about 44x40 feet, sloping 1 foot in 10 feet, and the water caught on the roof is drained into tanks and weighed. The discharge through the nozzle is figured from the pressure shown by a gage attached to a piezometer just beneath the nozzle, the coefficient for each nozzle having been determined by exhaustive tests made in the laboratory. From the tests on the Schutte & Köerting nozzles the following seem to hold true:

1. The temperature of the water after spraying is more dependent upon the temperature and humidity of the atmosphere and upon the fineness of the spray than upon the initial temperature of the water. Therefore, it is advisable to spray the water as hot as possible without excessive steaming.

2. At high humidities, say 80 or 90 per cent., the temperature of the water may be lowered to within 12 or 13 degrees Fahrenheit of the temperature of the air, with a total drop in temperature of 35 to 40 degrees Fahrenheit.

3. At low humidities, of 20 to 30 per cent., the temperature of the water after spraying may be as much as 8 degrees below the temperature of the air and the total drop in temperature 40 to 45 degrees Fahrenheit.

4. The loss of water by evaporation is approximately 0.15 pound per degree lowering of temperature per 100 pounds of water discharged, or a gross loss of about 6 per cent. for 40 degrees Fahrenheit lowering of temperature. In no case was the loss found to exceed 7 per cent.

The discharge from these nozzles was found to be as shown in the following:

DISCHARGE FROM NOZZLES UNDER TEST

Head in Feet at Base of Nozzle	Cubic Feet per Minute for 1-Inch Pipe. Diameter of Nozzle at Tip = 0.406 Inch	Cubic Feet per Minute for 2-inch Pipe. Diameter of Tip = 0.800 Inch	Cubic Feet per Minute for 3-inch Pipe. Diameter of Tip = 1.181 Inches
25	1.782	6.736	14.83
30	1.952	7.379	16.24
35	2.109	7.971	17.54
40	2.254	8.521	18.75
45	2.391	9.036	19.89
50	2.520	9.526	20.97
55	2.643	9.991	21.99
60	2.761	10.44	22.97
65	2.873	10.86	23.91

Cooling Ponds and Spray Nozzles

When there is a natural pond of moderate size adjacent to a power plant, sufficient cooling may be obtained by spraying all or a part of the condenser discharge, the cooling from the surface of the pond being of considerable assistance.

Cooling Ponds

Unless the pond is of considerable area the cooling from mere surface contact with the air is not usually sufficient to keep the temperature from rising, especially on hot damp days.

Bonom Steam Turbine

A brief description of a new development of the radial-flow turbine, showing the steps taken to secure a maximum number of expansions in a machine of comparatively small diameter and short length.

In the development of the steam turbine which has been more rapid than that of any other prime mover a great diversity of types has been evolved. In the axial flow in order to get the largest possible number of expansions it has been necessary to use designs involving rotors of either comparatively great length or of large diameter. In the radial flow the diameters have been large, and of comparatively low rotative speed. The Bonom turbine is a radial-flow machine of comparatively small diameter and short length and consequently capable of a high degree of rotative speed or of containing within a small space the number of stages necessary for efficiency at low speeds.

If the long rotor and case of an axial-flow turbine could be compressed accordion fashion into a series of rings of uniform diameter with deep recesses between, and with buckets or blades on the sides of the rings running between the redirecting buckets of the case it would in a way illustrate the Bonom idea of turbine construction.

The idea of the turbine is shown in the longitudinal and cross-sections, Figs. 1 and 2, the latter consisting of eight partial sections through the correspondingly numbered planes of Fig. 1.

At the left of the casing is the inlet chamber or steam chest extending entirely around the case furnishing steam to the ring of nozzles, which are opened and closed by a perforated ring valve under the control of the governor.

These nozzles are of the convergent-divergent type designed for a considerable initial fall of pressure with the production of a high jet velocity. They are shown in the section *I—I* of Fig. 2 which shows also the three rows of blades, the middle one stationary and the two others moving, through which this velocity is abstracted. The initial stage is thus of the double-velocity or Curtis type, expanding the steam to such a volume that even with full admission, that is, with steam admitted through the full circumference, the first blades may be of considerable size. This reduces the proportion of clearance to blade area, and the low pressure attained by expansion in the symmetrical nozzles reduces the tendency to leak by the blades in the later stages.

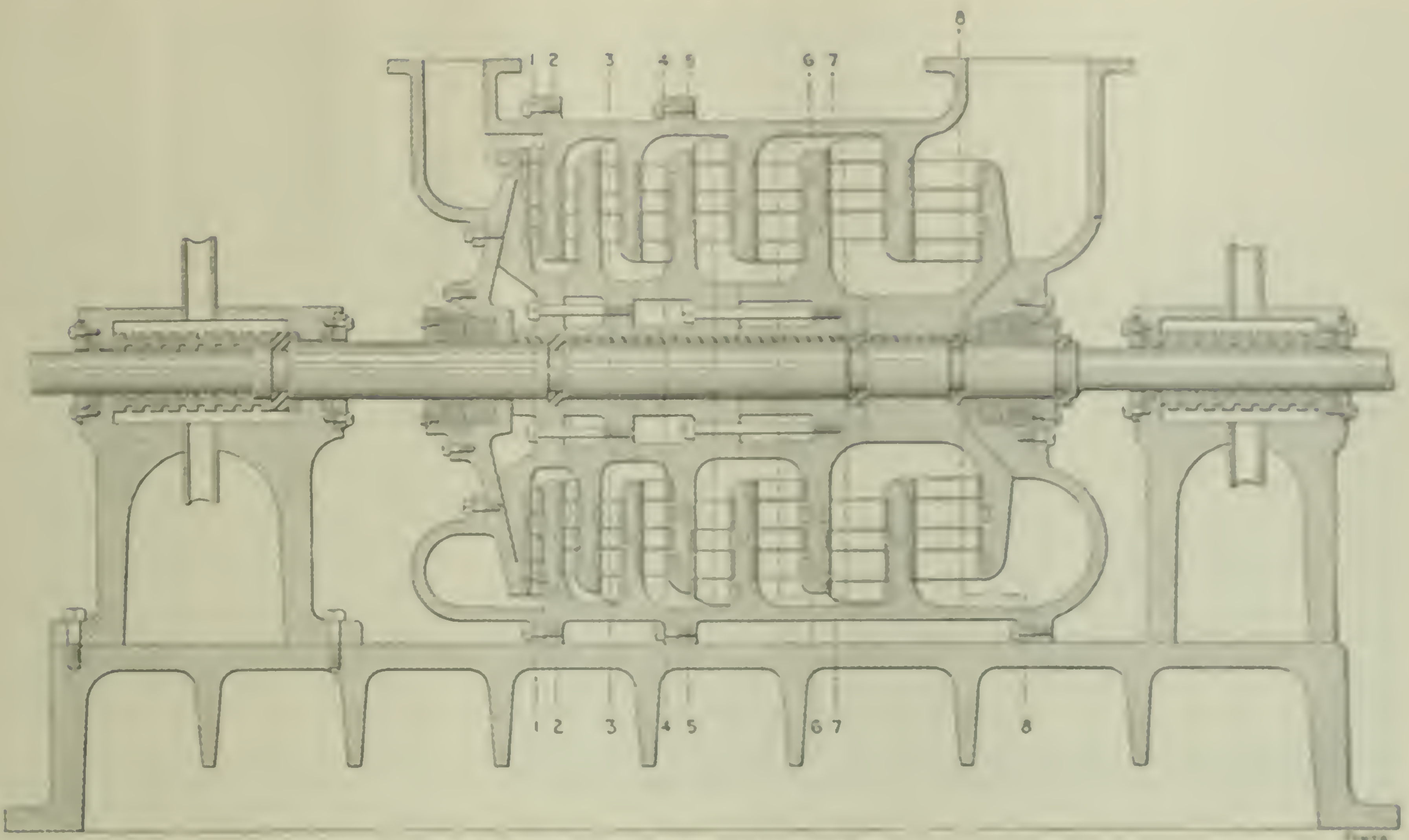


Fig. 1. Sectional View of Binom Steam Turbine

After the first stage the type becomes that of Parsons with continuous expansion through the constantly increasing passages of alternately rotating and fixed rows of blades. The peripheral velocity of the blades would be different, according as they were nearer to or farther from the shaft; but if the design favors those having the mean velocity it is suggested that a change in speed will improve the efficiency of those to one side of this line while diminishing that of those upon the other and thus permit a considerable change in speed with small variation in torque or efficiency.

Both the moving and stationary vanes are secured in dovetail grooves and are provided at the outer ends with lips which connect one to the next and form a complete shroud which except for the necessary mechanical clearance closely fits an annular groove at the opposite side of the chamber, making a smooth continuous path for the steam and preventing the in-

Fig. 2. Partial Cross-sections through Lines 1-1 to 8-8

Fig. 3. Blade and Method of Attachment

cape of steam around and over the ends. This is clearly seen in Fig. 1, while Fig. 3 shows the form of the buckets and their arrangement, both in the stationary and moving parts.

Fig. 4 shows the disassembled stator rings, and Fig. 5 the rotor rings reassembled on the shaft, giving a clear presentation of the progressive increase in the volume provided for the expansion of the steam as it gives up its energy in passing through the successive stages. In the stator ring at the right in Fig. 4 the first set of directing nozzles is plainly shown. Around the outside of this circle of nozzles there is another ring with perforations corresponding to the entrance openings of the nozzle which under the control of the governor is advanced or retrograded as the load demands, throttling the steam for light loads or giving a wide opening for heavy ones.

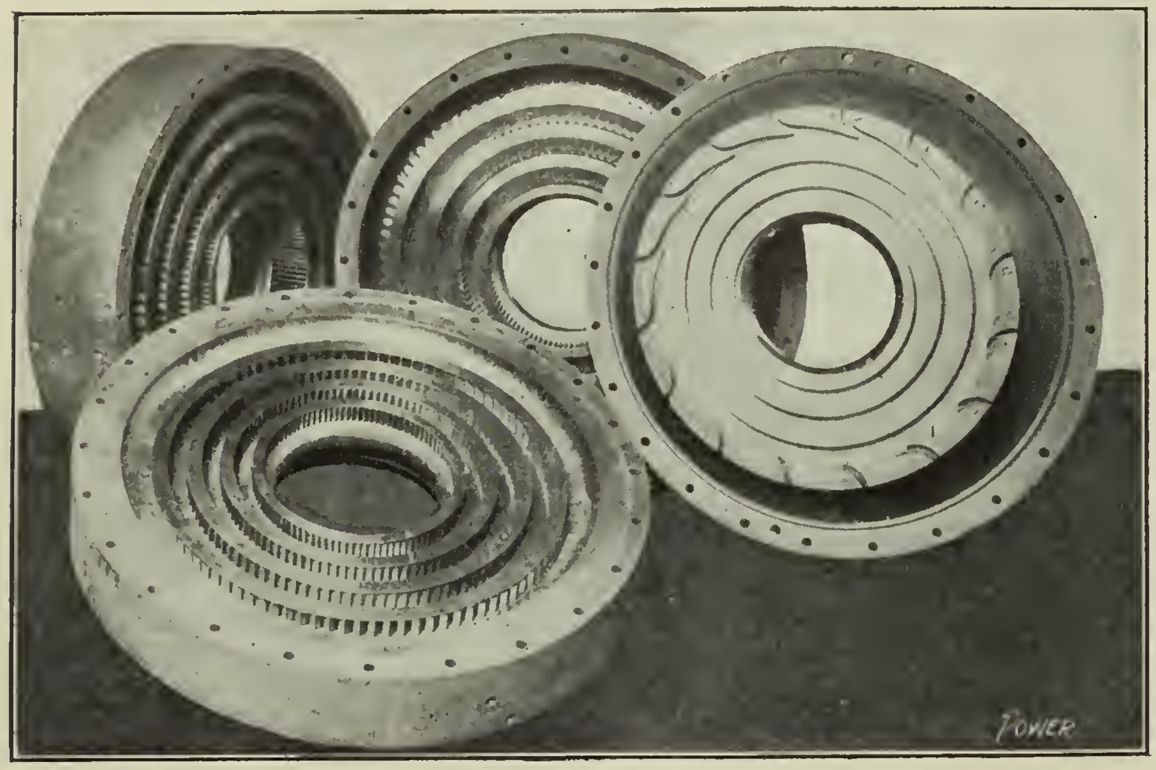


Fig. 4. Disassembled Stator Sections

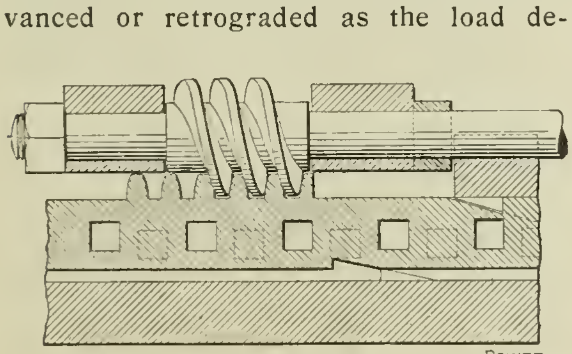


Fig. 6. Circumferential Valve

Fig. 6 is a short section, showing the construction and method of operating this admission ring which may be called the circumferential valve. This valve is moved circumferentially by the worm and is also guided in a sidewise direction by angle blocks which cause the openings through the valve to approach and pass over the entrance openings of the nozzle diagonally until full opening is obtained when the valve reaches full travel.

The drawings submitted do not show any provision for balancing the end thrust resulting from the differences of pressure on opposite sides of the rotating disks. This may be done by the use of a dummy piston which may be small on account of the absence of high-pressure steam in the bladed portion of the case; by reversing the flow and making the pressure act toward the nozzles in the later stages, or by splitting the turbine into a double-flow, a procedure favored by the original acceptance of the initial-velocity stage.

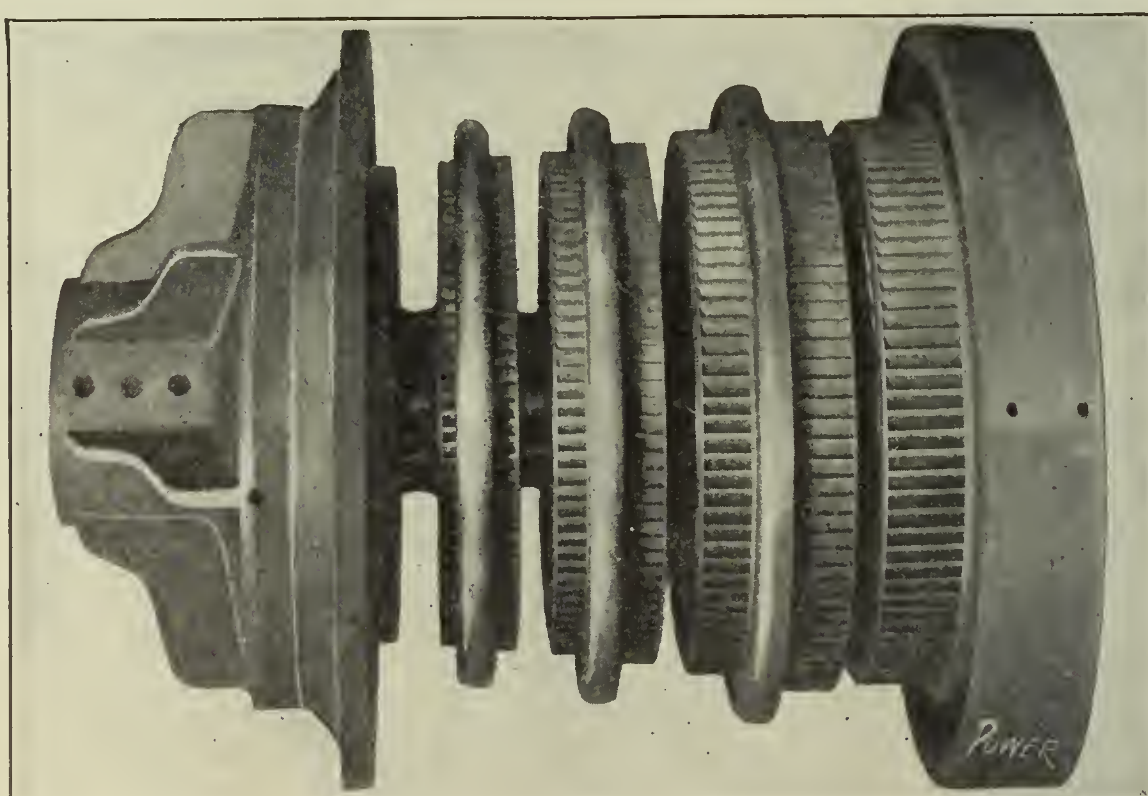


Fig. 5. Rotor Showing Progressive Increase in Width of Blades

It is intended to build these machines in convenient commercial sizes for all classes of work.

The inventor is Alfred Bonom and the turbine is handled by the Bonom Turbine Company, Central Bldg., Paterson, N. J.

The Value of the CO_2 Recorder

By H. S. Vassar

In a recent issue of Power there appeared a letter headed, "Economy in the Boiler Room," which called attention to the need of boiler-room records, especially in the case of electric-power plants. The article was a timely one, bringing out many points which certainly require watching if economies are sought.

I noticed, however, that more stress was laid on flue-gas analysis than on daily coal and water records. Personally, I am inclined to the opinion that without the latter, CO_2 records are of little use. Now, I have no quarrel with those who have so ingeniously devised automatic devices for flue-gas analysis as I fully believe that such instruments have a proper place in many boiler rooms. There are, though, other plants in which CO_2 apparatus has been installed with no facilities for daily coal and water weighing.

Such a condition reminds me of a hungry man who, neglecting the more substantial viands on the table, attempts to satisfy his appetite with pudding or pie. CO_2 enthusiasts often assume that a knowledge of the percentage of CO_2 carries with it something definite concerning the amount of air. While this is true of *excess* air it is not true of the converse, that is, CO_2 records tell nothing about an *insufficient* air supply, resulting in the formation of CO. Unfortunately, high CO_2 is frequently accompanied by a greater or less percentage of CO, the loss due to which sometimes more than offsets the gain due to the low excess-air volume indicated by the high CO_2. Therefore, while high efficiencies cannot be expected with low

CO_2 it does not necessarily follow that high CO_2 is accompanied by economical combustion. In other words, the indications of the automatic CO_2 machines appear to me to be largely negative.

After several years' experience with flue-gas analysis and boiler testing, I do not believe that CO_2 records are at all dependable as measures of furnace efficiency. In support of this contention Figs. 1 and 2 are submitted. These charts

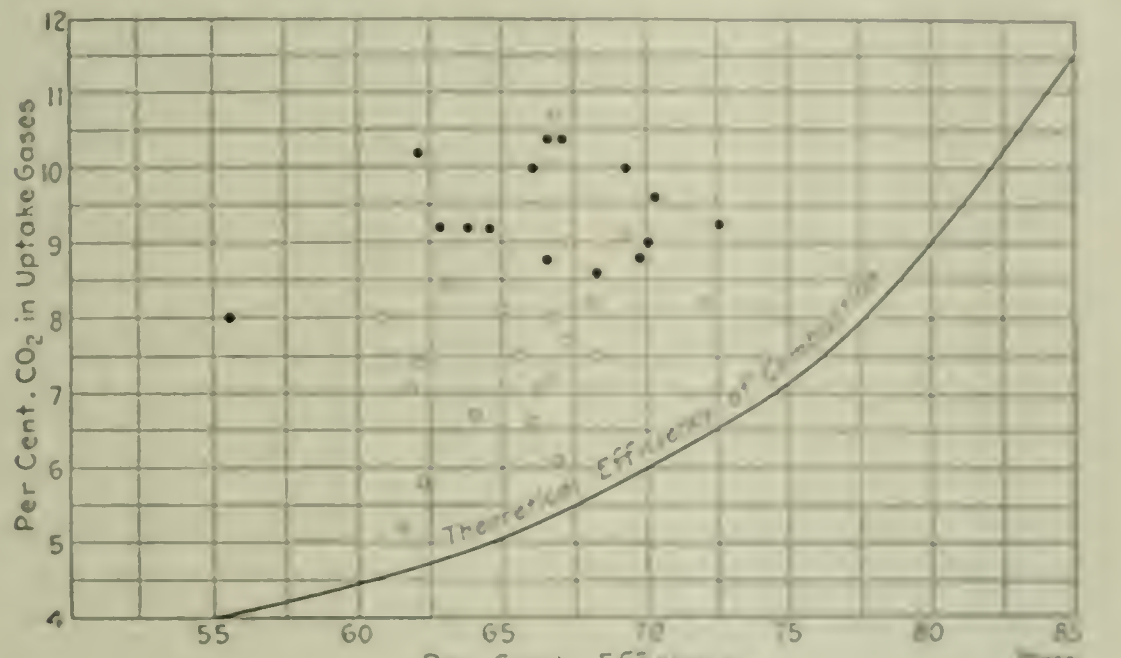


FIG. 1. COMPARISON OF CO_2 PERCENTAGE IN UPTAKE GASES AND EFFICIENCY OF COMBUSTION

were made to establish, if possible, some relation between the percentage of CO_2 in the gases of combustion and the combined boiler and furnace efficiency. They show the results of two series of 8-hour tests on Babcock & Wilcox boilers equipped with mechanical stokers of the inclined type. The tests of the first series, indicated by the black points, were all made on the same boiler and with the same fuel but with various changes in the grate equipment, draft, air admission, etc. In the tests of the second series, indicated by the open circles, several different fuels were burned. All of the coals used were Pennsylvania semi-bituminous.

The CO_2 figures are from continuous samples taken throughout the various tests. In Fig. 1 the samples were from the uptake while in Fig. 2 they were from the top of the first pass. The points at which the samples were collected and the apparatus used were the same in all cases.

The curves showing the theoretical efficiency of combustion were plotted from data given by several different manufacturers of CO_2 instruments and are supposed to show the efficiency of combustion as indicated by the CO_2 content of the flue gases.

I have also used other sets of test figures in the attempt to prove the value of CO_2 records, but with no better results than in the case given.

A word also relative to the paying of bonuses to firemen, based on their CO_2 records, may not be amiss. Two firemen handling boilers side by side may secure results something as follows: "A" burns 2000 pounds of coal in a given hour under his boiler with a CO_2 record of, say, 7 per cent. "B," who fires the adjoining boiler, may burn only half that amount of coal with correspondingly small steam output, but his CO_2 record may be 12 per cent. In other words, "A" does the work and "B" gets the glory and the cash. I do not say that such methods are followed, as, in plants where the system is in use, the supervision is such as to preclude tricks of this kind but, if it lies within the power of the individual fireman to alter his conditions of draft or air supply, such a thing could be easily brought about.

Some of those who have studied the matter of boiler-room management maintain that the chief value of CO_2 recorders lies in the increased attention which is given to the boiler room rather than to the records obtained. In these days, when we hear CO_2 recorders talked of on every side, perhaps some are a little timid about questioning their value. It reminds me of a fairy tale read during my boyhood. The story ran somewhat as follows:

Two strangers, pleasing in appearance and glib of tongue, appeared one day in the court of a certain king, announcing that they were the sole manufacturers of a most beautiful fabric for royal robes. Indeed, its texture was so wonderfully fine that it was rendered invisible to all save the very wisest of men. Samples were displayed to the king who, at a fabulous price, ordered a robe of the material. For days and days weavers worked at their looms weaving airy nothings from nothing. At last, the great day came when the king was to appear before his people arrayed in the wonderful robe which only the "wise ones" could see. Loud were the exclamations of admiration from his awe-struck subjects.

But, at last, a little child who had not yet become as worldly wise as his elders piped out, "But the king hasn't any clothes on at all."

Once more I would not be understood as condemning all gas analysis nor would I "damn with faint praise," but from experience and observation thus far I believe that there are other practical aids to economical operation which should be in every boiler room before the CO_2 recorder. An Orsat or other type of hand apparatus for gas analysis can be purchased for one-tenth part of the cost of a recorder and will often accomplish just as much.

I have not thus far even mentioned the difficulties involved in keeping a recorder in condition for use. Some of those who now have recorders in operation could doubtless write a volume on that subject.

Perhaps this will "start something."

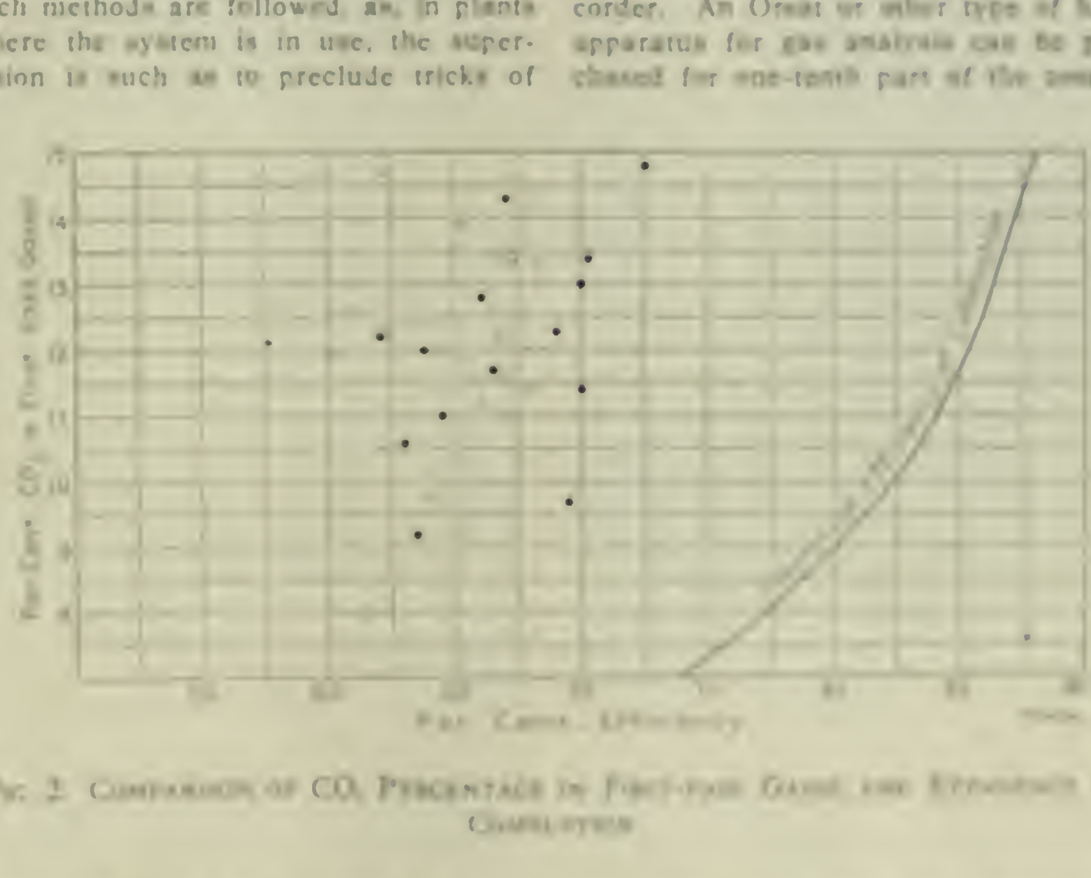


FIG. 2. COMPARISON OF CO_2 PERCENTAGE IN FIRST-PASS GASES AND EFFICIENCY OF COMBUSTION

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

The Care and Operation of Storage Batteries

By Norman G. Meade

An electric storage battery is a combination of cells, each of which is a unit. In the ordinary type a cell is made up of three parts: the jar, the plates and the electrolyte. The jar may be of any good nonconducting and acid-proof material of sufficient strength and rigidity to support the plates and the electrolyte. In the smaller stationary types the jar is generally made of glass or hard rubber. Large cells for central-station work have containing tanks made of heavy planks well joined and lined with sheet lead.

The plates are of two kinds, termed positive and negative, placed alternately, and the number of negative plates is always one more than the number of positives. The group of plates contained in one jar or tank is commonly known as an "element." All of the positive plates in one jar are connected together and all of the negative plates are similarly connected, but the positive plates are separated from the negative plates by insulating strips.

Storage batteries of the ordinary lead-sulphuric acid type are divided into two general types: the Planté and the Faure. Both consist of lead elements in dilute sulphuric acid but the plates are prepared differently. The Planté type of plate is constructed of solid sheet lead so fashioned as to present a large surface area to the action of the electrolyte; the active material is formed on the plates, either electrically, by charging and discharging, commonly called forming, or chemically.

In the Faure type the active material is applied mechanically to lead conducting plates or grids; for this reason the Faure battery is commonly called the "pasted" type. The active material may be in active condition when applied or it may be in such condition that it must be converted into active material by electrical or chemical formation. The positive plate is made of lead upon which a coating of peroxide of lead has been formed or mechanically applied. The negative plate is made of pure lead with a very spongy or porous surface. The peroxide and spongy lead are the portions of the plates which are subjected to chemical action and therefore constitute the active material; the plain lead body of each plate serves as a support for the active material.

The chemical condition of the plates and electrolyte changes when the cell is charged and discharged. At full charge the positive plates have a rich dark-brown coating of peroxide of lead, and the negative plates are a dark slate color. In this condition an electromotive force is set up in the cell, and if the positive and negative terminals be connected through an external circuit, a current will flow through that circuit from the positive to the negative terminals of the cell. When discharged, the positive plates are of a reddish brown or chocolate color and the negative plates a light slate color.

During discharge, the active materials are partly converted to lead sulphate at the expense of some of the acid of the electrolyte, so that the latter becomes weaker. The strength of the electrolyte at any time, compared with its strength when the cell is fully charged, is an approximate indication of the extent of the discharge. The specific gravity should not be more than 1.2 when fully charged nor less than 1.13 when discharged. It decreases proportionately as the cell discharges. The voltage of a cell on open circuit, that is, with no current flowing, is approximately 2.1 volts. This value is reached very shortly after either charge or discharge ceases, though it is somewhat influenced by the strength of the acid, temperature and, to a minor extent, by the state of charge. During discharge the voltage drops, the rate of decrease depending on the rate of discharge and its duration. Toward the end of discharge, the voltage falls off rapidly; when this point is reached the cell should not be further discharged. Conversely, during the charging period the voltage rises. Toward the end of the charge the rise of voltage is quite sharp and, the conversion of the lead sulphate formed during the previous discharge being fairly complete, the water of the electrolyte begins to decompose into its elements, hydrogen and oxygen. When the charge is complete, practically the entire input of electrical energy is used in effecting this decomposition and vigorous "gassing" ensues; then the strength of the electrolyte and the voltage cease to increase.

All of the materials of the plates, the lead, spongy lead, lead peroxide and lead sulphate, are practically insoluble in the sulphuric acid of the electrolyte, especially when there are no traces of other acids present. For this reason the plates are quite permanent. Great care is taken to attain the maximum purity of all materials of the plates and electrolyte so that the action described will not be undesirably varied or modified.

The lead sulphate formed during discharge has a greater volume than either the spongy lead or the lead peroxide; consequently, there is expansion and contraction of the active materials. The lead peroxide of the positive plate being somewhat noncohesive, it is gradually ground up and during the subsequent gassing at the end of charge some of it falls off, forming sediment. In the normal action of the cell the lead underlying the lead peroxide is very slowly corroded, forming new active material. With proper operating conditions the amount of new active material thus formed should balance the amount which falls off as sediment. The spongy lead of the negative plates being quite cohesive, it does not fall off if the cells are kept free from short-circuits and foreign materials, but it gradually becomes somewhat more compact and through the diminution of its porosity the capacity decreases. The rate of this decrease is greatest at the start and finally becomes very small. The negative plates are given sufficient initial capacity to provide for this shrinkage. If, in time, these plates show less than their rated capacity, they may be reversed by separately charging, with the proper precautions. This process causes the material to again expand and the initial capacity is restored.

In the action of the cell some water is lost through decomposition toward the end of each charge; this evaporation is made up by adding pure water to the electrolyte. It is usually necessary to add acid only when cleaning and removing the sediment. As already intimated, both the acid and the water used for making the electrolyte and replenishing it must be as near absolute purity as possible. Foreign acids (organic impurities are usually converted to acids in the action of the battery) must not be allowed to get in; they lead to rapid corrosion of the positive plates. Other impurities lead to local actions with consequent loss of charge and must therefore be avoided.

If a lead-acid cell is allowed to stand partly or wholly discharged for any length of time, the normal action is also departed from, especially at the positive plates. The active material is with difficulty converted back to peroxide and the underlying lead may be rapidly corroded under certain conditions. Charging should therefore follow a discharge as soon as practical.

FIG. 1. SAND TRAY

CELL STRUCTURE AND MOUNTING

Storage-battery cells for light and power plants are usually provided with either glass jars, glass tanks or lead-lined wooden tanks. The smaller cells are usually put in glass jars each of which is set on a bed of sand contained in a glass or wooden tray; the sand tray is supported by four glass insulators placed under the corners, as shown in Fig. 1. Cells of medium capacity are usually built with tanks of pressed glass; no sand trays are used, the glass tank resting directly on the glass insulators except for small cushions of either lead or rubber interposed to keep the hard surfaces of the two glasses out of contact.

Cells of the glass jar or glass tank type are the easiest to install because the plates are grouped at the factory. The plates of each cell are connected by cross-bars and terminal straps of lead, the negative plates to one cross-bar and the positive plates to the other as shown in Fig. 2. The plates and straps are connected by "burning." The cells are connected to each other by bolting the lead terminal straps together with lead-covered brass bolts.

Lead-lined wooden tanks are often used for plates of medium size and always for those of large size. The plates of this type of cell are grouped at the place of installation by lead-burning the lugs of the positive plates to a common bar and the negative plates to another bar. Fig. 3 shows how a tank cell of this type should be mounted.

All types of storage cell are usually installed with the supporting insulators resting on wooden stringers, these stringers having been previously covered with two or three coats of acid-proof paint. Cells of smaller types which are not too heavy are generally installed on two-tier wooden racks in order to economize floor space. The large cells are installed all on a single level, the wooden stringers being supported by vitrified brick set upon the floor or by another set of glass insulators resting on vitrified tiles.

Batteries should be installed in rooms especially prepared for them. The rooms should be dry and arranged for maintaining a moderate temperature during cold weather, otherwise the capacity of the battery will diminish by reason of the reduction in temperature. The batteries should also be located so that they will not be subjected to artificial heat during

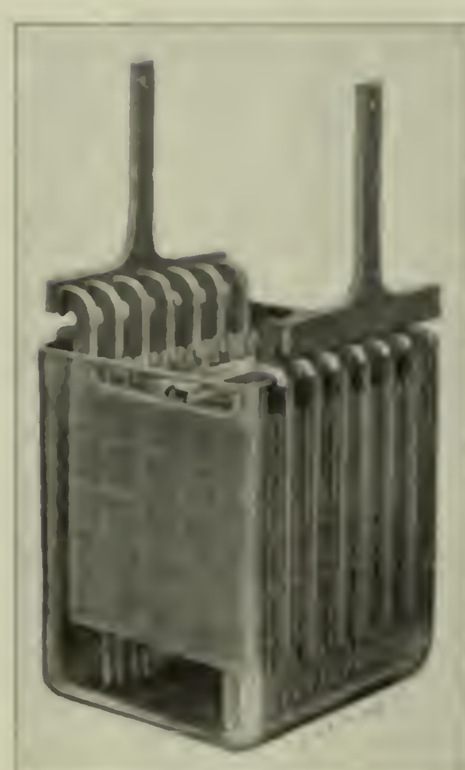


FIG. 2. CELL IN GLASS JAR

the summer and the temperature thereby raised above that of the external air.

Provision for ventilation and the removal of acid fumes should be made. The floor should be of asphalt, tile or cement, the last-named being the least desirable, and should slant slightly toward discharge drains in the floor. All copper work should be coated with tin or lead and all other metal work should be covered thoroughly with an acid-resisting paint. The cells should be arranged so that each one may be easily inspected and tested.

INSTRUMENTS AND IMPLEMENTS

For the proper care and inspection of the batteries certain accessories should be provided. One of the most important of these is a low-reading voltmeter with a range of zero to three volts; it should be accurate and of such design that its needle quickly comes to rest. A substantial thermometer should also be provided in order that the temperature of the electrolyte can be ascertained. Its mercury bulb should not be too thin; if broken while in a cell, the mercury would damage the tank lining and the plates. A hydrometer is indispensable because its use is for testing the strength of the electrolyte, which must be done frequently. It comprises a weighted glass bulb with a long graduated stem and is used in the following manner: Some of the electrolyte is siphoned out of the cell to be tested into a tall cylindrical jar, large enough in diameter to contain the hydrometer; enough liquid is withdrawn to float the hydrometer. The number on the scale of the hydrometer at the point where the liquid surface is in contact with the stem is the specific gravity of the liquid, expressed in degrees. The specific gravity varies with the temperature and it is therefore necessary to reduce the readings to a standard temperature, which is taken as 70 degrees Fahrenheit. The correction is approximately 0.001 degree specific gravity for each three degrees by which the actual temperature differs from 70 degrees; the correction is added if the liquid is warmer than 70 degrees and subtracted if it is cooler.

A convenient means for ascertaining the specific gravity is a hydrometer syringe, which consists of a glass tube about an inch in diameter, one end of

FIG. 3. METHOD OF MOUNTING A WOODEN TANK

which is drawn down to a nozzle of small diameter to take a rubber hose, and the other end is closed by a large rubber bulb. A hydrometer is contained in the barrel of the syringe and by squeezing the bulb, inserting the rubber tube in the electrolyte and then releasing the bulb, sufficient acid can be drawn into the tube to cause the hydrometer to float and give a reading.

Soldered joints cannot be used in the [illegible] rooms and [illegible] connections outside of the cells must be practised with caution. Soldering fluxes must not be allowed to get into the cells even in the minutest particles. In repairing, all joints must be made by lead burning. In this process a hydrogen flame is used which frees the melted lead from any slag, whereupon it welds readily. The hydrogen generator and the balance of the outfit can be obtained from dealers in storage battery supplies but it must be employed only after thorough instructions, as accidents may readily result through ignorance of the precautions to be taken.

In making bench tests of a battery it is advisable to know the relative condition of the positive and negative plates of the different cells. This may be done on the discharge of the battery by reading the voltage between either group of plates and an auxiliary electrode, preferably of cadmium, immersed in the electrolyte but not allowed to touch the plates. Cadmium can be obtained in sticks about a quarter of an inch in diameter and 6 inches long. One end of the stick should have a terminal wire soldered to it and over the other end should be drawn a piece of perforated pure soft-rubber tubing long enough to cover about three-quarters of the length of the stick. It should always be immersed in a glass of electrolyte for several hours before using. Cadmium sticks, properly made up, can be procured from storage-battery supply dealers and manufacturers.

The Electrolyte

It is always preferable to purchase the electrolyte already mixed and of guaranteed purity. If, however, concentrated acid is used in preparing electrolyte, the latter should be made by pouring one volume of pure concentrated acid of 1.84 specific gravity into about five volumes of distilled water. The vessel used for mixing should be preferably a lead-lined tank unless the quantity is small; then a vessel of hard rubber, earthenware or glass is suitable. In mixing the electrolyte, always pour the acid into the water very slowly and constantly stir the mixture, as much heat is generated by the mixing of acid with water. Never pour the water into the acid, as the resulting splashing is liable to cause painful and dangerous burns. The solution must be left for several hours to cool. Never add hot or even warm electrolyte to a cell, as the plates are liable to be very badly sulphated by so doing. The strength of the electrolyte should always be tested by a hydrometer reading, reduced to 70 degrees Fahrenheit. It is always advisable to use distilled water for the preparation and replenishing of the electrolyte because ordinary city water usually contains foreign substances of an objectionable nature.

Charging

As soon as the electrolyte is poured in the cells, charging should begin, because it hurts the plates to stand in the liquid without being charged. The first charge should be carried on for a much longer period than the subsequent or working charges, as it virtually completes the formation of the plates.

The positive terminal of the generator must be always connected to the positive terminal of the battery. The charging process commences at about 2 volts per cell and rises to approximately 2.6 volts at full charge while taking current at the normal rate specified by the maker. The first charge should be continued for at least ten consecutive hours, and twenty or thirty would be preferable. The first charge is usually about twice the capacity of a battery, and should be made at the normal current rate.

The specific gravity of the electrolyte will drop during the first few hours of the first charge but will rise again as the process continues; its maximum point is reached at full charge.

As the charge nears completion, bubbles will rise from both plates and the charging current should then be reduced, as the active material is almost fully formed and therefore cannot take up all the gas set free from the decomposition of the acid at the normal rate. As the amount of the gas liberated is in proportion to the current flowing, gassing will decrease when the current is decreased. It will take from twenty to thirty charges to fit a new battery to give its full capacity, and it is well to charge for 25 per cent. longer time at the normal current rate for the first few months. In ordinary work the battery will retain its normal condition with a charge of 10 per cent. in excess of the discharge.

During ordinary charging the normal rate or lower should be used, except in case of emergency. Under normal conditions 2.5 volts may be considered full charge, although the battery can be charged higher than that. After repeated charges, the water in the electrolyte will have evaporated to such an extent that the reduction in volume will expose the top of the plates unless water is added; this should be done through a hose or tube reaching to the bottom of the cell, as water added otherwise will stay on top, being lighter than acid.

Although it is not always the most economical procedure, the highest efficiency and longest life are obtained when the battery is charged slowly, never exceeding the normal rate. Conditions of plant operation will determine the most economical practice for each installation.

Discharging and Care

When discharging at the normal rate a battery should never be discharged below 1.8 volts per cell. In discharging at a higher rate than normal, however, 1.8 volts per cell will be reached before the battery is discharged to the same condition as at normal discharge, owing to the internal resistance producing a greater drop of potential, in accordance with Ohm's law.

The battery cells must be kept clean and the terminals covered by a coating of vaseline. Corroded copper, iron or any other foreign materials must not be allowed to get into the cells. If through accident this occurs, all of the electrolyte in such cells must be thrown away and new electrolyte put in them. Matches or exposed flames of any kind must not be allowed near a battery, especially when it is being charged, because the gases then given off are combustible and, if sufficiently concentrated, explosive. Temperatures higher than 100 degrees Fahrenheit should be avoided because the corrosion of the positive plates is accelerated by such temperatures.

Each cell should be tested with a voltmeter and hydrometer once a week. Any cell showing low voltage should be examined thoroughly for any foreign substance that may have short-circuited it. This will be indicated by a low specific gravity and deficiency or absence of gassing, the voltage rising slowly at the end of a charge when it should rise rapidly.

When inspecting and overhauling battery cells it is best to have them in a suitable battery house, placing the cells on a bench. Any sediment should be removed and the deficiency of electrolyte resulting from the sediment removal should be made up by the addition of fresh electrolyte.

Cells in poor condition can always be recognized through certain characteristics. The plates may be of poor color; the color of a wet positive plate in good condition varies from rich dark brown, almost black, when the plate is fully charged, to a reddish, chocolate brown when discharged. A light grayish coating on the positive plate is not a bad indication if by rubbing with a clean stick or a piece of hard rubber the proper color is evident under the surface. The color of dried plates is much lighter. Wet negative plates are of a light slate-gray color when charged and somewhat darker when discharged. When dry they are considerably lighter and may be even somewhat yellowish if allowed to heat in drying. If the color of a plate is not as described, it is probably sulphated. If the voltage of a cell is conspicuously lower during discharge or higher during charge than it should be, sulphating (the formation of lead sulphate on the active material or between it and the lead supporting grid) is indicated. If the strength of the electrolyte is low, the cell should be investigated for short-circuits or sulphated plates. Always be sure that the sediment does not touch the plates; it must be removed as soon as there is danger of contact occurring.

Usual Causes of Trouble

Plates may get in poor condition from any of the following causes:

Impure Electrolyte—This may be due to a poor quality of acid being used at the start or to the use of impure water or to foreign substances getting into the cell. The remedy, if the plates are in fair physical condition, is to displace the old electrolyte with new when the cell is in the discharged condition and then to give the battery a thorough charge.

Short Circuits—These are not frequent if the sediment is removed before it reaches the plates. When they do occur, the cell should be completely dismantled, the plates straightened and the cell assembled again, the separators being completely replaced. The cell should then be thoroughly charged.

High Temperature—At a temperature above 100 degrees corrosion is rapid. If it be possible to prevent it, the temperature should not exceed 90 degrees. The positive plates may be sulphated considerably from this cause and be considerably distorted. If they are thoroughly corroded, they must be displaced by new ones; if not, they should be discharged, straightened and recharged. The conditions should be changed so that the battery will not again be subjected to high temperature.

Standing Discharged—The positive plates are especially liable to be badly sulphated from this cause. The indication of this condition is a light color of the positive plates, possibly with blotches of grayish color. The remedy in this case is also a complete charge, though care must be taken that too much active material is not thrown off during the charge. The active material under this condition sometimes becomes quite granular and noncohesive; if it comes off easily the cells must be alternately charged and discharged until the plates are restored to normal condition.

General

In all cases of recharging a cell after treatment, the charge should begin at the "starting" rate of current and be kept at this value until vigorous gassing begins. The current then may be reduced to the "finishing" rate, at which it should be maintained until both the electrolyte and the voltage have remained at constant values for six or eight hours. If too much active material is thrown off by the gassing of the cells, the charge should be discontinued and the cells discharged, the subsequent charge being carried out as explained in the beginning of this paragraph. This process is to be repeated until the plates are again of good color and in good condition. Charging rates less than the "finishing" rate must not be employed under any condition; low charging rates are especially injurious to cells in poor condition.

The excessive use of water in cleaning batteries should be discouraged; it causes the positive plates to sulphate and lose their charge rapidly. The plates may be rinsed by dipping each group into a comparatively large tank filled with electrolyte. A good procedure is as follows: First, see that the battery cells are fully charged and provided an extra tank or other container suitable for immersing the plates. Remove an element from its tank and take out the separators, making sure that the plates are free from any particles liable to cause short-circuits. Replace the old or apply new separators and rinse the element in the clean tank which has been previously filled with electrolyte of the proper specific gravity. Special care should be taken that the plates are kept out of the electrolyte as short a time as possible because the air coming in contact with the negative plates causes them to heat and lose their charge. If the transfer is quickly effected, this method will be very efficient. The battery should then be charged until the specific gravity has ceased rising and remains stationary for one hour. Should any of the cells not come up in voltage along with the others they should be disconnected from the battery and treated separately. The specific gravity of the electrolyte should then be adjusted to the proper strength. If time permits it would be well to make a capacity test to make sure that the battery is in serviceable condition.

If the method just described cannot be carried out, the positive plates may be allowed to stand in the air for several hours without any damage, as the plates dry out slowly and do not lose much of their charge. The negatives, however, must be at once immersed in water or electrolyte, preferably the latter, for the reason already given.

LETTERS

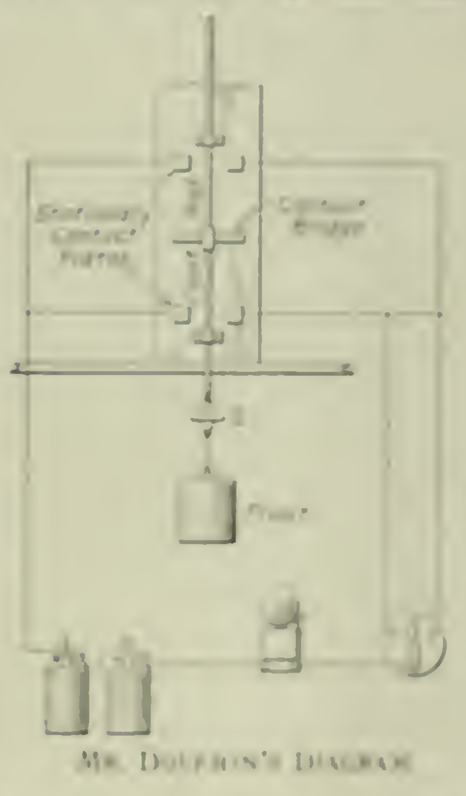
Water Tank Signal Systems

It seems to me that the water-tank signal system described in the March 28 issue may be improved as indicated by the accompanying sketch, which is practically self-explanatory. Only one bell is used instead of two and the battery wire has no motion and therefore no tendency to break off; moreover, provision is made in the insulating coupling S, to avoid grounding through the water.

The contact on the rod shown in the March 28 diagram is liable to turn away from the stationary contacts because the rod inevitably will revolve. The shape of the contact on the rod shown in this sketch will make such an occurrence impossible.

Alexander Dolphin

Jamaica, N. Y.



Mr. Dolphin's Diagram

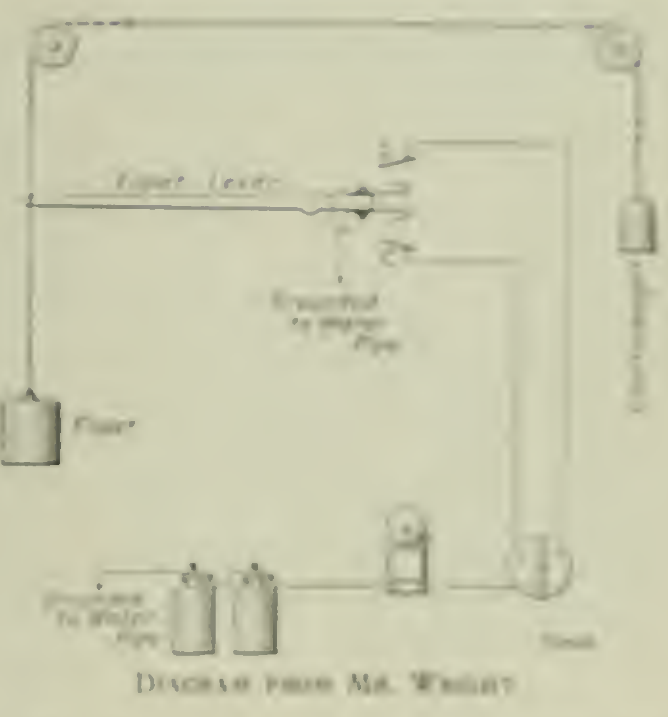


Diagram from Mr. Wright

The accompanying sketch represents a system that I installed some time ago and have been using satisfactorily ever since. It consists merely of a wooden lever pivoted near one end on which are mounted two contacts, made out of an old clock spring, and to the long arm of which are attached the float and counterweight suspensions. In line with the spring contacts are stationary contact plates C and C₁ connected to the two-wire bell switch. To allow the use of only one bell, that bell is connected between the switch and the battery, the return circuit is through the water piping instead of a third wire. The operation is obvious from the diagram.

John A. Wright

Jamaica, L. I.

[The use of one bell, connected as shown in both of these sketches, has also been suggested by Thomas W. [illegible], New [illegible]. It is, of course, preferable to the two bells originally shown.—Editor.]

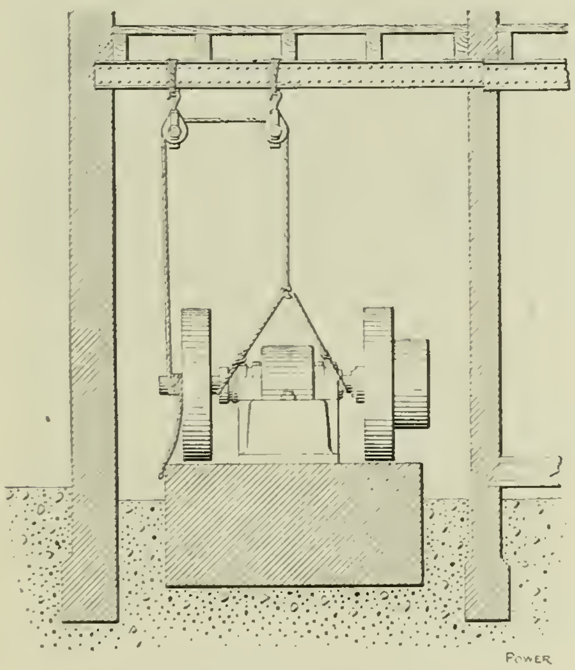
Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Making an Engine Lift Itself to the Foundation

By F. B. Hays

A short time ago I was called upon to set on its foundation a horizontal gas engine weighing about 1500 pounds. There was no crane, hoist, derrick or other lifting mechanism available, nor any means of installing anything of the sort if we had had any. The foundation bolts were very much out of alinement, due to a mistake on the part of the masons who built the foundation, so that the bolts would have to be sprung into the holes in the engine frame as it was let down into place. The space in which the engine was to be set was so small that only two men could work on the job at once, and there was no room to use pinch bars or levers long enough to be of any advantage. In short, the job seemed almost hopeless until the plan which we followed was devised.



Hoisting Itself

Just above the engine there was a heavy beam capable of supporting a couple of tons of weight. Two single-sheave pulley blocks were attached to this and a rope was fastened around the engine frame and run through the pulley blocks to the engine shaft, around which it was given several turns, as illustrated in the accompanying sketch. By revolving the flywheel of the engine, the shaft acted as a windlass and the engine could be raised or lowered with facility.

One man was placed at the flywheel to raise or lower the engine, while another one sprung the foundation bolts into the holes of the engine bed. By this means the engine was raised and lowered to its foundation with very little difficulty.

Development of the Gasolene Engine*

By Joseph C. Riley†

The development of the gasolene engine has been more rapid than that of any other form of motor, not even excepting the steam turbine. We all recollect with what curiosity, not many years ago, we regarded the new horseless carriages and how we wondered whether the noisy little engines which left a smell of half-burned gasolene behind them would ever become really desirable motors. The first part of this period of development saw radical changes in the design of these motors, but the use of light oil had come to stay. Although dangerously inflammable and five times as dear as the heavier grades of petroleum burned in larger oil engines, the cleanliness of gasolene and the ease with which it can be prepared for combustion are alone sufficient to dictate its use.

The gasolene engine has profited enormously by the rapid advance in all branches of mechanical work. Its own special improvements have been, for the most part, such as would naturally come from the thousands of ingenious designers, skilful mechanics and experienced motor-car drivers who have tested and tried it under all possible conditions of service. As a result, advancing by process of trial and error, the engine has reached a fair degree of perfection in two points at least: It has been made to develop greater power per unit of weight than any other form of prime mover and its reliability has been advanced to the stage which warrants its use even for such exacting service as propelling a lifeboat or driving a fire engine.

Little of this development, however, has been made possible by what may properly be called scientific study of the engine's performance. At first there was scarcely time for such work. The demand for engines was often greater than could be supplied, so the engineers' efforts were concentrated on increasing the factory output as fast as possible, consistent with a fair improvement in the product. The time for refinement in design had not yet come. Thorough trials of an engine with all its accessories were usually carried out to make sure that everything was assembled and adjusted well before the product was sold, but measured tests for anything except the power output—under somewhat uncertain conditions—were not considered necessary.

Aside from differences in general excellence of mechanical construction caused by variation in design, unquestionably there are inherent differences in the power developed by different engines and in their fuel economy. When operated at the piston speed corresponding to maximum power (a speed usually between 1100 and 1500 feet per minute) the best automobile engines give results nearly 50 per cent. better than those from the poor ones. But little of this discrepancy can be charged to imperfection of the mechanism causing surface friction, for even the cheaper motors are well built in this respect. It is influenced by the quality and quantity of explosive mixture, the amount of compression, the time and rapidity of ignition and the timing and size of the valves.

The interrelations of these many factors are very complex, but they may be summarized by saying that the power depends upon the pressure in the cylinder. The variation in the force behind the piston as it moves in and out is what does the work; the time at which pressure is applied and the rate at which it changes consequently determine the amount of work realized. The more we know about just how the pressure varies the better able we are to devise means for controlling its rise and fall and thereby producing a greater net output. The piston type of indicator has been of service in analyzing the performance of internal-combustion engines of moderate speed but for light-weight engines such as are used for driving automobiles, aëroplanes and small boats, the speed is

*Abstract of a paper presented before the Congress of Technology at the fiftieth anniversary of the granting of the charter of the Massachusetts Institute of Technology.

†Assistant professor of mechanical engineering, Massachusetts Institute of Technology.

much too high for any of the ordinary commercial forms of indicator. The natural cadence of vibration of the indicator springs and moving parts is altogether too slow for anything like such high speeds; the waves introduced into the diagram by violent explosions would be too long and might be misleading.

What is needed is a recording mechanism with a period of vibration of high frequency, more like that of the electrical oscillograph, say between 500 and 1000 per second. Moreover, if incorrect deductions are to be avoided, great care must be taken to insure that the indicator diagram starts from its dead points exactly in phase with the engine piston. Within the past three or four years optical indicators capable of producing satisfactory results at 1000 revolutions per minute and upward have been used in research work in a few technical schools and private testing laboratories. They cannot be handled successfully, however, except by skilled observers and in general they cannot be used at all with the engine in actual service. The engine must be mounted on a rigid testing block and studied under artificial, ideal conditions.

Little improvement in power can be expected from the best engines; they are already excellent. There are automobile and marine engines today, working on the four-stroke cycle, that give mean effective pressures above 100 pounds, even when driven at extremely high speed. On the other hand, there are small two-stroke marine engines, the mean effective pressures of which range anywhere from 85 down to less than 60 pounds, depending on how well or how badly the fuel charge is supplied, exploded and rejected. The energy wasted in getting the charge into a three-port engine, or in dragging it into the crank case against the pressure of a check valve with too tight a spring, or blowing it into the cylinder after needlessly high compression, materially decreases the horsepower output. In some of the poorer engines the entering charge is further obstructed by insufficient passages through the carbureter; the charge is not merely throttled, it is fairly strangled; the wonder is that it gets in at all. Crank-case diagrams from such engines would set the designers to thinking.

Between the better and the poorer designs of gasolene engines there are wide margins in power, to say nothing of fuel economy. The dynamometer shows that they exist, but it does not show whether deficiency in power is due to constricted passages, defective ignition and combustion, or any other definite fault. Now, the scientific way to remedy a defect of any kind is to begin by investigating first its magnitude and then its cause; and the instrument adapted to such a study in the case of the gasolene engine is the indicator—in the "half-size" pattern within limits and in the optical type beyond those limits.

With all fast-running reciprocating engines the necessity for arranging the cylinders to secure regularity of driving effort and for balancing the moving parts to prevent excessive vibration is apparent. Good mechanical balance is particularly desirable for the class of engines discussed in this paper. The best engines for automobiles, boats and aeroplanes give evidence of having been planned by men trained in the principles of dynamics, as well as in all other elements of mechanical design. Some builders, however, have but hazy notions on methods of balancing. In fact, they seem to associate vibration with the sudden rise in pressure due to explosion within the cylinder, as if the shaking of the frame were due to the shock of explosion. That vibration results from the motion of the masses and that it would be practically the same even if the cylinder heads were removed and the shaft were revolved by power supplied from some other source is new to them.

There are many problems which arise in the design of machinery which cannot be solved even approximately until after the machine is built and tested. The experience gained by operation of the first few imperfect machines then furnishes the information required for modifying and improving existing forms, in varying sizes and powers, and thus the machine is gradually perfected without the application of purely theoretical reasoning.

CORRESPONDENCE

An Inconsistent Engine

If the engine described by Mr. Hall in the March 28 issue does not run faster than normally when *all* the priming cocks are open, the mixture cannot be at fault, except in the unlikely event of each cylinder having a separate air intake. In this case it is possible that No. 3 is not getting enough air for some reason. The first thing to do is to verify the timing of the spark in No. 3 cylinder. It is possible that the spark is timed so as to cause slightly premature ignition and excessive back pressure is relieved by opening the priming cock. Preignition from incandescent deposits or from gas burning in pockets might be the cause of such back pressure, but as the engine is said to be in good condition, this does not appear to be likely to be applicable to this case.

The valve gear of cylinder No. 3 should next be gone over as to the timing of opening and closing and the amount of lift and compared with the settings for the other cylinders. If the valve motions are the same as for No. 2 cylinder and if Nos. 2 and 3 cylinders are fed by a symmetrical manifold from a centrally connected carbureter and No. 2 cylinder does not behave the same way, it is permissible to ignore the possibility of the nature of the charge or its distribution being to blame. If, however, the manifold is so shaped or the carbureter so located that No. 3 gets more than its proper share of gas, it is just possible that, provided all the compression spaces are of equal volume, with normal valve lifts and timing, the compression in No. 3 may be too high, and this, in conjunction with a rich mixture and early timing, might cause the trouble.

All these theories may sound rather far-fetched to those who are not acquainted by experience with the immensity of the range of vagaries that a gasolene engine can display on occasion; but as Mr. Hall did not give any data to enable one to eliminate anything and as I have never observed a similar stunt on the part of a gasolene engine, they are put forward for what they may be worth, which may or may not be much.

If Mr. Hall solves the problem it will be interesting to learn the cause of the trouble, how it was traced and how it was remedied.

John S. Leask.

Manchester, England.

Mr. Hall's trouble is probably due to faulty ignition. Should the charge taken into cylinder No. 3 not be fired, the engine would be working against the compression in that cylinder. Opening the pet cock on this cylinder would, of course, relieve the compression and reduce the amount of work that the remaining three cylinders have to do, thereby speeding up the engine.

Donald [illegible]

New Orleans, La.

Corrosion of Water Cooled Exhaust Pipes

I am in charge of a gas-power plant in which the engines were formerly arranged so that the exhaust gas was cooled by injection of water from the cylinder jackets. After a few months' operation the exhaust piping was so corroded by the action of what appears to be sulphuric acid that it had to be replaced.

I am now running without the water injection and obtaining good results as far as the exhaust piping is concerned. I would like to know if any other readers can tell me how to overcome this difficulty so that I can cool the exhaust gas without detriment to the piping. I have tried cast iron and wrought iron pipe with the same result.

Jas. W. Wick.

Garfield, N. J.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Isolated Power Plant Makes a Good Showing

The original mechanical equipment of the Missouri Baptist Sanitarium, St. Louis, Mo., consisted of two high-pressure return-tubular boilers, furnishing steam for heating and domestic purposes; light and power, however, were purchased from a central station. This arrangement was in force for over ten years.

During the year 1905, a small engine and generator were installed which furnished a portion of the light, and the results were so gratifying that a complete plant was installed during 1908. The new equipment consists of two return-tubular boilers of 100 brake horsepower each; two 60-horsepower, 10x11-inch piston-valve engines that drive two 35-kilowatt, 125-250-volt direct-current generators. The lighting load consists of 540 sixteen-candlepower lamps distributed throughout the institution, a motor load of 47 horsepower for operating laundry, elevators, ventilating apparatus, pumps, etc., a total load of 68 kilowatts.

The buildings are heated by exhaust steam, both direct and indirect methods being employed. The total heating surface is 11,282 square feet. The demands upon a plant of this type are exacting and require heat, light and power throughout the year. The entire equipment is in duplicate, and the service has been uninterrupted since starting the plant, nearly two and half years ago.

The cost of heat, light and power for the fiscal year of 1904, which was the year preceding the installation of the small generating unit, was $5955.09, and of the fiscal year of 1910, the second year after a complete plant was installed, the cost of operation, including cost of fuel, labor, all supplies, maintenance, etc., as charged on the treasurer's books, interest and depreciation on electrical equipment, was $4958.86, a saving in 1910 over 1904 of $966.23. These figures do not take into consideration the fact that the light, power and heat have been materially increased since 1904. For instance, the increase in the lighting load over that of 1904 is 54 per cent.; increase in connected power load over that of 1904, 92 per cent., and the increase in the heating system, 22 per cent.

The cost of heat, light and power for 1910, if electrical energy had been purchased, as in 1904, would have been $7444.86. The cost of this service from the isolated plant represents a saving of $2486.

In this instance the engines, generators and all additional equipment necessary for the electrical plant cost a little less than $6000. The saving in the fiscal year ending with September 10, 1910, over and above the cost of current and heat, if current had been purchased as in 1904, would show a net return on the investment, after allowing for interest and depreciation, of over 40 per cent.

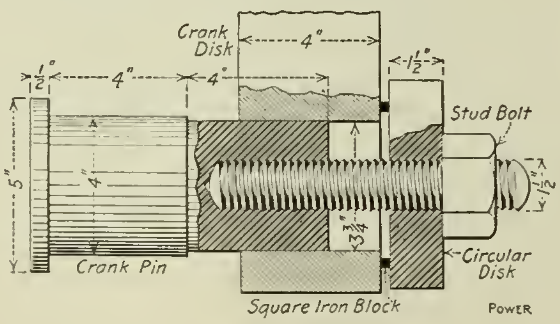
The present service is more satisfactory than the original arrangement, and the splendid showing is due to high-grade equipment and the intelligence with which it is handled.

VICTOR AZBE.

St. Louis, Mo.

Crank Pin Repair

The accompanying illustration shows a method used in putting a new crank pin in the crank disk of an ammonia compressor. The original pin became loose in the disk and a new one had to be fitted in as short a time as possible.



DETAILS OF REPAIRS

The new pin was made at a local shop and had a hole drilled and tapped in the center for a ½-inch stud bolt. The hole in the disk was reamed out 1/32 inch larger than the original hole in order to get it true; the pin was turned for a 20-ton pressure fit.

The pin was started into the hole and a washer put on the back side of the crank disk, with two pieces of square iron between them to act as distance pieces.

The stud, having been screwed into the pin, was slipped through a 1⅝-inch hole drilled in the circular disk and a nut screwed on. While one man with a 24-inch wrench took up on the nut, two others, with a heavy block of wood, driving the other end, soon had the pin in place. The next step was to rivet the back end of the pin over on the disk.

Since this repair was made the compressor has been running constantly for about 12 months and the pin shows no signs of working loose.

D. M. GROVE.

Covington, Va.

Changing Shifts

There are a number of ways by which men who are working 8-hour shifts can change from one shift to another at regular intervals. Suppose that the hours for relieving the watch are at 7 a.m., 3 p.m. and 11 p.m.,

Of the various ways of changing, the following two methods are most commonly used. First, by the night crew working a double header of 16 hours, say from 11 p.m. Saturday until 3 p.m. Sunday. The crew that has been working the 7 to 3 shift lay off from 3 p.m. Saturday to 3 p.m. Sunday, and the crew working from 3 to 11 p.m. lay off from 11 p.m. Saturday until 11 p.m. Sunday.

The second plan is for the men going off the 7 to 3 watch, to lay off for 32 hours, that is, from 3 p.m. Saturday until 11 p.m. Sunday. The men coming off the 3 to 11 watch have an eight-hour lay off and come on duty at 7 a.m. Sunday. The night-watch men get through work at 7 a.m. Sunday, and return to work at 3 p.m. the same day.

There is another plan that I have seen worked which I consider very much more advantageous to the men, for the reason that they get one day off duty. By this plan the crew that quits work at 11 p.m. Saturday lays off until 7 a.m. Monday. They thus have all day Sunday free from any thoughts of having to go to work, which would not be the case with either of the other plans. The men who have been working from 7 to 3, lay off from 3 p.m. Sunday until 11 p.m. the same night. The men coming off duty at 7 a.m. Sunday return to work again at 3 p.m. that afternoon. Where this plan has been tried the men rarely wish to give it up for any other.

H. X. GSKHE.

North Cambridge, Mass.

Condensing Apparatus

Some time ago, while talking with the chief engineer of a large power plant, we fell to discussing condensing apparatus and surface condensers in particular, bringing out some points that are usually taken for granted without very much thought as to the why and wherefore.

One of the first things considered was the location of the dry-air pump and the advantage gained by placing it as close to the condenser as possible. Upon first thought it may seem that the location of the dry-air pump in relation to the condenser is immaterial as long as all the joints, etc., in the dry-air line are kept tight and free from leaks; but suppose, for example, that the temperature of the room where the condensing apparatus is situated is above the temperature of the condensation; then if the pump is placed at a considerable distance from the condenser the air has to travel through a long line exposed to this higher temperature which, consequently, increases the volume of air, forcing more work on the pump and usually resulting in a drop in vacuum. Of course, the conditions may be such that it would be impracticable to have the air pump close to the condenser, in which case the usual method employed to overcome the difficulty is to cover the dry-air pump with a good thickness of lagging.

The next point brought to my attention was the proper size of pipe to use and if any advantage was to be had by using a larger pipe than that for which the pump was designed. For instance, if the diameter of the intake port of the pump were 6 inches, would anything be gained by running a 12-inch line from the condenser to the pump instead of a 6-inch line, as would naturally be the first inclination?

The main object of an air pump is to get rid of whatever air collects in the condenser as quickly as possible and, as pipe friction is something to be taken into consideration, it would seem plausible that the larger the pipe the less the effect of friction, but as there is only a very small quantity of air passing through the pipe the friction is practically negligible; on the other hand, the larger the pipe the more surface is exposed to the effects of the outside temperature.

There is in use in a certain steam plant a combined wet- and dry-air pump of a rather original design. This pump is steam driven and has separate cylinders for air and condensation. The dry-air cylinder exhausts into the wet-air or water cylinder between the foot valves of the wet-air cylinder and the cylinder itself, having to pass through two valves in a small valve chamber located at the bottom of the cylinder. When new, this pump used a normal amount of steam to drive it and was controlled by a throttling governor, but after being in service for several years the pump developed a decided tendency for speeding up and could only be controlled by the throttle.

The logical explanation seemed to be that the governor was badly in need of repairs, but after having been thoroughly overhauled and replaced on the pump the conditions were not changed in the least. Finally the governor was cut out altogether and the pump run on the throttle. This pump is now running with the throttle open a little less than one-quarter of a turn and yet the vacuum is as high, if not a little higher, than it ever was, which causes one to question if sometimes it is not possible to get something for nothing. All other conditions have remained the same, but there is a reason and I would like to hear an opinion from some of the readers of Power as to the cause of this peculiar condition.

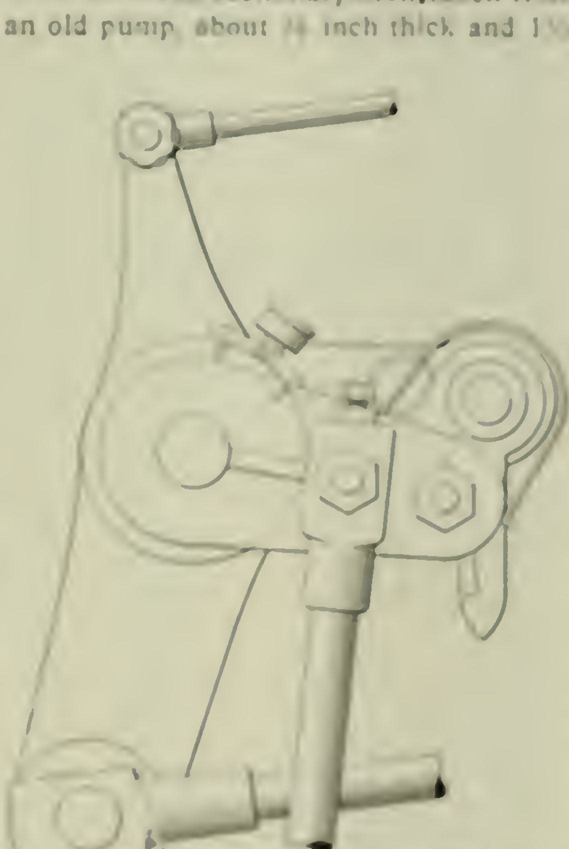
Howard Barr.

New Rochelle, N. Y.

Lubricating the Bell Crank

While visiting an engineer recently, I was interested in his method of lubricating the valve gear of a Corliss engine, as shown in the accompanying illustration.

This engineer had hunted up two pieces of an old brass sectional piston, taken from an old pump, about ¼ inch thick and 1½



Grease Cup on Bell-crank Bearing

inches wide. He fashioned these pieces to fit the outer surface of the bell crank and, drilling and tapping a hole for a ¼-inch pipe, screwed a 2-ounce grease cup in place.

Two ¼-inch holes were drilled and tapped on each side of the slot in the bell crank and holes were drilled in the circular piece of brass plate to correspond. The plate was then screwed fast to the casting by 2 ¼-inch brass screws, first putting a piece of soft leather underneath for a packing to prevent the grease from squeezing out around the edges of the plate.

This rig enabled him to keep the double bearing full of grease at any time, thereby preventing any little noise and wear as the grease did not run through the bearing.

Charles H. Taylor.

Bridgeport, Conn.

Improved Engineering Conditions

It should be very encouraging to steam engineers to note the trend of things that vitally concern him. However, engineers are asking such questions as, "Are conditions becoming better or worse; if better, in what way; if worse, in what particular, and for what class are conditions becoming better or worse?" These are pertinent questions.

It is well to take a broad view of the field of work in which engineers are engaged. Three years ago, we had not a weekly paper devoted to operative engineering in this country. The monthlies, with two or three exceptions, were unpretentious, and the matter they contained would not compare in any way, either in quantity or quality, with that which is supplied today. The contributions and discussions in the technical journals evidence greater activity among operating engineers than ever before, which means that engineers are growing into a more responsible and respected class. One must be blind who does not realize that this change has taken place in many instances and the tendency is toward this condition generally.

A few years ago, fuel cost less than half what it costs now and everything used in the operation of a power plant cost much less than it does now. The charges for public service, however, have not kept pace with the increased cost of fuel, labor and supplies.

So long as fuel and supplies were cheap, employers did not look so closely into matters of fuel consumption and other items of expense in the production of power as they do now. These conditions call for better brains to meet them. Business men began to see that the economical operation of power plants is a scientific proposition, instead of a mere matter of manual labor. From an engine- and boiler-room laborer, the engineer has become the adviser of the management. His position is fast becoming respectable. There is more ahead of the ambitious man at the lower rungs of the ladder than ever before and the prospects are becoming better every year.

Some years ago fuel was never purchased except by the ton. Now heat units govern the price, and the owners of power plants are looking for the man who can turn the last available heat unit in the coal into effective work. They know that the man who can do this is not a cringing thing in greasy overalls, but is a man with real gray matter under his hat.

In the future it is going to be a scramble and a case of the "survival of the fittest." But with the means available for self-education, any man with a reasonable amount of "horse sense" will be able to get in line for the better things in store for the engineering fraternity.

There is ample room for improvement, but the manner in which engineers are meeting the changing conditions promises well for the future, both for the owners of power plants and for themselves.

Ten or fifteen years ago an engineer who could set the valves of a Corliss engine so that it would run at all was considered a very good man. Now we find them conducting hair-splitting discussions as to the proper hight of the compression curve, whether it shall be allowed to run to one-third or one-fourth the hight of the diagram, or less. Lead must be adjusted to a nicety that our fathers never thought of, and operating engineers are found laying off the lines for isothermal and adiabatic expansion on the indicator diagrams and checking the actual by the theoretical.

These things indicate that engineers are progressing, and will be, for several reasons, two of the most important being the increasing pressure of conditions, and the increased ease of obtaining knowledge and applying it. What the engineers of the past had to arrive at by long and tedious calculation is now obtained at a glance from handbook tables.

William Westerfield.

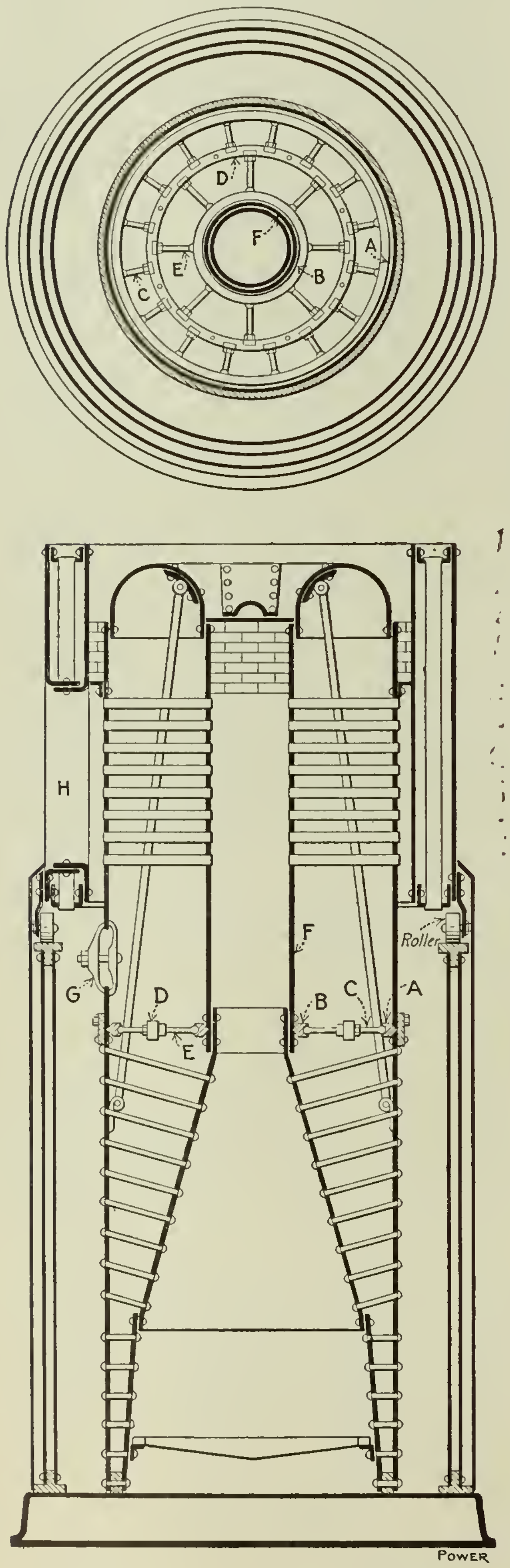
Concordia, Kan.

Novel Boiler Construction

While visiting a small boiler shop, I was shown a boiler that had features which were extremely novel. The boiler was destined for a mountainous part of the country where fuel was scarce and dear, and where transportation of the boiler from place to place would be difficult.

The accompanying illustration shows a sectional view of the boiler, but is drawn from memory and from such description as was detailed to me, and, therefore, is to be considered as simply portraying the chief features and not as accurately setting forth the constructional details. The boiler can be divided into two sections, at the joints *A* and *B*. The lower half of the strap at *A* is riveted and calked in the usual manner, but the upper half is only bolted on and is not calked. The joint is made tight by means of a triangular-shaped cast-iron ring, which fits accurately into the V-slot machined at the intersection of the two halves of the shell. The ring *A* is cut slightly larger than the inside diameter of the shell, like the packing ring of a steam piston.

Before being snapped into position, a narrow strip of a flexible alloy is placed in the bottom of the groove. When in place, the packing ring is evenly set out by the bolts *C*, bearings for which are furnished by the built-up wheel *D*. The inner ring *B* is set by the bolts *E*, and the band *F* is riveted on to complete the joint at this juncture. The ends of the setting-out bolts are upset and rounded to fit into recesses in the packing ring to allow flexibility in case of unequal expansion of the inner and outer shells. Details of the bolts, wheel and packing rings are shown in the plan view. Some of the braces of the upper half connect below the joint to the shell of the lower half. On some of these braces are turnbuckles of a special make, which are used to raise the upper half clear of the other when dismantling the boiler. The two halves of the shell are guided to a correct position by two keys (not shown). Access to the interior of the boiler is obtained through a manhole, the position of which is shown at *G*.



Sectional View of the Boiler

As this boiler had to be operated under economical conditions it was necessary to have a large heating surface proportionate to the grate surface, which was difficult to provide without making the boiler too bulky. The designer, however, hit upon the plan of using a one-tube economizer for heating the feed water. By this means the waste gases are utilized to a certain extent, but the heating surface of the boiler is materially increased by compelling the gases to return along the outer shell before entering the economizer. But the economizer so covers the boiler tubes as to prevent access for cleaning them. To offset this the economizer was set on rollers, and a long but narrow door *H* cut in it. By disconnecting two unions, one on the feed-water inlet and one on the outlet, the economizer can be revolved entirely around the boiler, thus bringing the door opposite each row of tubes. The economizer is set on a framework of T and angle iron, around which is a covering of sheet iron.

The more one studies the design of this boiler, the more he recognizes the ease with which it can be thoroughly cleaned and repaired.

While this boiler may be expected to operate with a fair degree of economy, considering its type, there are several doubtful elements in the construction, which the reader will doubtless perceive.

R. O. Richards.

Framingham, Mass.

Standpipe on Heating System

A certain heating plant will soon have to be extended in order to heat an annex to the main building. The job should be done as cheaply as possible as the building will be vacated next year. The old traps are overloaded, and a new trap is not wanted. The system is made up of 1-inch pipe, and operates by gravity. The pressure is from 5 to 8 pounds, and discharges through traps into an open tank and is then pumped into the boilers.

How about putting up a standpipe of a convenient hight and letting the water overflow into the open tank; would this work and, if not, what else could be done?

Alex Dolphin.

Jamaica, N. Y.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

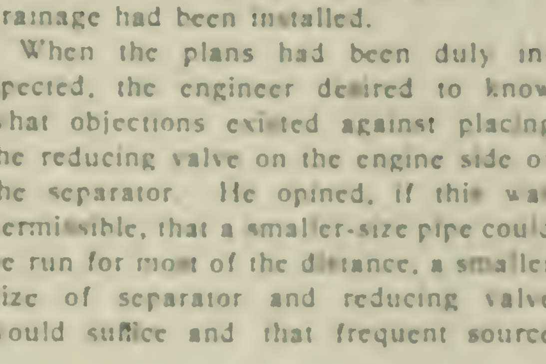
Specialists

I was interested in James Scotch's letter which appeared in the issue of March 21, under the above title. I believe that he writes too harshly of the "dinky little" engineer, who presumes to dictate to specialists summoned for especial work in his plant. Personally, I bear the opinion that the *thinking* man, be he engineer or coal passer, can, at times, present highly intelligent hints to any master-of-trade; especially is this so when the latter is one of that numerous class of craftsmen who have achieved proficiency in their vocation solely by imitation and who not only copy the merits of their models, but, likewise, commit their faults or, ignorantly, maintain a custom that has, since their apprenticeship, become obsolete. I refer to that large class of so called specialists who are adepts at doing things which they have seen accomplished before but who are easily confounded when asked for reasons why one thing is performed this way and another the other way. I contend that these men are but cogs in the huge industrial wheel and, compared with them, the little free-thinking engineer becomes "the man of broader education" that Mr. Scotch refers to "as the man who rises highest in the engineering profession" and, I may add, "sets the cog wheel in motion."

We all find it easy to criticize the handiwork of these specialists; but small indeed is the number of those who can suggest ideas that will correct the faults perceived. When, by concentration of mind, we are enabled to do this, and the expert finds the idea practical, have we not every reason to "crow" of our ability? And if the idea be worthy and general in its application, what better could we do with it than have it appear in the columns of POWER that others may profit thereby? As an instance for comparing a specialist and a *thinking* engineer I commend the following.

At the invitation of a friend whose plant was undergoing partial remodeling, I was present in the engine room when a steamfitter unfolded a blueprint upon which plans were drawn showing a method for connecting an old Putnam poppet-valve engine, built for 70 pounds steam pressure, to a battery of modern boilers capable of withstanding a pressure of 150 pounds. A portion of the drawing is reproduced in the accompanying figure. As a part of the improvements introduced, the Holly system of drainage had been installed.

When the plans had been duly inspected, the engineer desired to know what objections existed against placing the reducing valve on the engine side of the separator. He opined, if this was permissible, that a smaller-size pipe could be run for most of the distance, a smaller size of separator and reducing valve would suffice and that frequent source of trouble, the trap, could be eliminated. Furthermore, he argued that the separator, if installed according to the specialist's plan, would be altogether useless as a means for reducing the percentage of moisture present in the steam as it is well within the bounds of reason to credit the steam upon leaving the reducing valve with more or less superheat depending on the amount of moisture present in the high-pressure steam. Thus, the separator, according to my friend's supposition, would be curtailed in its functions to a mere safety device against the flooding of the engine and even this function would depend on the condition and capacity of the trap. In my estimation, the same object would be accomplished by a pair of well designed relief valves placed on the engine cylinder. In answer to all the arguments enumerated the specialist could invoke but one, that was: "It is not customary to install the apparatus in that arrangement"—a truly characteristic reply of the majority of his class when confronted with debatable reflections.



Specialist's Plan

Engineer's Plan

Of course, it is far from my desire to be understood to mean that there are no bright exceptions and, no doubt, I shall hear from some of these, who will deem it incumbent to swing the cudgels for their more unfortunate brothers, even as I do for the "dinky little one-horse engineer." Yet, it is my sincere conviction that any alert engineer, who keeps abreast of his times by reading, digesting, appropriating and using the thoughts and suggestions found in the abundant literature of his trade, can at times furnish pointers which NO specialist need be ashamed to accept.

OWEN R. OWEN.

Roxbury, Mass.

Size of Turbine Exhaust Pipes

R. M. Neilson, in the issue of March 28, gives an interesting formula for the area of steam-turbine exhaust pipes but he does not give the data from which it was derived. It appears that the formula is defective in not including the length of the pipe and the allowable drop in pressure between the condenser and the turbine or the ratio of these two quantities, or else Mr. Neilson has neglected to state what constant ratio of these quantities he used in constructing his formula.

I have made some calculations from the formula for two assumed cases: 1000 and 20,000 horsepower; steam consumption, 12 pounds per horsepower-hour and 28 inches of vacuum.

The data from the Marks-Davis steam tables are:

V = Volume of one pound of steam = 350.8 cubic feet;

W = Weight of one cubic foot of steam = 0.002851 pound.

The formula is

[illegible]

W = weight of steam in pounds per hour, and f is a factor for the smoothness of the pipe = 2.55 for a riveted pipe.

[illegible]

For 1000 horsepower,

$$W = 12{,}000;\ W^{0.8} = 1{,}834$$

$$A = 1834 \times 18.73 \times 1.715 \div 16{,}000 = 3.682 \text{ square feet}$$

or 26 inches diameter.

For 20,000 horsepower,

$$W = 240{,}000;\ W^{0.8} = 20{,}140$$

$$A = 20{,}140 \times 18.73 \times 1.715 \div 16{,}000 = 40.44 \text{ square feet}$$

or 86 inches diameter. The velocity of the steam in the first case is:

200 *pounds per minute* × 350.8 ÷ 3.682 = 19.055 *feet per minute* = 318 *feet per second*

In the second case it is:

4000 *pounds per minute* × 350.8 ÷ 40.44 = 34,700 *feet per minute* = 578 *feet per second*

The common formula for the flow of steam in pipes (See "Mechanical Engineers Pocketbook," page 845), is,

Loss of pressure in pounds per square inch =

$$p_1 - p_2 = \frac{W^2 L}{C^2 W d^5}$$

in which W is in pounds per minute, and D, the diameter, in inches; C is an experimental coefficient. Taking L at 100 feet and C at 63.4 for the first case and 64 in the second (figures derived from Darcy's experiments on the flow of water) gives in both cases

$p_1 - p_2 = 0.029$ *pound per square inch,* or about 0.06 inch of mercury. As in modern large turbine practice L may be nearer 10 than 100 feet, this would reduce the drop in pressure to one-tenth of these figures, or to 0.006 inch of mercury, an exceedingly low figure.

It is possible that Mr. Neilson intended his formula to cover not only the loss of head (or pressure) due to friction of the pipe, but also the pressure required to cause the velocity, and also the "entry head" or the pressure required to overcome the resistance of the orifice. As the latter may be made bell-mouthed, its resistance may be neglected. If we assume that the steam in the exhaust side of the turbine has no velocity in the direction of the pipe, the velocity head may be calculated from the formula

$$h = \frac{V^2}{2g}$$

in which V is in feet per second and H, the hight, in feet of a column of steam of the given density. For the calculated velocities, 318 and 578 feet per second, h is, respectively, 1570 and 5188 feet. Reducing this to the equivalent pressure of steam occupying a volume of 350.8 cubic feet per pound gives pressures of 4.48 and 14.8 pounds per square foot, or 0.031 and 0.128 pound per square inch, respectively. These figures added to the 0.029 pound already found as the loss of pressure due to friction for a pipe 100 feet in length, gives the total loss of pressure as 0.06 and 0.157 pound, or, say, 0.12 and 0.31 inch of mercury.

As the steam leaving the vanes of the turbine must have considerable tangential velocity, with reference to the earth, and the exhaust pipe may be taken from the casing in the tangential direction, it is probable that there is no such loss of head in creating velocity as the last calculation indicates and, in that case, a material decrease in the diameter of the pipes (with consequent increase in velocity) from the diameters given by Mr. Neilson's formula might be made without any serious loss of vacuum between the condenser and the turbine, especially if the distance between them is short.

The exponent 0.4 of the factor f should be explained. According to the common formulas for flow of water, the area required for a given flow under a given head varies inversely as the square root of the mean hydraulic radius, which would make the exponent of f 0.5 instead of 0.4.

William Kent.

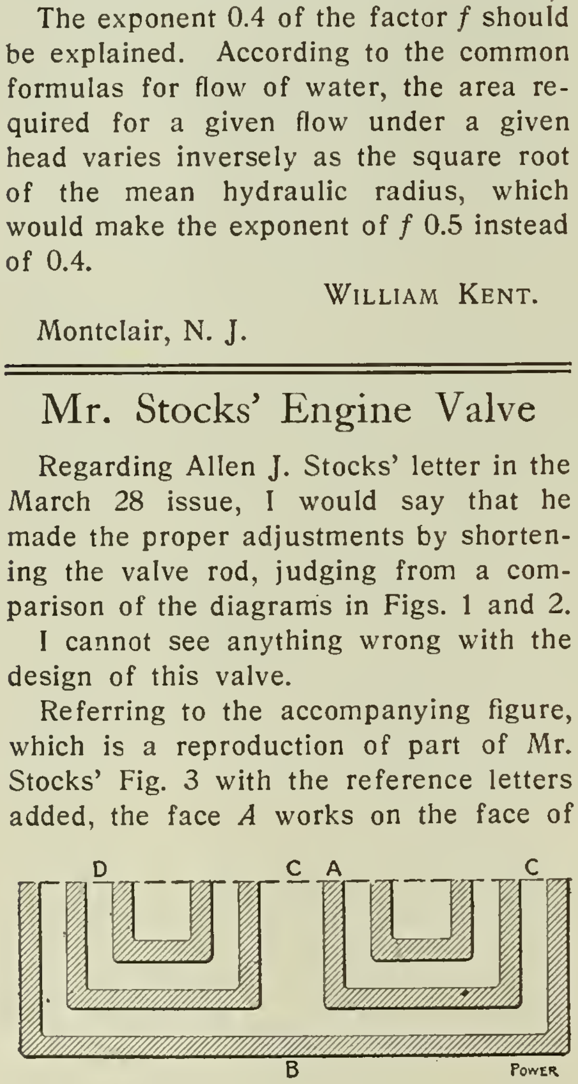
Montclair, N. J.

Mr. Stocks' Engine Valve

Regarding Allen J. Stocks' letter in the March 28 issue, I would say that he made the proper adjustments by shortening the valve rod, judging from a comparison of the diagrams in Figs. 1 and 2.

I cannot see anything wrong with the design of this valve.

Referring to the accompanying figure, which is a reproduction of part of Mr. Stocks' Fig. 3 with the reference letters added, the face A works on the face of the valve seat. The face B is subjected to the steam-chest pressure, which pressure tends to hold the valve hard against the valve seat. The channels C are to allow a certain amount of steam to remain between the valve and its seat, tending to balance or resist the pressure on the face B.



Mr. Stocks' Valve

It seems plain that the inventor's aim was to design a balanced slide valve without a pressure plate and his aim was in the right direction to reduce the friction and allow the automatic cutoff governor to work effectively.

The diagrams showed that the governor was handling the valve all right.

If Mr. Stocks had given a sketch of the valve seat, I might have been able to tell him more about this valve, as I think the channels D are probably meant to give the valve a double-ported effect which is common practice in the design of most automatic single slide-valve engines. The valve is made double ported to get a large port opening with a comparatively short valve travel.

Most designers know something.

W. H. Magee.

Brooklyn,, N. Y.

Record Breaking Turbine Test

The test performance, cited in the April 18 issue, of the 6000-kilowatt turbine unit designed by Brown, Boveri & Co., and installed in the Dunston station at Newcastle-on-Tyne, shows the best steam economy which I have seen reported, and since it was accomplished with a high degree of vacuum, the efficiency is remarkable. There are, however, certain important matters which must be considered in comparing this result with the claims and accomplishments of other large turbines of the Parsons or other types.

The machine at Newcastle is designed for a capacity of 6000 kilowatts, it operates at 1200 revolutions per minute, and in spite of this relatively low speed in proportion to its rating, the low-pressure end is arranged for double flow. The Parsons construction can be made highly efficient at the low-pressure end if space could be afforded for moderate steam velocities. The limitation of most Parsons designs lies in the fact that such space cannot be afforded and it is only in such extreme designs as the one under consideration, that the steam at the low-pressure end is not congested when operating with a good vacuum. A machine of the Curtis type operating at 1200 revolutions per minute can be proportioned with single flow for 11,000 kilowatts output without serious congestion in the low-pressure end, while the machine at the Dunston station is designed for only 6000 kilowatts and is provided with two low-pressure elements in parallel. The building of such an elaborate and expensive machine for so small an output is undoubtedly well justified by the fine results accomplished and is creditable both to the purchasers and to the designers. The practice, however, is very different from that which has been followed by many designers of Parsons turbines, particularly in this country where it is common to find single-flow machines rated at 5000 kilowatts operating at 1800 revolutions per minute, and double-flow machines rated at from 10,000 to 15,000 kilowatts operating at 1800 revolutions per minute.

I do not know how the initial cost per kilowatt of this machine would compare on an equal basis with such Parsons units as have been mentioned. It is obvious that the cost is relatively much greater and that these fine results cannot be accomplished without such increase of cost.

The machine at Dunston was built with an unusual degree of care and accuracy, it is operated continuously without variation of load, and in starting it an unprecedented length of time is expended. Under these very favorable conditions of operation it is probable that it can run with very small clearances so that the leakage losses are presumably smaller than those which are necessary in a Parsons machine run in the usual manner.

Brown, Boveri & Co. have been leaders both as to quality and quantity in the production of Parsons turbines as they have been in many other branches of engineering, and this machine represents the latest product of their experience. If other designers of Parsons turbines follow equally conservative and correct lines, they also can undoubtedly obtain equivalent results if the test reported in this case is correct. If, however, in the interest of economy they follow radically different lines, it may be presumed that they violate principles which govern quality in this art.

W. L. R. EMMET.

Schenectady, N. Y.

Preventing Power Plant Losses

The editorial in the April 4 issue of POWER under the above heading is worthy of careful attention by all progressive engineers and covers a subject that is of vital importance, not only in engineering, but in all branches of human activity.

Many are the men that have gone to the wall because of their failure to look after the little things; they take care of the large items that thrust themselves in the way but never see the small things that have to be searched for. Just as a grain of dust will stop a watch or a bolt wreck a turbine, so unseen losses will wreck a business.

With the very best of equipment and administration hardly more than 10 per cent. of the energy in coal can be realized at the switchboard. Yet, with only this small amount of power as an asset and the many and varied losses as a big debit, the engineer instead of watching such losses and trying to keep them as small as possible, lets them increase because he does not see where they go to and in addition allows a lot of unnecessary ones to creep in.

The causes that lead up to these unnecessary losses are varied, but usually come from a false sense of economy. To spend a dollar today in order to save two dollars tomorrow is unheard of.

Economy is the slogan! Buy cheap supplies! Save the dollars! The fact that the quality is as cheap as the cost is forgotten.

Pay small wages! Cheap men will make the wheels go around just the same as good men. Maybe true, but what is saved in wages is lost many times over in other ways.

Bookkeeping costs money. Cut it out. What do we care how much each item costs, as long as we know the total. Yet that is the only way in which the invisible leaks can be discovered.

All of which reminds me of a friend who walked three miles to save 5 cents carfare, and after he had gone about a mile stopped at a cigar store and spent 15 cents on cigars to keep him company the rest of the way.

W. L. DURAND.

Washington, D. C.

Pressure on Pump Plunger

In regard to B. U. Potter's inquiries in the issue of March 28, the following may be of interest to him:

In Fig. 1, let A be the position of the crank pin at top center and B the position after the crank has moved through any angle θ. Then, AC will equal the displacement of the piston.

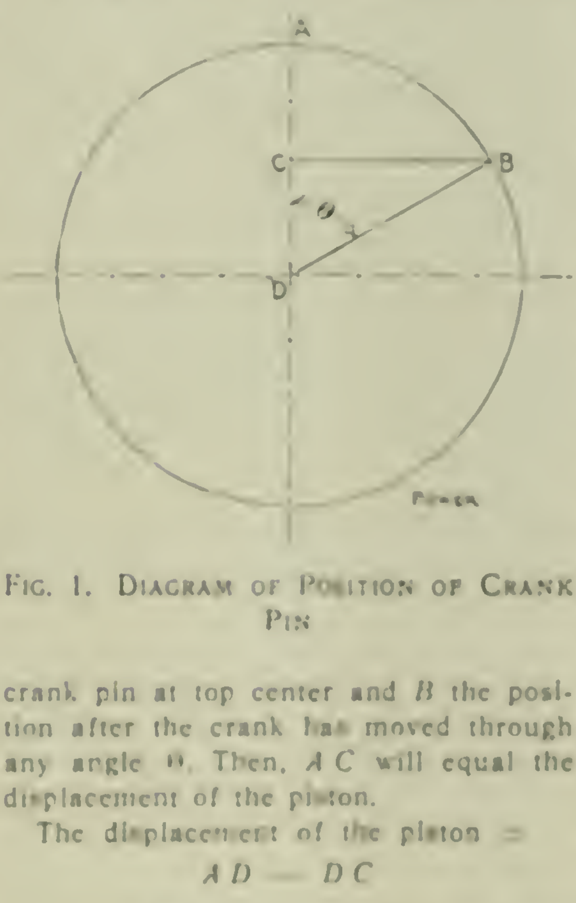


FIG. 1. DIAGRAM OF POSITION OF CRANK PIN

The displacement of the piston =

$$AD - DC$$

and

$$DC = \frac{DC}{BD} \times BD$$

or

$$DC = \cos \theta \times BD$$

and

$$AC = R - (\cos \theta \times R)$$

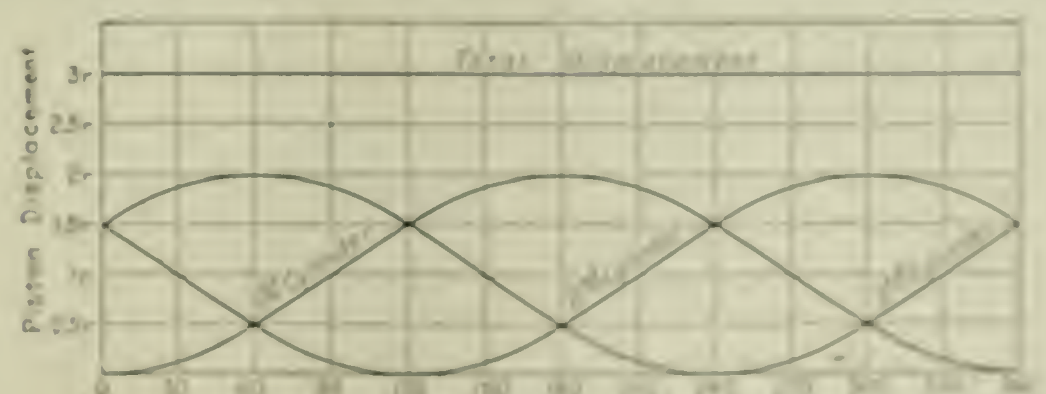


FIG. 2. DIAGRAM OF CYLINDER DISPLACEMENT

In Fig. 2 the displacement of piston No. 1 was plotted as ordinates and the degrees of revolution of crank shaft as abscissas. That of No. 2 was plotted in the same manner, but 120 degrees later, and that of No. 3 120 degrees later still. This gives the three curves as shown.

Adding the ordinates for the different positions of the crank shaft gives the line of total displacement, which is constant and equal to 3r or 1½ times the displacement of one cylinder.

The angularity of the connecting rod would change the volume slightly but not enough to affect the pump.

The easiest proof of the above is to assume any position of the plungers and solve for the total displacement.

JOHN BAILEY.

Milwaukee, Wis.

Advice on Giving Advice

I have read the letter by Owen R. Owen in the March 28 number and I believe the suggestion that the editors review replies sent in by readers is a good one.

I imagine that Mr. Owen's letter will mix things up more than ever for Mr. Morris. He states that my suggestion of adding a drip at the end of the feed branch at the farthest radiator might be inconvenient. What about his idea of increasing the size of all of the pipes under certain conditions as brought up by Mr. Dixon? The drip which I suggested need only be of ½-inch pipe and need not cost very much in cash or labor.

If there is no obstruction, such as dirt of any kind (and the chances are 1000 to 1 there is no such obstruction), the drip will certainly cause the steam to circulate in the radiator.

I do not agree with Mr. Owen that it should be taken for granted that air vents are installed. The suggestions offered were based upon the description given and the sketch shown.

The connection which was shown by Mr. McCabe is quite correct, but I have seen dozens of connections "bull headed," as shown in Mr. Morris' sketch, where dissatisfaction in results was excountered; but in every case ample provision was made to carry away the condensation from the branch feed connections at the radiator end by a drip when these connections were over a few feet long.

The risers shown in the sketch (2½ inches) should be of ample size to heat any three radiators unless they are altogether larger than any generally used, and if the branch pipes are large enough (1¼ inches will supply up to 96 square feet under 5 pounds pressure with a two-pipe system) and contain no pockets, there will positively be no trouble in heating all three radiators with a one-pound steam pressure, gage, providing drips are installed.

The change suggested by Mr. Owen is all right, but it is not a sure cure; drips or bleeders are, if falls are right and all pipes are clear.

J. E. Noble.

Toronto, Can.

Stress in Boiler Sheets

Referring to the editorial in the February 28 issue, consider a rectangular plate as in Fig. 1, with a tension of p_1 pounds per square inch of sectional area applied in one direction and p_2 pounds per square inch of sectional area applied at right angles to the first. Let the thickness of the plate be t.

Now conceive a right-angled triangle cut from this plate as in Fig. 2. The side whose length is A is subjected to a tension of p_1 pounds per square inch of sectional area, and the side whose length is B is subjected to a tension of p_2 pounds per square inch of sectional area. The hypotenuse, whose length is C, is then subjected to a tension whose direction is perpendicular to C and whose intensity is p pounds per square inch (as yet unknown). There may also be a shearing action along C; if there is, let its intensity be S pounds per square inch.

Since t is the thickness of the plate in inches, the sectional area along the edge A is $A \times t$ square inches; hence the total force acting upon A, and perpendiuclar to it, is $A \times t \times p_1$ (Fig. 3). Similarly, the total force acting on the edge B is $B \times t \times p_2$. Acting perpendicularly to the hypotenuse is the force $C \times t \times p$, and if there is a shearing action along this edge, its total value will be $C \times t \times S$.

There must be equilibrium among these four forces. Resolving into components perpendicular to the hypotenuse,

$$C \times t \times p = A \times t \times p_1 \sin.\alpha + B \times t \times p_2 \cos.\alpha$$

and resolving parallel to the hypotenuse,

$$C \times t \times S = A \times t \times p_1 \cos.\alpha - B \times t \times p_2 \sin.\alpha$$

Dividing by $C \times t$ in both cases,

$$p = \frac{A}{C} \times \sin.\alpha \times p_1 + \frac{B}{C} \times \cos.\alpha \times p_2$$

$$S = \frac{A}{C} \times \cos.\alpha \times p_1 - \frac{B}{C} \times \sin.\alpha \times p_2$$

But $\frac{A}{C} = \sin.\alpha$, and $\frac{B}{C} = \cos.\alpha$

Hence

$$p = p_1 \sin.^2\alpha + p_2 \cos.^2\alpha \qquad (1)$$

$$S = p_1 \sin.\alpha \times \cos.\alpha - p_2 \sin.\alpha \times \cos.\alpha = (p_1 - p_2)\sin.\alpha \times \cos.\alpha \qquad (2)$$

These equations give the values of p and S under the most general circumstances.

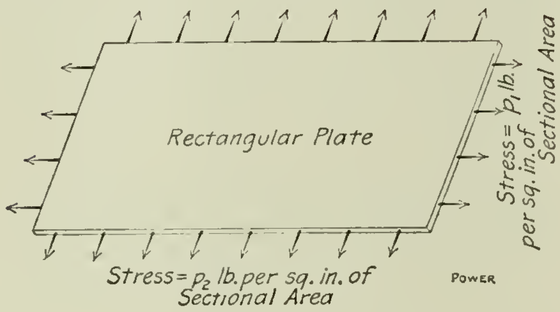


Fig. 1

There is a shear S along the hypotenuse except when α equals zero or 90 degrees, in which case $\sin.\alpha$ and $\cos.\alpha$ are zero respectively; also in the special case where the plate is pulled equally in both directions, that is, $p_1 = p_2$, there is no shear. If p_2 be equal to p_1, equation (1) becomes

$$p = p_1 \sin.^2\alpha + p_1 \cos.^2\alpha = p_1(\sin.^2\alpha + \cos.^2\alpha) = p_1$$

Hence, when the plate is subjected to a stress of the same intensity sidewise and endwise, the tension acting perpendicularly across any diagonal is the same in intensity.

Going back to the general case, in which p_1 is not equal to p_2, assume first that p_2 is greater than p_1.

$$p = \frac{p_1 + p_2}{2} + \frac{p_2 - p_1}{2} \times \cos.2\alpha \qquad (3)$$

This expression may be verified as follows: Substituting $\cos.^2\alpha - \sin.^2\alpha$ for $\cos.2\alpha$, equation (3) becomes

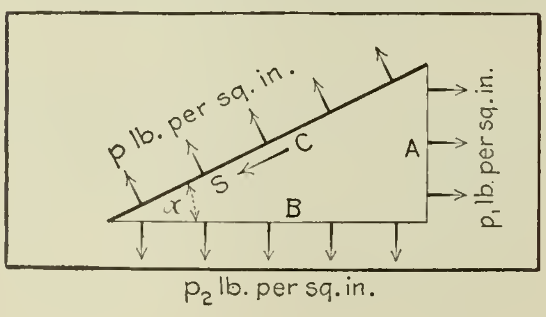


Fig. 2

$$p = \frac{p_1 + p_2}{2} + \frac{p_2 - p_1}{2} . (\cos.^2\alpha - \sin.^2\alpha)$$

$$= \frac{p_1}{2} + \frac{p_2}{2} + \frac{p_2}{2}\cos.^2\alpha - \frac{p_2}{\alpha}\sin.^2\alpha - \frac{p_1}{2}\cos.^2\alpha + \frac{p_1}{2}\sin.^2\alpha$$

$$= \frac{p_1}{2}\sin.^2\alpha + \frac{p_1}{2}(1 - \cos.^2\alpha) + \frac{p_2}{2}\cos.^2\alpha + \frac{p_2}{2}(1 - \sin.^2\alpha)$$

$$= \frac{p_1}{2}\sin.^2\alpha + \frac{p_1}{2}\sin.^2\alpha + \frac{p_2}{2}\cos.^2\alpha + \frac{p_2}{2}\cos.^2\alpha$$

$$= p_1 \sin.^2\alpha + p_2 \cos.^2\alpha$$

which is the same as equation (1).

In the formula

$$p = \frac{p_1 + p_2}{2} + \frac{p_2 - p_1}{2} \times \cos.2\alpha$$

the greatest value that $\cos.2\alpha$ can have is $+1$; hence, the greatest value p can have is

$$p = \frac{p_1 + p_2}{2} + \frac{p_2 - p_1}{2} = p_2$$

This happens only when $\cos.2\alpha = 1$, or $\alpha = 0$. Similarly, the least value $\cos.2\alpha$ can have is -1, which can only be when $2\alpha = 180$ degrees, or $\alpha = 90$ degrees. Then

$$p = \frac{p_1 + p_2}{2} - \frac{p_2 - p_1}{2} = p_1$$

From this it will be apparent that when p_2 and p_1 are unequal, p is always less than p_2 (the greater of the two), except when $\alpha = 0$, when it becomes equal to p_2. Similarly, p is always greater than p_1 except when $\alpha = 90$ degrees, when it becomes equal to p_1.

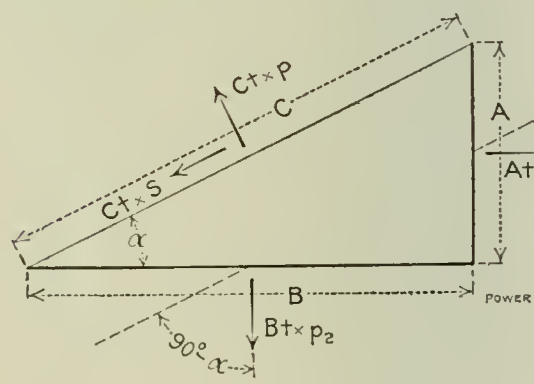


Fig. 3

As for the shear S, it may be expressed as

$$S = \tfrac{1}{2}(p_1 - p_2)2 \times \sin.\alpha\cos.\alpha = \frac{p_1 - p_2}{2} \times \sin.2\alpha$$

The greatest value $\sin.2\alpha$ can have is $+1$. Hence the greatest value of S will be $\frac{p_1 - p_2}{2}$. This occurs when $\sin.2\alpha = 1$, or $2\alpha = 90$ degrees, that is, $\alpha = 45$ degrees.

Some have been confused with the fact that the diagonal extension of a rectangular plate is greater than the extension parallel to the edges. The trouble here is, that the stress in the plate is not proportional to the absolute extension, but to the ratio that the distortion bears to the unstretched length. For example, consider a rectangle acted upon by a force of p pounds in each direction. Representing the modulus of elasticity by E_1 and referring to Fig. 4,

$$\frac{p}{E_1} = \frac{(G\,F)}{(F\,A)} \text{ along } A\,F$$

and

$$\frac{p}{E_1} = \frac{(B\,C)}{(A\,B)} \text{ along } A\,B$$

The test is not that $BC = FG$, but that $\frac{BC}{AB} = \frac{FG}{FA}$.

Let p_o be the diagonal stress. Then

$$\frac{p_o}{E_1} = \frac{DE}{AD}$$

And since,

$$\frac{DE}{AD} = \frac{BC}{AB}$$

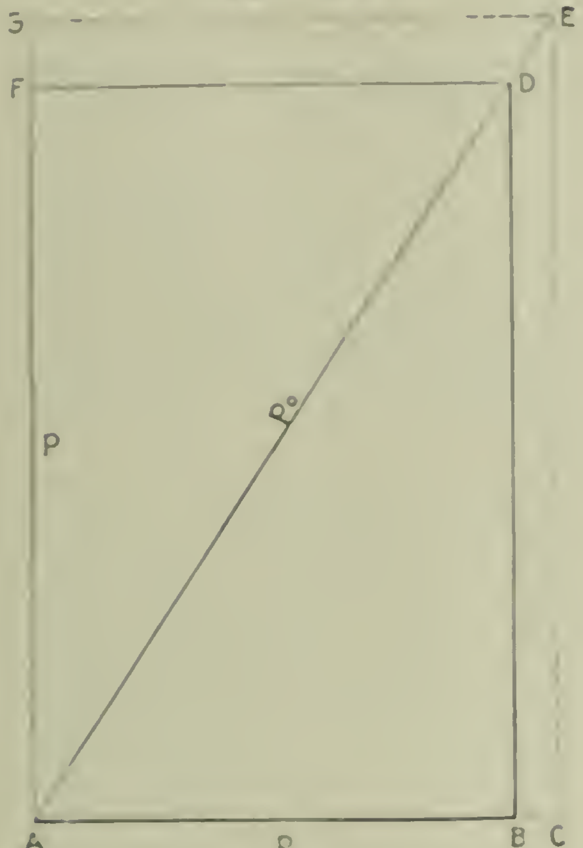


FIG. 4

it follows that

$$\frac{p_o}{E_1} = \frac{p}{E_1}, \text{ or } p_o = p$$

This is when the rectangle is stressed equally in both directions. When stressed unequally the case is more complicated

A. D. RISTEEN.

Hartford, Conn.

The following has special reference to an editorial in the February 28 issue of POWER under the above caption:

Proposition: Through the shell of a steam boiler are there any cross-sections on which the stresses, normal or tangential, are greater than on a cross-section which contains the axis?

A discussion of this problem involves a theorem of internal stress, known as the "Ellipse of Stress." The conditions of the problem give two simple tensile stresses perpendicular to each other, one produced by the pressure on the heads, the other by the radial pressure on the shell; and in a boiler without tubes or stays, the intensity of the stress on a plane parallel to the axis is twice that on a section perpendicular to the axis.

Let Fig. 1 represent a portion of the boiler which is subject to an internal pressure p; then the stress on any horizontal plane XX, per unit of length, is pr, and the intensity of stress or the stress per square inch is $\frac{pr}{t}$, where r is the radius of the boiler and t the thickness of the shell.

The stress on any plane YY perpendicular to the axis is $\pi p r^2$, and the stress per square inch is

$$\frac{\pi p r^2}{2 \pi r t} = \frac{pr}{2t}$$

where $2\pi r$ is the circumference. This also proves that the intensity of stress on XX is twice that on YY as previously stated.

To determine the stresses on any plane ac which makes an angle ϕ with the XX plane consider the small rectangular part of the shell $abcd$, and, by changing the ratio between the length of the sides, angle ϕ may have any value between 0 and 90.

Represent the unit stress acting parallel to YY by p_1, and that parallel to XX by p_2. It will simplify the solution and not change the principles if the thickness of the shell is assumed as unity; then the area of the sections ab and bc may be represented by ab and bc. The total stress on bc is $bc \times p_1$; this will

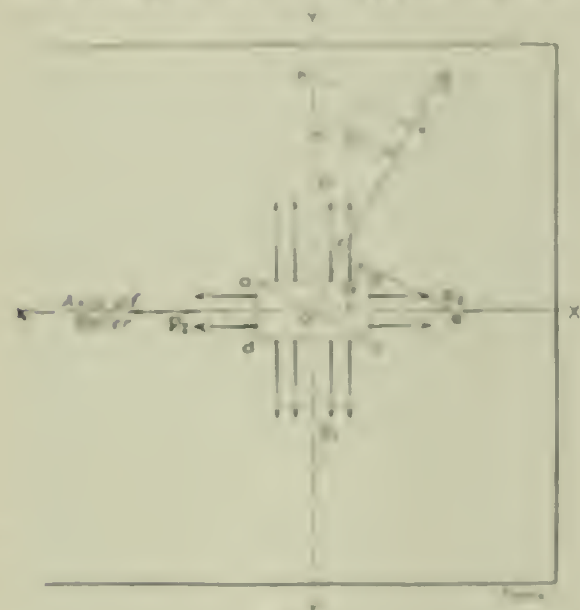


FIG. 1

be distributed over the section ac, acting obliquely thereto, the angle of obliquity being ϕ.

The area of ac is greater than that of bc, and is equal to $\frac{bc}{\sin \phi}$. If the total stress $p_1 \times bc$ is divided by this area the unit stress is obtained, or

$$\frac{p_1 \times bc}{\frac{bc}{\sin \phi}} = p_1 \sin \phi$$

which is the oblique unit stress on ac due to p_1. This oblique stress may be resolved into a normal stress p_{n_1} and a shearing stress q_1. Assume oe equal to the unit stress $p_1 \sin \phi$, then of represents the normal stress p_{n_1}, and fe the shearing stress q_1.

$$of = oe \sin \phi = p_1 \sin \phi \sin \phi = p_1 \sin^2 \phi = p_{n_1}$$

$$fe = oe \cos \phi = p_1 \sin \phi \cos \phi = q_1$$

The arrows indicate the directions in which the stresses act.

Similarly, $p_2 \times ab$ equals the total stress distributed over ac due to p_2. Representing the area of ac in terms of ab and ϕ, area ac equals $\frac{ab}{\cos \phi}$, and dividing the total stress by this area the unit stress on ac is

$$\frac{p_2 \times ab}{\frac{ab}{\cos \phi}} = p_2 \cos \phi$$

the line of action making an angle ϕ with the normal og to ac. Assume oh equal to this unit stress $p_2 \cos \phi$, then ok is equal to the normal stress p_{n_2}, and kh the shearing stress q_2.

$$ok = oh \cos \phi = p_2 \cos \phi \cos \phi = p_2 \cos^2 \phi = p_{n_2}$$

$$kh = oh \sin \phi = p_2 \cos \phi \sin \phi = q_2$$

For the combined unit stresses on ac, take the algebraic sum of the stresses obtained from p_1 and p_2. Noting that the shearing stress q_2 acts opposite to q_1, the normal stress equals

$$p_{n_1} + p_{n_2} = p_1 \sin^2 \phi + p_2 \cos^2 \phi$$

and the shearing stress equals

$$p_1 \cos \phi \sin \phi - p_2 \cos \phi \sin \phi = (p_1 - p_2) \sin \phi \cos \phi$$

This gives the normal and shearing unit stresses on a section making any angle ϕ with the axis of XX.

In this solution, p_1 and p_2 are both taken as tensile stresses, but generally p_1 and p_2 can be either tensile or com-

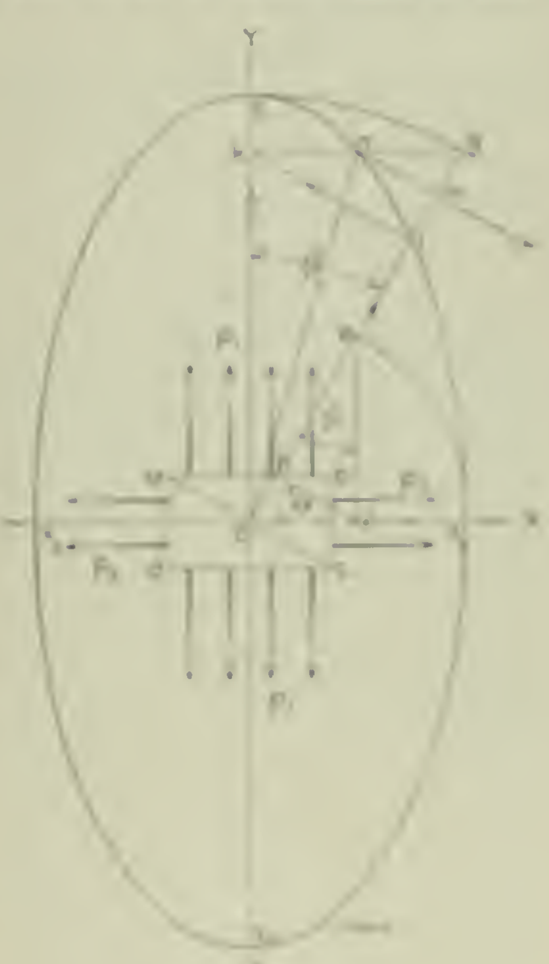


FIG. 2

pressive stresses; when both are tensile or compressive, the shears are of opposite sign; when one is tensile and the other compressive, the shears are of the same sign and the normals are of opposite sign.

In the problem under consideration, p_1 equals 2 × p_2. Substituting this value for p_2,

$p_{n_1} + p_{n_2} = P_n = p_1$ (sin² φ + ½ cos² φ) and

$$q_1 - q_2 = Q = \frac{1}{2} p_1 (sin. \phi \, cos. \phi).$$

Compounding these will give the resultant stress R equal to

$$\sqrt{P_n^2 + Q^2}$$

Next will be shown a graphical method of handling the problem. In Fig. 2, let p_1 and p_2 be the unit stresses on the faces $a\,b$ and $b\,c$. Represent these stresses by $o\,y_1$ and $o\,x_1$. All angles which are equal to ϕ and employed in the solution are marked.

On the normal $o\,g$, take $o\,e$ equal to the unit stress p_2, and draw $e\,f$ normal to $X\,X$. Then $o\,f$ equals the unit stress on $a\,c$ parallel to $X\,X$, since $o\,f$ equals $o\,e$ $sin.\ \phi$. Draw the normal $f\,h$ from f to $o\,g$; then $o\,h$ will equal the normal unit stress p_{n_2} on $a\,c$ due to p_2, since

$$o\,h = o\,f\ sin.\ \phi = o\,e\ sin.^2\ \phi$$

$h\,f$ equals q_2, the shear on $a\,c$ due to p_2, since

$$h\,f = o\,f\ cos.\ \phi = o\,e\ sin.\ \phi\ cos.\ \phi$$

Similarly, take $o\,g$ equal to p_1 and draw the normal $g\,k$ to $Y\,Y$; then $o\,k$ will equal the unit stress on $a\,c$ parallel to $Y\,Y$ due to p_1, since $o\,k$ equals $o\,g$ $cos.\ \phi$. Draw the normal $k\,l$ from k to $o\,g$; then $o\,l$ equals the normal unit stress p_{n_1} on $a\,c$ due to p_1, since

$$o\,l = o\,k\ cos.\ \phi = o\,g\ cos.^2\ \phi$$

and $l\,k$ equals q_1, the shear on $a\,c$ due to p_1, since

$$l\,k = o\,k\ sin.\ \phi = o\,g\ sin.\ \phi\ cos.\ \phi$$

Combining these results

$$o\,l + o\,h = o\,m, \text{ and } - h\,f + l\,k = m\,r + r\,n = m\,n$$

The line $o\,n$ represents the resultant R in direction and magnitude. The point n falls on the line $g\,k$, for the same result may be obtained by combining the unit stresses on $a\,c$ at once; $o\,k$ equals the stress parallel to $Y\,Y$ and $o\,f$ equals $k\,n$ which, in turn, equals the unit stress parallel to $X\,X$, and their resultant is $o\,n$.

The line $y_1\,n\,x\,y_2$ represents the path of the point n when both p_1 and p_2 are tensile stresses; the part below the $X\,X$ axis is the path when the same stresses are considered on the conjugate diagonal planes. If one stress is compressive, the path will be the line $y_2\,x_2\,y_1$. The complete path is an ellipse with the major and minor axis respectively p_1 and p_2. This can be readily proved as follows: The coördinates of the point n are

$$o\,k = y = p_1\ cos.\ \phi,\ k\,n = x = p_2\ sin.\ \phi$$

$$p_2\,y = p_1\,p_2\ cos.\ \phi, \quad p_1\,x = p_1\,p_2\ sin.\ \phi$$

$$p_2^2 y^2 = p_1^2 p_2^2\ cos.^2\ \phi, \quad p_1^2 x^2 = p_1^2 p_2^2\ sin.^2\ \phi$$

$$p_1^2 x^2 + p_2^2 y^2 = p_1^2 p_2^2 (sin.^2\ \phi + cos.^2\ \phi) = p_1^2 p_2^2$$

This is the well known form of the equation of an ellipse: $b^2 x^2 + a^2 y^2 = a^2 b^2$.

The analysis of the problem shows that there are no planes of section on which the stress is greater than on the plane of section parallel to the axis; and it is evident when two simple stresses act on planes perpendicular to each other (on these planes there is no shear) that these are planes of maximum principal stress, since R, the resultant, cannot be greater than the major axis. In fact, the absence of shear on the planes shows that they are planes of maximum principal stress, for any condition of stress acting in the plane of the paper can be reduced to two sections perpendicular to each other and to the plane of the paper on which there is only simple stress, that is, no shear. If the two stresses are of the same kind they will be maximum and minimum values; if of opposite kind, both will be maximum.

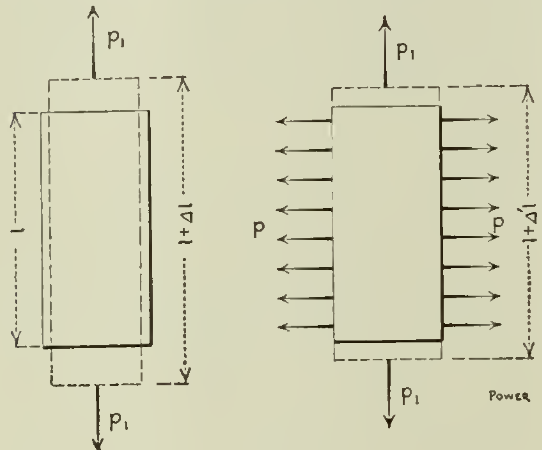


Fig. 3

As to whether the two forces acting at right angles to each other tend to raise or lower the yielding point of the material in directions parallel and perpendicular to the axis, the following extract from Greene's "Structural Mechanics," page 203, may throw light on the subject: "A plate is stronger to resist two pulls at right angles than when subjected to one only." Calculations are also made for a boiler plate subjected to a tension p_1 on a section parallel to the axis, and $\frac{1}{2}\,p_1$ on a section perpendicular to the axis, and this conclusion is arrived at: "Hence the true unit tension is less than the apparent tension by 12½ per cent., and the boiler is stronger than it would be if the longitudinal tension from the steam pressure on the heads did not exist."

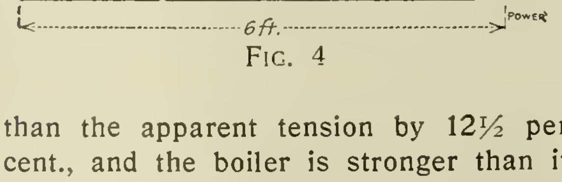


Fig. 4

Cotterill's "Applied Mechanics," page 412, states that the coefficient of elasticity E is increased in value, or, in other words, if the metal is subjected to a lateral pull, the piece will not elongate as much from the direct pull as when this lateral pull is not present.

It is difficult to see just how the unit stress can be reduced, since the stress in a body originally free from stress is caused by an external force and the unit stress is obtained by dividing this external force by the area; hence, to reduce the unit stress it would seem necessary to decrease the external force or else increase the area, and this is not done.

In Fig. 3 the left-hand sketch shows the change in shape of a rectangular piece subjected to the pull of an external force p_1; the full lines represent the shape before the force p_1 is applied and the dotted lines the shape after the force has been applied. It may be seen that when a single force p_1 acts on a bar there is a lengthening parallel to the line of action of the force, and a contraction perpendicular thereto. The unit stress on a right section is p_1 divided by the area.

In the right-hand sketch the piece is subjected to a lateral force p, the intensity of which is such that no contraction takes place when the force p_1 is applied. Here the elongation will be less than in the first case. The unit stress will be p_1 divided by the area as before.

In the left-hand sketch the length after the force p_1 has been applied is $(l + \Delta\,l)$, where l is the original length and Δl is the increase per unit length. In the right-hand sketch the length will be $(l + \Delta' l)$, where $\Delta' l$ is less than $\Delta\,l$. Where E and E' represent the coefficients of elasticity,

$$E = \frac{p_1}{\Delta\,l} \text{ and } E' = \frac{p_1}{\Delta'\,l}$$

Hence E in the first case is less than E' in the second case. The conclusion that E is less than E' may be arrived at by considering the unit stress on a cross-section the same in both cases; and the conclusion that the stress on a cross-section is decreased may be arrived at by considering that E', the coefficient of elasticity, does not change.

From what has been written on the subject it appears safe to assume that the two stresses at right angles do not, on any plane, subject the shell to a stress greater than that on the longitudinal plane, and it is possible that the material may be able to resist a greater pull when subjected to a lateral stress than when not, due to the fact that it will take a greater force to produce the same elongation and not any decrease in the unit stress.

This problem suggests a way in which the weakness of the shell due to the riveted joint may be overcome. Assume, for example, a boiler with a triple-riveted butt joint having an efficiency of 85 per cent. If this joint coincides with a plane on which the resultant stress R is less than 85 per cent. of the stress on a plane parallel to the axis, the joint will be stronger to resist the bursting pressure than the shell itself. Proceed to locate this plane when p_2 equals ½ p_1. Noting that the resultant

$$R = \sqrt{p_1^2 \cos^2 \varphi + p_2^2 \sin^2 \varphi}$$

and that R equals 85 per cent. of p_1,

$$(0.85\, p_1)^2 = p_1^2 \cos^2 \varphi + \tfrac{1}{4} p_1^2 \sin^2 \varphi$$

$$(0.85)^2 \times 4 = 4 \cos^2 \phi + 1 - \cos^2 \phi = 3 \cos^2 \phi + 1$$

$$1.89 = 3 \cos^2 \phi,\ \phi = 37\tfrac{1}{2} \text{ degrees}$$

From this it will be seen that if the seam made an angle of 37½ degrees with the axis, the seam would be as strong as the

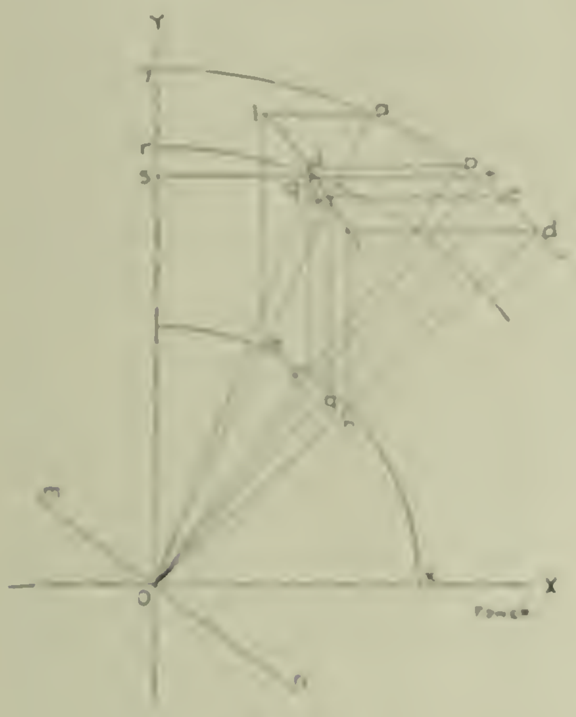


Fig. 5

shell to resist the stresses acting, and this on the assumption that p_2 equals ½ p_1, which, generally, in a steam boiler is not true, due to the tubes and bracing.

Consider a horizontal tubular boiler 72 inches in diameter and with through braces. If it is assumed that the shell carries the pressure on the heads which fall within 6 inches of the shell, the error will be on the safe side. This gives as the total stress on the shell when p is the pressure per square inch

$$p\,(36^2 \pi - 30^2 \pi) = 1244\, p$$

Dividing by the circumference,

$$\frac{1244}{226}\, p = \text{approximately } 5\tfrac{1}{2}\, p$$

as the stress per lineal inch on a section perpendicular to the axis. The stress per lineal inch in the shell due to the radial pressure is 36 p. From this is obtained the ratio,

$$\frac{p_2}{p_1} = \frac{5\frac{1}{2} p}{36 p} = \frac{11}{72}$$

and

$$p_2 = 0.15\, p_1, \text{ or } p_2 = \frac{2}{13}\, p_1$$

Solving the problem on this basis,

$$(0.85\, p_1)^2 = p_1^2 \cos^2 \phi + \frac{4}{169} p_1^2 \sin^2 \phi$$

whence

$$\cos^2 \phi = 0.846 \text{ and } \phi = 32 \text{ degrees}$$

If the sheet be 6 feet wide, the seam will extend around the shell (see Fig. 4)

$$6 \times \tan 32 \text{ degrees} = 6 \times 0.625 = 3.75 \text{ feet}$$

It seems that this should not be a serious difficulty, practically, when it is considered that a quadruple-riveted butt joint is used to increase the efficiency of joint to about 92 per cent., while this construction makes it as strong as the shell.

I also add an easy graphical method of locating the required plane (see Fig. 5). Take p_1 equal to $o\,y$ on the Y-axis; p_2 equal to $o\,x$ on the X-axis; and $o\,r$ equal to the resultant R. Draw arcs of circles with these distances as radii. Through these circles draw the radial lines $o\,a$, $o\,b$, $o\,c$ and $o\,d$, and from the points where these lines cut the circles locate the points i, j, k and l, of the ellipse as shown. A line drawn from o to the point where the ellipse cuts the circle of radius r is the resultant, and a line drawn through this point parallel to the X-axis cuts the large circle of radius p_1 at the point t; $o\,t$ is normal to the plane $m\,n$ on which R is the resultant stress; hence, $m\,n$ is the required location of the seam.

Bradford, Penn. JAMES CLARK.

The editorial under the above caption in the February 28 issue set me to thinking, and I worked out the following:

Laying out a force diagram, as in Fig. 1, with two units of force acting in one direction and one unit of force acting at right angles to the first, the resultant force acts along the hypotenuse and equals 2.23607 units of force.

A piece of boiler plate one inch square is so nearly flat that it may be considered as such, and if twice the stress be applied in one direction as is applied in a direction at right angles it will represent the conditions to which the shell of a

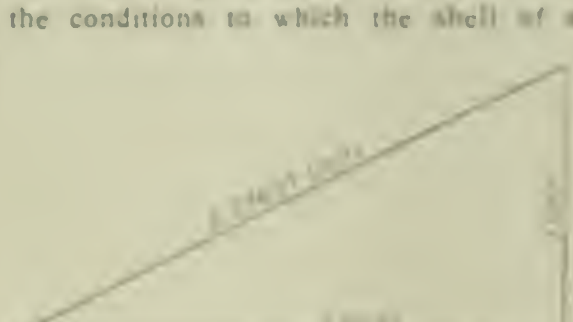


Fig. 1

boiler is subjected, so far as pressure is concerned. Up to the elastic limit the change of length will be proportional to the stress.

Let the two units of force representing the circumferential stress lengthen this side 0.2 inch, and with one unit applied to the other side it will be lengthened 0.1 inch; this represents the girth stress. The square will then have changed to a parallelogram having sides respectively 1.2 and 1.1 inches.

Laying out a second force diagram, as in Fig. 2, the line of the resultant force is found to extend from the lower left-hand corner to a point half way up the short side. This force, as in Fig. 1, equals 2.23607 units, but it is resisted by the metal along a line at right angles to its line of action, that is, along line $A\,B$.

$$\text{Tan. } d\,c\,b = \tfrac{1}{2}$$

Angle $d\,c\,b$ = 26 degrees 33 minutes 53.5 seconds

Angle $a\,c\,d$ = 90 degrees − 26 degrees 33 minutes 53.5 seconds = 63 degrees 26 minutes 6.5 seconds

Line $a\,d$ = sin. $a\,c\,d$ × 1 = 0.89442

Line $c\,d$ = cos. $a\,c\,d$ × 1 = 0.44727

Line $d\,b$ = tan. $d\,c\,b$ × $c\,d$ = ½ × 0.44727 = 0.223635

Line $a\,b$ = $a\,d$ + $d\,b$ = 0.89442 + 0.223635 = 1.118055

Hence

Fig. 2

$$\frac{2.23607}{1.118055} = 2 \text{ units stress}$$

per inch width of metal in the direction of the resultant force.

The cosine of angle $d\,c\,b$ equals 0.89442, and the length of the line along which the resultant force acts is

$$\frac{1}{0.89442} = 1.118 \text{ inches}$$

before the force is applied.

If one unit of force will lengthen an inch of the metal 0.1 inch, 2.0000 units will lengthen the line of the resultant force

$$1.118 \times \frac{2.0000}{10} = 0.2236 \text{ inch}$$

which added to the original length equals

$$1.118 + 0.2236 = 1.3416 \text{ inches}$$

If the long side of the plate be divided by the cosine of angle $d\,c\,b$ the result will be

$$\frac{1.2}{0.89442} = 1.3416 \text{ inches}$$

which was previously obtained.

I believe that this shows that the greatest stress is along the longitudinal line. Of course, the deformations here assumed are greater than an actual boiler plate would be subjected to, but the proportions will remain the same.

L. A. [illegible]

West Fitchburg, Mass.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Small Filter Tank

I have a large wood tank which I wish to convert into a filter for boiler-feed water. Please tell me how to do it correctly.

S. F. T.

Across one part of the tank, near the bottom, a loose floor of slats should be laid. On this floor put a layer of burlap, excelsior or gravel, and cover with coarse sand. Let the water in on top of the sand at one end and pump from the bottom of the tank at the other.

Valve Setting on Armington & Sims Engine

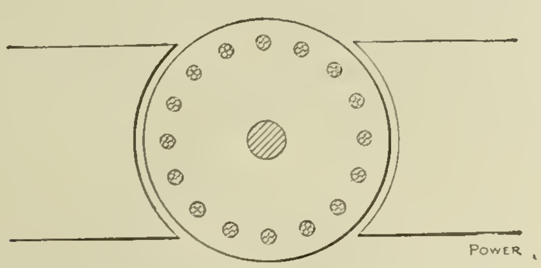
How can I set the valves on a cross compound-condensing Armington & Sims engine? Also, how can I prevent the engine from running away when working condensing and the load is suddenly released?

W. J. P.

The Armington & Sims engine belongs to the class in which the valve setting is by lead. All that the engineer can do is to keep the valve stem of such a length that the lead will be approximately equal at both ends. In this engine the lead is constant for all points of cutoff, and it is possible that with a condenser steam enough may be admitted through lead to run the engine above a safe speed without load. If such is the case a separate speed-limit or safety-stop appliance is the only remedy.

Completely Embedded Armature Wires

If the wires of an armature winding were threaded through holes some distance from the edge of the core, as shown in my sketch, would the armature generate any electromotive force when revolved between field-magnet poles, as in an ordinary dynamo?



ARMATURE WIRES COMPLETELY EMBEDDED

W. C. T.

Yes; but not quite as much as though open slots were used, as in the usual form of armature. Some of the magnetic lines would pass from pole to pole through the narrow strip of core metal between the holes and the periphery without affecting the armature conductors at all, but a large proportion would have to pass to the inner part of the core because the annular strip around the edge would not carry all of them. Those that pass to the inner core body would generate an electromotive force in the wires.

Cause of Knocking

At times my engine has a peculiar knock. If I feed a lot of oil the sound is reduced but not entirely removed. Can you tell me the cause of the knock and the remedy?

G. B. S.

It is doubtful if a lack of oil will cause knocking. Insufficient lubrication will cause harsh grinding noises, but not knocks. It sometimes happens that the piston ring has "play" in its groove, which will result in a knocking that is difficult to locate and a flood of oil will reduce the sound by partially filling the waste space and reducing the lost motion. The remedy in such a case is a new ring properly fitted.

Water Meter in Feed Pipe Line

I am about to install a water meter on my feed line to the heater. The supply pipe is two inches. I have been told that a 1-inch meter will be of ample size to deliver all my water; but I want to know whether the pressure on the discharge side of the meter will be reduced or whether an increased velocity through the meter will hold the pressure.

W. J. M.

The reduction in pressure on the discharge side of the meter in the feed line will be only that required to overcome the friction of the meter and is negligible.

If the demand for feed water requires the use of a 2-inch pipe, a meter with 2-inch connections should be installed, as one with 1-inch connections will require a velocity of flow through the meter four times as great as that for which it was designed.

Blow Back in Crane Safety Valve

Can the amount of blow back in the Crane Company's pop safety valve be changed by dismantling the valve and changing the tension of the auxiliary spring?

L. B. R.

The blow back in the Crane pop safety valve depends on the tension of the auxiliary spring, which is adjusted at the factory. If there were no tension at all on the spring, the disk which forms the huddling chamber would slide up the stem whenever the valve opened, and there would be no blow back at all. If the tension of this spring were made equal to or greater in proportion to the area of the huddling chamber than that of the mainspring, the blow back would depend on the area of the huddling-chamber disk. Hence, at any tension between zero and that of the mainspring, the blow back will depend on the auxiliary spring, and may be adjusted or altered by increasing or diminishing its tension.

The Six-stroke Cycle

What are the successive strokes in the six-stroke gas-engine cycle?

L. A. B.

(1) Mixture intake; (2) compression; (3) expansion; (4) expulsion or exhaust; (5) intake of air alone; (6) scavenging, driving out the air just taken in, together with a large part of the burned gases from the previous combustion.

Compounding and Overcompounding

What is the difference between a compound-wound and an overcompound-wound dynamo?

E. R. K.

A "flat"-compounded dynamo gives exactly the same voltage at its terminals at full load that it does at no load. An overcompounded dynamo gives a higher voltage at its terminals at full load than at no load. The difference is produced either by proportioning the series field winding differently or by the adjustment of a resistance strip in parallel with the series field winding, commonly called a "shunt" strip. Read the "Primer of Electricity" in the January 10 and February 21 numbers.

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Contents

POWER

The Alaskan Coalfields

The *Philadelphia North American* is authority for some disclosures regarding the Alaskan coalfields which should make the conservationists sit up and take notice.

According to this report it appears that on October 28, eleven days before the last election and several months after the attempt to turn over the Alaskan coalfields to the Morgan-Guggenheim interests had been frustrated by public sentiment, President Taft himself gave actual control of the coalfields to this same syndicate.

In the Ballinger investigation the fact was brought out that the claimants to these coalfields, which had been thrown open to public entry, had signed an agreement with the Morgan-Guggenheim syndicate by which a half interest in the property was to pass to the latter. Furthermore, all coal was to be sold at a fixed price to the syndicate, which was already building a railroad to the fields from Cordova bay, and any further sale to consumers was to be made by the syndicate. The unexpected opposition which developed against turning over these public lands to claimants who were no more than representatives of the Morgan-Guggenheim interests, made the outcome of the scheme somewhat doubtful. Hence, the syndicate began to look about for other outlets, from the mines to the sea, than those already under its control.

There remained just one other outlet to a natural harbor (Controller bay) and this lay in the Government forest reserve and was thus protected against private interests. The President, however, signed an order withdrawing this strip of land from the reserve and throwing it open to public entry. It appears that this order was not made public until a short time ago and it is charged that during the intervening time representatives of the Morgan-Guggenheim interests have taken up claims upon the land and have thus secured for the syndicate absolute control of the only possible outlet from the mines to tidewater, not already under their control.

To the general public the motives underlying the President's actions in this case must remain more or less a matter of conjecture. He may have been the victim of misrepresentation, or he may have taken the stand that these coalfields should be developed as soon as possible and that only a concern of such magnitude as the Morgan-Guggenheim syndicate would be in a position to effectively carry out the development. Whatever the motives, the action was untimely in view of the pending investigations and the public attitude regarding conservation, and the preservation to the people of their interest in the country's natural resources.

Firing Boiler Furnaces

Various articles have been published giving advice as to the best method to pursue to get better results in the boiler room.

It is well known that the principal losses are due to poor firing, improper working of the stokers, where used, excessive air admitted to the furnace and improper furnace design. Then there are scaly boilers, steam pipes radiating heat, and leaky inlets and valves.

It is within the province of every engineer to eliminate to a great extent these sources of loss, if he goes about it in the right way. Doubtless the problem of getting the firemen to handle their fires properly is the most difficult one that the engineer has to solve.

How often should the firemen fire the boilers? How much coal should they put in the furnace at one firing, and how thick a fire should be carried? It has been urged that the greatest economy is obtained when the least amount of fuel is put into a furnace at any one time that will maintain a constant steam pressure. Throwing in from ten to fifteen shovelfuls of coal at one firing is wasteful and should not be countenanced.

Some engineers contend that a thin fire is the better; others that a thick fire gives better results, and still others that a medium fire is the most desirable.

Doubtless the advocates for each thickness of fire have good and valid reasons for preferring one method over the other, but how have they arrived at the conclusion that their methods are the best and most economical?

In a certain plant in a manufacturing city, the firemen fire at a given signal, slice the fires at another signal, and level at a third signal and good results are said to be obtained. In another plant the firemen fire when they think the fires require a new charge of fuel. In fact, they use their own judgment as to the way the fires ought to be handled and, although an exceedingly thick fire is carried, the plant is said by those who are in a position to know to be one of the most economically operated plants in the New England States.

Why should two steam plants, operated under such radically different lines, give the good results that are claimed for them?

It would seem that there is more to this firing problem than has been determined. It would also seem that it is not a safe thing for an engineer to follow one method of firing just because someone else has been obtaining good results. A better way would be to carry on experiments with various methods of firing to find out just what method is the most economical for any particular plant. If a thin fire and frequent firing are best, use this method; if heavy firing and a thick fire give better results, use that method. It is not the way coal is fired that counts; it is the economical results obtained from the burning fuel that are of real importance.

Who Is Responsible

If the news items sometimes seen in the daily press are a criterion of the intelligence of the men who are often entrusted with the care of steam-power machinery, the efforts of the advocates for engineers' license laws should also cover the field of watchmen and wipers.

It is recorded that "a watchman in the employ of the Diamond Sand and Gravel Company, of Bedford, O., was severly scalded while attempting to make some slight repairs to a safety valve." How he discovered that repairs were necessary or on whose authority he started the work does not appear. There was pressure on the boiler, so he drew the fire, climbed to the top of the boiler and with a large monkey wrench started to unscrew the valve from the boiler. While doing this the valve opened, the discharge striking him fair in the face, scalding him badly and probably destroying his sight.

It is a pitiful story. A young man blinded and disfigured for life because someone blundered. But who? Was it the man himself or the one who made him a watchman? Why should a watchman in a State full of licensed engineers meddle with a safety valve whether on or off a boiler?

Did he think that the steam pressure would cease as soon as the fire was drawn?

Every few days someone is killed or injured because someone else did not know that the gun was loaded. But everybody knows that the steam boiler is loaded. Yet accidents both painful and fatal are of daily occurrence because the simplest of natural laws are recklessly violated.

In one State a boiler explodes because the man in charge screws down on the safety-valve spring and in another because the stop valve is opened too suddenly. Who is responsible for such blunders, the man who knows no better or his employer?

The paths of progress in all lines are marked by martyrs and perhaps the human race will not be slower to learn at the costly school of experience than are the lower animals. It is to be hoped not.

Machine-Made Engineers

There seems to be an impression permeating some quarters that the Institute of Operating Engineers is to be used for the purpose of turning out a supply of "machine made" engineers to compete with and displace the homemade variety now operating most of the power plants.

Nothing could be further from the truth. The primary idea of the Institute is to direct intelligently the education of the present engineer, and of the power-plant worker who desires to become one. Far from bearing the "machine made" earmarks of mediocrity, each individual will be advanced in his standing in the Institute as he demonstrates his fitness for advancement.

The Institute has nothing to offer to the contented worker but everything to the one who, possessed by an intelligent dissatisfaction with his present position and attainments, is willing to earn preferment.

To the engineer who recognizes the fact that he owes to himself as well as to society the duty of making the most of his opportunities for mental and manual training the Institute will be an ever welcome guide and help. But there is no room on its membership roll for the names of those who are satisfied to continue as manual workers for wages alone.

Comparative Steam Turbine Performances

Upon page 595 of the April 18 issue was given a comparison of results obtained with Curtis turbines as built by the Allgemeine Elektricitäts Gesellschaft, of Berlin, and the General Electric Company, of Schenectady. While the steam actually used is less for the German turbine, 11.9 and 11.97 pounds per kilowatt-hour against 12.9 and 13 for the American, the German turbine was tested with a much higher degree of superheat, and in the later test with a better vacuum. The pressure was about the same in all four tests, from 188 to 195 pounds, but the temperature in the German tests was 601 and 630 against 525 and 505 degrees, giving the German turbine 256 and 285 degrees against 95 and 125.1 for the American. Here is a difference of 160 degrees of superheat and the experience of the General Electric Company has been that the performance of its turbine is improved one per cent. for about 12.5 degrees of superheat. The performance of the German turbine in question with the higher degree of superheat is only about eight per cent. better than the American with 160 degrees less which ought to improve its performance about 13 per cent.; and the German turbine had a somewhat better vacuum.

The American turbine was designed for the conditions under which it ran and converted 66.2 per cent. of the heat available by the Rankine cycle, while the German turbine converted only 63.6 of the available heat under the conditions of its test.

The use of high degrees of superheat is not common in America, and it is hardly fair to compare water rates obtained under conditions involving greater possibilities with those obtained here under less favorable conditions.

Investors in water-power development want to know what the Government will do with their property at the end of a limited franchise.

Self-respect and a definite knowledge of one's ability are requisite to complete success in engineering or anything else. But self-inflation and the unproved assumption that you are just as capable as any other man are fatal, especially in power-plant work.

Because it is sold as "carbonless antifriction unchangeable cylinder lubricant," some men will unquestioningly torture the cylinder of a gas engine with stuff that is about as healthy for it as axle grease would be for a watch.

An average boiler efficiency of 80.47 per cent. is unusually high. This was obtained at the Redondo plant of the Pacific Light and Power Company, using crude oil as fuel.

Where a cooling tower is used a moderate vacuum under some conditions is preferable to a high vacuum.

In the power-plant field there are specialists in all branches of the trade—even brake specialists. See page 723 of this issue.

The season of refrigeration is now at hand and our new department will be right in line. Good practical articles on the operation of refrigerating machinery and special kinks installed in your plant is the kind of material needed to make this department a success. We are depending on our readers to come to the front.

It is one thing to know how to play a scientific game of pool and another to run a power plant; the pool game will not give many pointers.

Government Water Power Developments

In the power field there is no question of more pressing importance than Government control and development of water power. The recent discussion before the National Electric Light Association brought out some interesting points on the subject. It is high time for the Government to get busy and establish some definite policy. On this same general question an interesting editorial on water powers was recently published in the *Engineering Record* and is reproduced in the following paragraphs:

The utilization of water power in Sweden at the present time has an aspect which deserves to be investigated carefully and the details put on record for the benefit of those interested in the rational development of our own water powers. New York State has an area only one-fourth that of Sweden, but its population is almost twice as great. Although its resources, per capita or per square mile of territory, are much greater than those of the Scandinavian kingdom, and, although a State Water Supply Commission has made an analysis of its water-power possibilities which points with the utmost clearness to the desirability of developing these resources under some system of State control and aid, nothing has been done along these lines but to talk. As a result, the choicest power sites in the State are being developed quite quickly by companies and, if legislation is not more rapid than hitherto, the people of the State will shortly find that any rational utilization will be extremely costly, owing to the rights that are now being secured so diligently and unobtrusively by private parties. No one can read the reports of the New York Water Supply Commission and the monograph on hydraulic power development written by M. O. Leighton for the United States Geological Survey without being thoroughly convinced that State control and State aid in this work are desirable theoretically and very necessary practically.

In Sweden the early hydraulic-power development was done by the private companies and there are many of them in that country. A study of the water resources of the State showed, however, that a large amount of power was not being utilized by those companies which could nevertheless be developed and sold on a profitable basis. Coal is expensive in Sweden and power developed at hydroelectric plants has a wider range of commercial value than is the case where fuel is less costly. The government has undertaken the construction of hydroelectric plants which it proposes to run as revenue-producing establishments, if possible, and in any case in such a way as to meet all charges. The government works now under construction at the Trollhättan and Porjus falls have been described in numerous electrical publications and these will be ready for service before long. Their manifest success has led to the development of a third project, at Alfkarleby falls on the Dals river, which it is believed will receive the approval of the legislature. Some figures recently published in *Engineering* show that within 65 miles of the power station there is a probable consumption of nearly 15,000 kilowatts, which will call for development of about 22,000 hydraulic water power. If the uses of electricity are still further extended the plant can be increased to a capacity of 45,000 horsepower. The initial installation will cost something like $125 per horsepower, but the total cost of the final installation of 45,000 horsepower will be at the rate of $55 per horsepower. These figures are only approximate, for the information at hand does not indicate how much reserve capacity is included, although it is understood that there is a reserve and that the rating of the station is that for continuous operation.

The technical details of these government plants are decidedly interesting, but they are subordinated by the important economic principles involved in their construction. The Swedish government sends engineers to this country to report on what is being done in the way of developing water power in the United States. It is highly desirable for our Government or for one of the States to send representatives to Sweden in order to find out just what that enterprising kingdom is doing. It is certainly showing more sense in dealing with hydraulic power than we are.

A Busy Day at the Plant

By A. E. Dixon

Of course, you know things happen in bunches. Well, we got ours the other day. First round was called off in the smiths' shop, where the boss told one of the "Hunkies" to liven up a fire a bit. Well, he just selected the wrong Hunkie, and one who happened to know the location of a loose five-gallon can of benzine. Mr Hunkie sure did liven that fire some. The boss got his share of it, or rather more than his share, while the Hunkie got his hands burnt. Better luck than management.

The next episode was trying to put a belt on. This was called off before we'd got quite quieted down from the explosion. The machine hand had seen that belt put on a dozen times and so he concluded he'd put 'er on. Well, he sure was a lucky boy; his overalls was old, but he was one scared kid and will leave the putting on of belts to the right man hereafter. He climbed the ladder and got the belt on, but he got the skirt of his overall jacket in the belt and a single yank took it off him. The cloth was rotten from alkali and tore easy or Johnny would have gone over the shaft and into the ambulance. He was so scared he could not get down the ladder.

Mechanical Engineers at Pittsburg

The application of mechanical engineering in the field of cement manufacture will be one of the important questions considered by the American Society of Mechanical Engineers at their annual spring meeting, to be held in Pittsburg, Penn., May 30 to June 2. Papers will be presented covering different phases of the subject.

In addition to papers dealing with machine-shop practice, there will be papers on the "Commercial Application of the Turbine Turbo-Compressor," by R. H. Rice, of the General Electric Company, West Lynn, Mass.; and upon "Hydraulic Forging Presses and Blowing Engines"; and on miscellaneous topics, including papers on "Stresses in Tubes," by Reid T. Stewart, professor of mechanical engineering of the University of Pittsburg; the "Purchase of Coal on the Heat Unit Basis," by Dwight T. Randall, engineer in charge of the fuel-engineering department of Arthur D. Little, Incorporated, Boston, Mass.; "Energy and Pressure Drop in Compound Steam Engines," by F. L. Cardullo, of the department of mechanical engineering of the New Hampshire College of Agriculture and the Mechanic Arts; and "A Pressure Recording Indicator for Punching Machinery," by Gardner C. Anthony, dean of the engineering school of Tufts College. There will also be a session on gas power, with papers to be announced.

The convention will open on Tuesday afternoon, May 30, with the registration and reunion of members at the headquarters in the Hotel Schenley, followed by an informal reception for members and guests on the evening of the same day. There will also be an opportunity on Tuesday and Wednesday afternoons for inspection of the Foundry and Machine Exhibition Company's exhibit, which will be in progress in the exhibition building. On Wednesday morning, "The Mechanical Engineering of Cement Manufacture" will be the subject of the first of the technical sessions, all of which will be held in Carnegie Institute, in close proximity to the society's headquarters. In the afternoon a trip to the works of the Universal Portland Cement Company will be made, with a stop at East Pittsburg to allow those who desire to visit the plants of the Westinghouse Electric and Manufacturing Company and the Westinghouse Machine Company. The second technical session, at which the papers on "Machine Shop Practice" will be presented, is scheduled for the evening of the same day. The professional session of Thursday morning will deal with miscellaneous topics and will be as brief as possible, in order to leave ample time for an excursion up the Monongahela river, including a visit to the National Tube Company's works at McKeesport. A reception and informal dance will take place in the evening at the convention headquarters. The concluding professional session, at which "Steel Works Practice" will be the subject for consideration, will take place on Friday morning. An inspection trip to the Mesta Machine Company's works at Homestead, Penn., is planned for the afternoon of Friday, and the convention will close that evening with a smoker and entertainment given by the Engineers' Society of Western Pennsylvania at their rooms in the Oliver building. A ladies' committee, Mrs. Chester B. Albree, chairman, will care for the pleasure of the guests of the society and will, as is usual at these conventions, do much to add to the social features of the occasion.

N. A. S. E. State Conventions

The following is a list of the annual conventions of the various State associations, giving the place of meeting and the date for each State in alphabetical order:

California	San Francisco	June 5-10
Colorado	Pueblo	June 9, 10
Connecticut	Hartford	June 23, 24
Illinois	Ottawa	May 19, 20
Indiana	Terre Haute	June 9, 10
Iowa	Ottumwa	May 25-27
Kentucky	Louisville	June 2, 3
Massachusetts	Worcester	July 14, 15
Michigan	Saginaw	July 21, 22
Minnesota	St. Paul	August 23-26
Missouri	Kansas City	July 12-14
New Jersey	Newark	June 3-5
New York	Albany	June 9, 10
Ohio	Cincinnati	September 11, 12
Pennsylvania	Johnstown	June 2, 3
Texas	San Antonio	
West Virginia	Clarksburg	
Wisconsin	Milwaukee	June 8-11

SOCIETY NOTES

At the second annual meeting of the American Institute of Steam Boiler Inspectors, held at the Parker house, Boston, the following officers were elected for the ensuing year: President, J. F. Molloy; vice-president, A. D. Evans; treasurer, Adam Oldfield; secretary, T. G. Ranton, 112 Water street, Boston; executive committee, E. R. Doherty, M. S. King, E. J. Scanlan, H. Van Ormer and R. L. Hemingway.

The tentative program of the coming convention of the National Electric Light Association, May 30 to June 2, provides for two sessions daily for four days and over sixteen sessions in all, there being several parallel sessions. There are twenty-four papers in the program and nearly forty committee reports. In all there are some seventy items in the order of business and it will take the full time of the convention to dispose of them.

Detroit is planning for the convention of the National Gas and Gasolene Engine Trades Association meeting of June 20 to 23, inclusive. President C. O. Hamilton is planning a convention that will consist of snappy sessions, comparatively short in length, with plenty of opportunities for discussions, seeing of the exhibits, viewing the many civic and commercial attractions of Detroit and leaving time for much in the way of entertainment. Exhibit space will be provided without charge for any light articles which can be shown without damage to woodwork or floors of the Hotel Pontchartrain, where the convention will be held.

The third international congress of refrigeration will be held in the United States in 1913 under the auspices of the American Association of Refrigeration. The second international congress was held at Vienna in October of 1910. Theodore O. Vilter, of Milwaukee, who represented the American association at the Vienna congress, who was active in obtaining the third congress for America and who is now the president of the American association, has isued an urgent appeal for members and contributions to an extent which will allow the American association to provide a reception and entertainment which will compare with that which was accorded to the congress at Vienna.

PERSONAL

A. H. Foster, formerly with the Clement Restein Company, has recently changed his position and is now connected with the Henry Johnson Packing Company, of Jersey City.

Henry R. Cobleigh has resigned as mechanical editor of *The Iron Age*, which position he has held for the last seven years, to take charge of the advertising and publicity of the International Steam Pump Company, 115 Broadway, New York City. He entered upon his new duties May 1.

Percival Robert Moses, consulting engineer, 366 Fifth avenue, New York City, announces that he has associated with him the following engineers as permanent additions to his staff: John Fallon, industrial engineer, recently mechanical engineer of the Tennessee Copper Company, and Stanley G. Flagg & Co.; Arthur V. Farr, textile engineer, formerly Szepesi & Farr, 90 West street; Alphonse Kaufman, formerly manager and chief engineer of the Alaska Chemical Company, and associated with Charles B. Jacobs industrial laboratories; J. N. Walton, recently power engineer and storage-battery expert of the Brooklyn Edison Company. The office is prepared to handle complete industrial equipments.

BUSINESS ITEMS

The Rateau turbine, which has been heretofore built in this country by the Bail & Wood Company, is now manufactured by the Southwark Foundry and Machine Company, Philadelphia. The company, already has under construction some large turbine-driven centrifugal biowers for steel-works service.

Beginning May 1 the Bundy steam trap, which has always been manufactured by the Nashua Machine Company, Nashua, N. H., and marketed through selling arrangements, formerly with the A. A. Griffing Iron Company, and later through the American Radiator Company, will be sold through the selling department of the Nashua Machine Company, located at 127 Federal street, Boston, Mass. The sales manager will be John Sabin, who was the first man to introduce a tilting trap on the market over twenty years ago and who has been closely associated with the Bundy trap ever since.

A book which should prove very attractive to engineers has just been issued by the George M. Newhall Engineering Company, of Philadelphia, manufacturer of the Vance steam trap. The book is called the "Engineers' Reference Book," and is more than half composed of valuable information for the engineer, gleaned mostly from Kent's "Mechanical Engineers Pocket Book." There are between 50 and 100 subjects reprinted from Kent's alone, embracing information which the engineer has almost daily need for. It will be sent to anyone requesting a copy, and is partly devoted to a discussion and comparison of the different types of steam traps: a large portion of which is regarding steam-trap capacities. A very original and practical method is given for determining what capacity of traps are required under all different conditions. The book also contains complete description of the Vance steam trap. Anyone desiring a copy can obtain one without cost from George M. Newhall Engineering Company, 136 South Fourth street, Philadelphia, Penn.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

POWER

NEW YORK, MAY 16, 1911

MANUFACTURING in the New England States dates back to the landing of the Pilgrims at Plymouth, Mass. It was not always carried on by means of the steam boiler and engine. The early looms and spinning wheels were deftly operated by the dexterous fingers of the settler's wife and daughters.

Whenever the arms tired with the wielding of the "wheelboy" the speed of the spinning wheel was reduced and the output of home-spun yarn fell below the average.

Conditions have changed since the days of the spinning wheel. Today more cotton and wool are spun in one hour in the mills of New England than could have been spun in years by all the settlers' wives put together.

But the relation of speed and output remains the same. If the engineer today allows the steam pressure to drop and the speed of the engine is reduced but one-half turn per minute, the speed of the spindles on the spinning machine in the factory is reduced several revolutions, the threads of yarn are not twisted as rapidly and the output of the mill falls below its rating.

This is one of the losses which is hidden by the turning of the wheels. To all appearances the speed is as it should be, but the loss of that one-half turn of the engine flywheel is multiplied a good many times by the thousands of spindles in the mill.

And the engineer is the one man to blame. He can prevent this loss if he will. There are some mighty good engineers in the New England States in charge of cotton- and woolen-mill steam plants, but it is a certainty that all of them do not keep their engines right up to the maximum speed all of the time.

It is evident that the engineer who does keep his engine up to speed is the man who is giving his employer the better service.

Of course, loss of speed reverts back to the boiler room, but it is the business of the engineer to run the boiler room. If he does not get 100 pounds of steam it is his own fault.

Thousands of dollars are never earned in manufacturing plants because the speed has been below that required to give normal capacity.

The loss of one-half turn of the flywheel per minute is seemingly a small matter, but it costs money. The loss is seldom traced to the engineer, but if he knows of the loss and fails to improve conditions, he is missing a great opportunity to make a saving for the firm.

In many cases it means just as much as keeping the cost of fuel down to the lowest possible amount.

By the way, how much does the speed of your engine affect the output of your finished product?

New Power Plant of Dennison Mfg. Co.

By W. O. Rogers

> *This modern installation takes the place of two old plants. Noncondensing Corliss engines, coupled to direct-current generators, are installed, and the exhaust steam is used for manufacturing purposes. Four Wickes boilers fitted with Dutch-oven furnaces and mechanical stokers supply the steam.*

The Dennison Manufacturing Company, South Framingham, Mass., has just completed a new, modern power plant. The building, 110 feet long by 110 feet wide, is constructed of brick and is large, light and roomy.

Engine Room

In the engine room, Fig. 1, are two Hewes & Phillips twin engines, each cylinder being 14x33 inches and capable of producing 225 horsepower or 450 horsepower for each engine. There is also one single unit of 225 horsepower, having a cylinder of the same size as the twin engines. Each engine is direct coupled to a Crocker-Wheeler direct-current generator. Each twin engine drives a 350-kilowatt generator, which delivers a voltage of 240 to the line, at 150 revolutions per minute. The single engine is direct coupled to a 150-kilowatt generator, of the same voltage and speed as the other two units. These three engines are fitted with the new Franklin valve gear.

No pipes show in the engine room, as the live- and exhaust-steam pipes are attached to the cylinders underneath and drop to the basement, where they connect with the main steam and exhaust lines. The live steam is controlled by means of floor-stand operated valves located conveniently beside the engine cylinders. The engine cylinders are lubricated by force-feed lubricators. The engine oil drains from the engine bearing into a filter located in the basement and is then elevated to an oil reservoir, placed above the smoke flue in the boiler room, thus keeping the oil warm, without the aid of heating coils in the filter.

An interesting device is shown in Fig. 2, midway between the two frames of the twin engines. It consists of a floor stand supporting an arm from which an adjustable hanger containing two rollers is suspended. The cross rod extending from the governor on one side of the engine to the reach rods controlling the valve gear on the other side passes this hanger and is supported at the center by the two rolls, the hight of which can be adjusted by moving the bracket up or down. This prevents vibration, supports the rod and reduces friction.

A gageboard, on which is mounted a clock, steam gages for live steam, steam heating and vacuum, also the water pressure on the city main, is mounted on the wall between the engine and boiler rooms. There is a Laidlaw-Dunn-Gordon 10 and 10 by 10-inch air compressor that supplies air for shop work. The pressure is maintained at 45 pounds per square inch. There is also a 40-horsepower Terry turbine, direct coupled to a Diehl direct-current generator of 25 kilowatts capacity, which runs at a speed of 2500 revolutions per minute. This unit is used for lighting the engine and boiler rooms, and several rooms in the factory building when the main units are shut down.

Fig. 1. View of the Engine Room of the New Power Plant of the Dennison Manufacturing Company

The foundations of the twin engines have been so designed that one of the high-pressure cylinders can be removed and a low-pressure cylinder substituted in case it ever becomes necessary to do so. Provision has also been made for installing a receiver between the two cylinders should the engines be compounded.

The switchboard shown in Fig. 3 is located between No. 1 unit and the end wall of the building and is designed in two sections, devoted to motor and lighting circuits, each section having its own recording instruments and circuit-breaker control.

The former plant operated upon 115 volts and in various departments were located 125 motors ranging from 1/10 horsepower to 60, many of these being special motors for variable-speed work and direct connected to special machinery. Provision was made when installing the new plant to keep all motors in use up to and including the 15-horsepower sizes on 115 volts. All motors larger than this size and all new motors were installed for 230 volts.

Both power and lighting circuits are carried into the plant on a three-wire system and two balancers are installed with a capacity of 100 and 200 amperes respectively. The balancers can be run separately on power and lighting circuits or can be operated in parallel.

Fig. 3. Switchboard and One of the Balancing Units

Boiler Room

In the boiler room, Fig. 4, there are four Wickes vertical water-tube boilers set in two batteries. Each boiler is equipped with a Murphy stoker, with an extended dutch oven giving a large combustion chamber. A smoke flue connects with the bottom of each boiler and extends up to the main smoke flue, which runs the entire length of the boiler room and connects with the 150-foot brick stack, located on the outside of the building.

Each boiler is fitted with a damper in its individual uptake; the main flue is also fitted with a damper which will eventually be operated by a damper regulator and the draft of all the boilers will then be controlled by the one damper.

The settings of these boilers have been built in accordance with the specifications

Fig. 2. View of Engines from the Generator Side, Showing the [illegible] System

demanded by the Massachusetts Board of Boiler Rules. Each boiler is set on a concrete base, which is made hollow, as shown in Fig. 5, an end elevation of the engine and boiler rooms. The bottom head of the boiler extends down into this hollow foundation so that it is easily accessible for external inspection, a space having been especially provided opposite the riveted joint of the head and barrel of the boiler, as shown in Fig. 5. This permits of inspection of every rivet of the bottom head joint at any time and decreases the liability of the failure of the joint or the wearing away of the head at this point by external corrosion occurring without being noticed.

Piping

The boiler blowoff pipe extends down from the center of the bottom head and passes out through the concrete foundation, and is fitted with a tee connection, the outer end of which is fitted with a blank. From the side connection of the tee, two valves connect with a Y-connection on the blowoff pipe, as shown by the dotted lines in Fig. 6. The valve nearest the boiler is of the asbestos-packed type; the second is a straight-way valve. All blowoff pipes run under the boiler-room floor and the valve-stem extension rods pass up to and almost through the boiler-room floor; the valve stems are operated by means of a detachable wrench. When not in use the opening over each valve-stem extension rod is covered by a floor plate. This blowoff arrangement is a very desirable feature, as a fireman is not obliged to go down under the boilers when blowing them down, thus reducing the element of danger in case a blowoff pipe should burst.

Steam is taken from the top of each boiler through a 6-inch extra-heavy pipe, fitted with a long radius bend and is led down to a 12-inch steam header, that is supported on suitable concrete piers arranged back of the boilers. The header is divided into two sections by a valve, so that either section can be cut out of service. From this steam header, 7-inch steam pipes are run to the two twin engines and a 6-inch pipe is run to the single engine. Two 8-inch pipes connect the 12-inch main steam header to an 8-inch steam header, which extends from a point under the second twin engine to the pump room, from which the auxiliary units are supplied and from which live steam is taken to feed into the exhaust-steam main in case there is insufficient exhaust steam supplied to the factory.

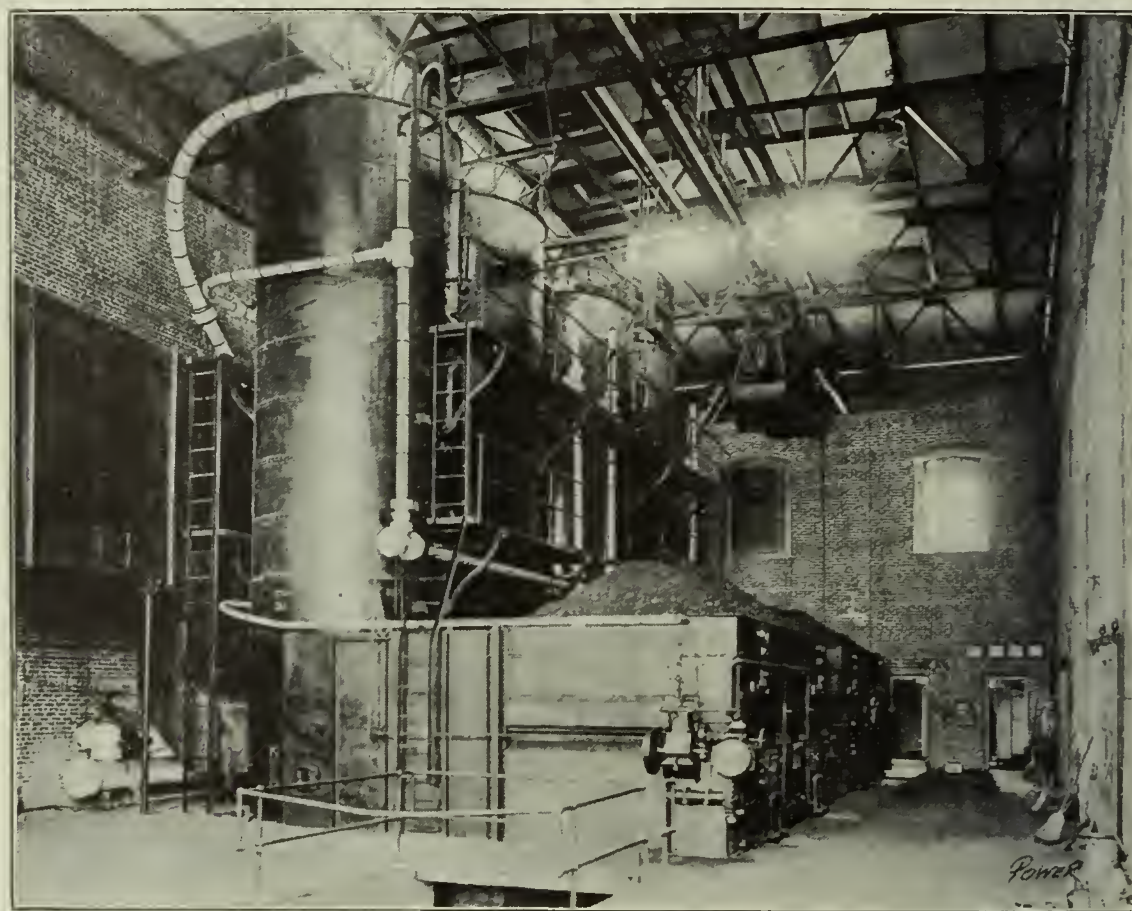


Fig. 4. Boiler Room Containing Four Wickes Boilers

Another live-steam line is tapped to both sides of the cutout valve in the main 12-inch steam header which extends to the pump room located at the front end of the building. The exhaust pipe from the single unit is 7 inches in diameter; it increases to 10 inches for the second unit and to 15 inches at the third engine, beyond which connection is made with a

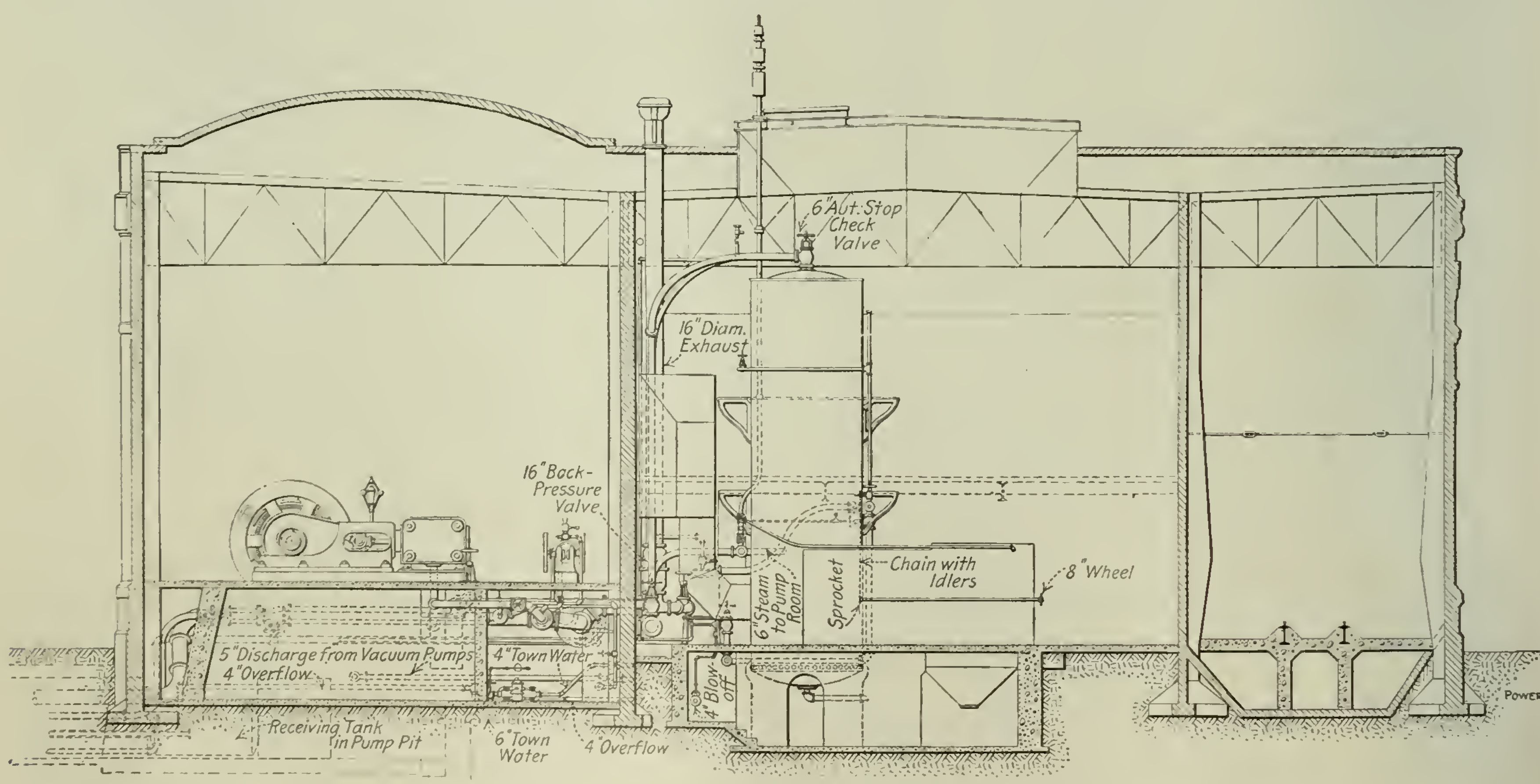


Fig. 5. Elevation of the Engine and Boiler Rooms

17-inch exhaust main, which provides for a future unit and which runs the length of the engine room in the basement toward the front and on to the factory through a tunnel that is 200 feet in length. All wires, pipes for live and exhaust steam, water and air are carried to the factory through this tunnel.

A 16-inch Hoppes oil eliminator is placed in the exhaust line; connection is also made through the wall between the boiler and engine rooms, so that exhaust steam can be passed through a Reilly multicoil feed-water heater. A vertical galvanized, spiral-riveted exhaust pipe

driven by a 20-horsepower Diehl motor with a speed variation of three to one. The speed of the pump is regulated by hand by means of a field control. Surplus is bypassed into the suction pipe by means of a regulator valve. There is also one 12 and 7 by 12-inch Deane duplex pump, used for boiler feeding, when electrical power is not available. Fig. 7 shows the layout of the piping in the pump room.

Fire protection is afforded by a Knowles 18 and 10 by 12-inch duplex pump which has a capacity of 1000 gallons at 70 revolutions per minute. This

in which these pumps are piped up either one can take water from the heating system direct and at the same time from the receiving tank, the height of water in the receiving tank being controlled by a Utility pump governor. Suppose the pump is pumping from the return main of the heating system. As the water in the receiving tank lifts a float ball, a valve is operated in the governor chamber, which permits the water to be drawn from the receiving tank through the governor, until a certain predetermined level has been obtained, when the valve closes, which operation takes place

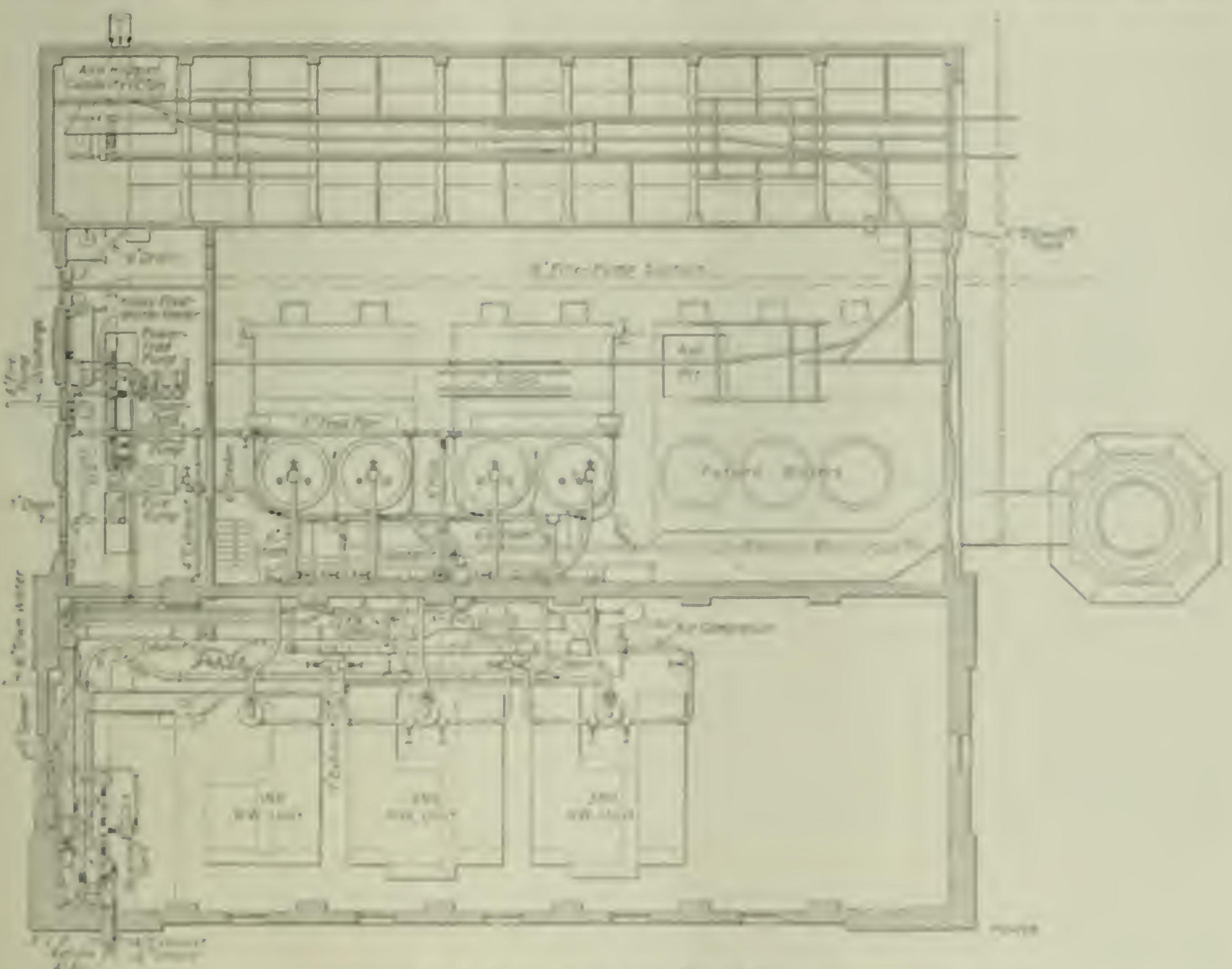


Fig. 6. Plan View of the Power Plant

extends to the atmosphere and is fitted with an Atwood back-pressure valve; this pipe connects with the exhaust pipe between the main exhaust header and the heater. The general arrangement of the piping is shown in Fig. 6, which also gives a view of the layout of the plant, showing the space reserved for three additional boilers in the boiler room.

Pump Room

In the pump room there is one Rumsey 8½x10-inch, triple-plunger, motor-driven power pump. This pump is

pump is connected by means of a 12-inch suction pipe to a reinforced-concrete reservoir in the rear of the power house. This reservoir is about 54 feet in diameter and has a capacity of 125,000 gallons of water.

In a pit under the engine-room floor, is an 8 and 10 by 12-inch Blake vacuum pump for handling the returns on the heating system. There is also an 8 and 10 by 12-inch Knowles pump, either one of which can be used on either the vacuum heating system or to pump from a receiving tank. On account of the manner

before air can be drawn into the pump cylinder.

Feed-water System

A feed-water heater is placed between the two batteries of boilers and next to the dividing wall between the engine and boiler rooms. Feed-water is taken from the make-up tank and is forced through a Blackburn-Smith feed-water filter and the heater to the feed line. The feeding of water in the boilers is regulated by means of a handwheel and shaft, the latter extending to a point under the feed pipe and connection made to a sprocket wheel on the valve stem by means of a chain. This enables the fireman to regulate the water from the front of the boiler furnaces.

The 5-inch brass feed-water main extends along the front of the boilers, and vertical pipes are run up and over to the rear of the boiler, connecting near the top; a tee joint is placed where the vertical and horizontal branch pipes connect and a vertical piece of pipe, capped at the top end serves as an air chamber to prevent water hammer in the feed pipe.

Coal and Ash

Coal is delivered to the stokers by means of a ¾-ton Sprague electric traveling conveyer, which runs on a suspended track reaching from one end of the coal shed its entire length and, making a curve at the stack end of the plant, extends back over the stokers of the boilers. Before the bucket discharges its load, the coal is weighed on a Fairbanks scale which enables a tally to be kept on the amount of coal delivered and the amount burned each day. A spur track extends the length of the coal room on heavy beams and the coal is discharged into the pit below the rails. The coal shovel is of such proportions that it can be dropped between the rails when picking up its load.

Under the boiler-room floor, and directly under the outlet of the ashpits, which are made with slanting sides, is an industrial car track, on which an ash car runs. When ashes are to be removed, they are dumped into this car, which delivers them to the ashpit, shown in Fig. 6. From the ashpit the traveling coal bucket picks up the ashes and conveys them to an ash hopper, shown in Fig. 6, located at the extreme end of the coal shed. This hopper has a capacity of 12 tons and is fitted with a gate on the outside of the building, so that the ashes can be readily loaded into a wagon and carted away.

The author is indebted to the engineering staff of the Dennison Manufacturing Company for data and illustrations concerning this installation.

License Agitation in Rhode Island

By William E. Francis

In Rhode Island, as in many other States, boiler-inspection and engineers'-license legislation is being urged by progressive engineers. That these efforts are meeting with a great deal of opposition from those who imagine that their interests are threatened, is evidenced by the statements made by persons who were called before the House Judiciary Committee on the afternoon of March 29, where it was disclosed by evidence that there are two steam boilers in use at the Technical High School which are considered dangerous and which, though made in Massachusetts, the manufacturers admitted at the time of putting them in do not comply with the Massachusetts law and could not be used in that State.

Among others who appeared before the committee was B. McCabe, of Boston, Mass., who said he was opposed to the bills and that he had come to the hearing to intercede for the engineers and to save the public of this State from the troubles which had been experienced in Massachusetts. The object of the bills, he said, was to legislate certain men out of positions. He told of the injustice which he claimed the law had worked in the neighboring State, in depriving good men of positions they held in order that someone else might get them.

After the hearing, one of the aldermen said that he was unaware that anything was wrong with the boilers but that about a year ago his attention was called to the fact that the building was being heated with condensed steam and that there was a big waste because the return steam could not be used. This was due to the poor circulation of the oil in the boilers and a leakage in the tubes sometimes resulted. Large quantities of caustic soda had to be used in order to prevent this and a request was made for an oil filter. This was obtained and since that time he has heard no complaint as to the condition of the heating apparatus. Continuing along these lines he further said that the boilers consumed an extravagant amount of coal and that it cost more to heat the Technical school building than it did to heat all the buildings of the new City Hospital.

One thing stands out quite prominently: The statement of the engineer in charge that these boilers, bought and installed in the Technical High School building, were known to be at the time of installation of such construction as would not meet the requirements of the Massachusetts boiler-inspection laws. This would appear to be poor business policy, but if the board having this matter in charge was as intelligent as regards engineering subjects as the alderman quoted, it can be easily understood. It is a little surprising to learn that a Boston man spoke against the bill on the ground that it intended to legislate good men out of positions, that others might get them

License laws are usually intended to keep out the poor men, not the good ones. I once met a bright appearing young fellow who had served as an oiler in a power house for three months and who intended to take an examination for a second-class engineer's license. He was very positive that he knew all about getting a license.

"This license business is all graft," he said. "Take a pint of whisky with you and you get your license." I guess he forgot to take along the whisky, for he didn't get so much as a fireman's license and as a result is very bitter against the license laws.

Is this the kind of good men who will be kept out of positions by the license law? The objection of a Boston man who said that the grading of licenses by classes is class legislation and unconstitutional is absurd. The claim is often made that a man who can handle a 50-horsepower plant of a certain type can handle a 500- or 1000-horsepower plant of the same type. While this should hold good in theory, it does not in practice, hence classification is advisable.

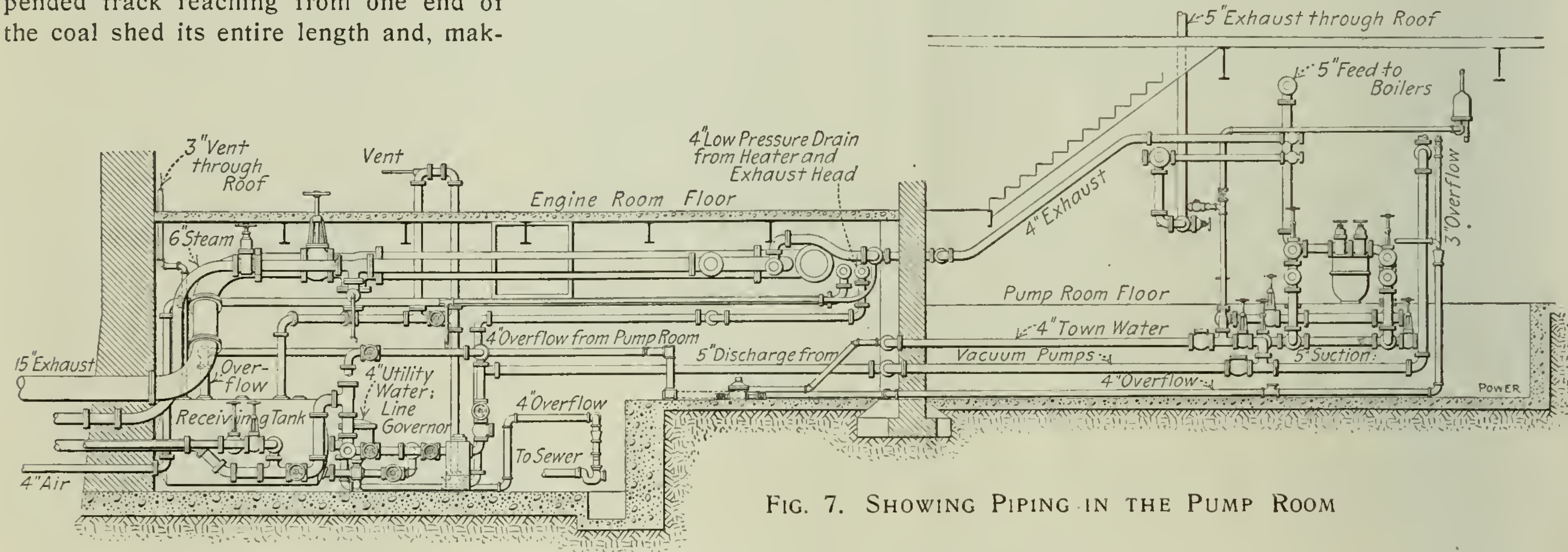


Fig. 7. Showing Piping in the Pump Room

Overcoming Shortage in Feed Water

> *The water supply to a large power plant was suddenly cut off, owing to drought. By means of locomotives, tank cars and an oil barge enough water was supplied to keep the plant in operation until a permanent water supply was obtainable.*

"Is this Mr. Wildin, mechanical superintendent of the New York, New Haven & Hartford Railroad? Well, this is Mr. Peterson, chief engineer of the Cos Cob central station. The Greenwich Water Company has just notified me that it will be obliged to shut off our water supply in 15 minutes as their supply has run dry."

While this was not the actual conversation that took place over the telephone three days before Christmas of 1910, it presents the important point, that owing to the exceedingly dry season throughout Connecticut last fall, the Greenwich Water Company's water supply failed, which necessitated cutting off the supply to the Cos Cob water plant of the New York, New Haven & Hartford Railway, with but 15 minutes' notice.

FIG. 1. LOCOMOTIVE PUMPING AIR INTO TANK CAR, FORCING WATER INTO THE RESERVOIR

This power plant supplies electrical current to electric locomotives running between Mott Haven, N. Y., and Stamford, Conn., a distance of about 20 miles. All passenger trains are drawn by electric locomotives over this stretch of track, and shutting down the power plant meant a suspension of passenger traffic until steam locomotives could be put in commission.

Without water it would be impossible to keep the steam plant going and with Christmas but three days away, when the passenger service would be taxed to its utmost, the power plant could not be shut down; it just had to run.

There was no time to sit down and cuss the weather or fate. Action was required, and quick work at that. The first thing Mr. Wildin did was to order out the wrecking train with a supply of piping and a locomotive water tank placed on a platform car which was run onto a siding at the power plant and the tank deposited on the ground near the concrete reservoir shown in Fig. 1. At the same time four freight locomotives were despatched from New Haven, each with a tank full of water, and by the time they arrived at the plant, a temporary pipe line had been run from the siding at the end of the boiler room in through the door, around in the back of the boilers to a hotwell that was located below the boiler-room floor at the extreme end of the building. This pipe line consisted of boiler tubes that were kept on hand for repairs. They were placed end to end, the joints plastered with putty and wrapped with rubber and burlap. One of the freight engines was run to a point opposite the end of the pipe line at the boiler house. The injector was started, but the water was allowed to escape through the overflow pipe into the pipe line running to the hotwell. This, together with a portion of the salt circulating water, which made the water somewhat brackish, was sufficient to keep the wheels moving, which was the main thing.

While this makeshift was keeping the plant in operation, two of the locomotives were placed at a point opposite the cement water tank that held 600,000 gallons of water.

When word was received that the supply had failed, about one-half of this supply ran back into the water main of the water company before the valves could be shut. As about 12,000 gallons of water were used per hour, it was a necessity to get this reservoir filled in order to have a reserve supply. The discharge pipes of the injector on these locomotives were connected to a line of wrought-iron pipe that ran to the concrete reservoir, and the water in the tank was injected into the cement reservoir at a rate of about 12,000 gallons per hour.

This gave two sources of water supply; but, in order to be on the safe side,

FIG. 2. OIL BARGE LOADED WITH WATER FOR THE POWER PLANT

20 tank cars were put into service drawing water from Stamford, four miles distant. When these arrived in trains of six cars each, one car was allowed to discharge its contents into the pipe leading to the hotwell. Two other tank cars discharged their contents into the water tank, from which it was pumped into the concrete reservoir by means of a steam pump that had been loaned by a contractor. This pump was supplied with steam from the boiler room through a temporary pipe line run on the ground. Two other cars were placed opposite the reservoir and the outlet connected to pipes leading to the cement reservoir. The locomotives were supplied with two air connections, one on the front and one on the rear end of the engine. Each of these air pipes was connected to the top connection of a tank car. The air pump on the engine was started with the air valve so set that a pressure of 30 pounds per square inch was maintained. This air pressure on the water in the tank car forced it up into the reservoir, and as each car held 8000 gallons, the reservoir was filled by Saturday morning, less than 48 hours after the water supply failed. As there was no knowing how long the water famine would last, it was decided to utilize another method of supplying water; therefore, an oil barge having a capacity of 200,000 gallons was obtained. A 3-inch pipe was run from the reservoir to the oil barge that was tied up to the coal-delivery pier, shown in Fig. 2. A steam pump on the barge, supplied with steam from a tug accompanying it, pumped the water into the reservoir through this pipe. A 2½- and a 2-inch fire hose were also used. After the reservoir was once filled, all but the 3-inch pipe was removed, the engine and tank cars were put back to their legitimate service and the barge of water kept up the necessary supply, although but two barges could be delivered per day owing to a sand bar at the mouth of the river which necessitated the barge coming in at high tide.

Due to these methods, the plant was kept in operation, the public was not incommoded, and the operating officers of the road were well pleased with the able way in which a most difficult problem had been handled.

The writer is indebted to G. W. Wildin, mechanical superintendent, for the foregoing details, who not only directed the work, but lived on the job until all danger of a possible shutdown had been avoided.

The Old Mill at New London, Conn.

There are many historical points of interest scattered through the New England States. Some of them date back to the settler days and their traditions are interwoven with romance and legend. The "Old Mill" now running at New London, Conn., and illustrated in Fig. 1, takes a prominent place among the many historical relics of days long past. It was built in 1650, after a special town meeting, held for the purpose of considering the question of erecting a mill to grind corn for the settlers. Gov. John Winthrop was the leading spirit of this new enterprise. Under his supervision the plans were perfected. The erection of a dam and the mill on his estate, then called Winthrop's Neck and now East New London, was the outcome.

This old grist mill was built under the direction of Governor John Winthrop in 1650. For 261 years it has been grinding corn into meal. It is 19 feet in diameter and is 6 feet 8 inches in width.

Six men were appointed to build the dam and mill and they were instructed to make it "substantial and sufficient." They did so, for the original wheel was in use up to four years ago, when it was supplanted by a new one. The old framework of the mill appears to be as solid now as on the day it was put in place. The management of the mill in the old days savored somewhat of the trust methods of today, for with the building of this mill it was agreed that:

"No person or persons should set up any other Milne to grind corn for the town of Pequott within the limits of the town, either for the present nor for the future so long as John Winthrop or his heirs do uphold a milne to grind the town's corn."

Fig. 1. The Old Mill at New London, Built in 1650

Fig. 2. Sluiceway Running from the Dam to the Waterwheel

The old mill is located beside a rocky glen, and the flow of water is through an iron pipe to a sluiceway that is supported by a trestle illustrated by Figs. 2 and 3, and upon reaching the overshot waterwheel, fills the buckets.

The water is controlled by a gate valve in the iron-pipe outlet and by a trap gate in the sluice. This gate is hinged on the end next to the waterwheel and is held up at the other end by means of a rod and lever which reaches into the mill. This allows the water to flow through an opening in the bottom of the sluiceway on the inverted buckets of the wheel. When it is desired to run the wheel the gate is dropped and the water then flows to the end of the sluice and into the buckets of the wheel. After leaving the wheel the water flows through a raceway into the bay fronting the city of New London. All surplus water not

FIG. 3. SLUICEWAY AND SUPPORTING TIMBERS

used by the wheel passes over a low portion of the dam and after dashing over and around the rock-studded glen, flows into the bay.

The wheel has a diameter of 19 feet and is 6 feet 8 inches wide. The outer rims which support the buckets are secured to wooden spikes which fit into a hub 26 inches in diameter. The hight of each bucket is 15 inches, the width 10 inches and the length 6 feet 8 inches. The wheel runs at a speed of 15 revolutions per minute, and it is estimated develops approximately 18 horsepower with a full head of water. The capacity of the mill is between 40 and 50 bushels of meal per hour. The old mill is now operated by George H. Smith, of New London.

The dam is now covered by a wide gravel walk. The old Winthrop home site is now occupied by the modern Winthrop public school. The old wheel has been replaced by a new one and the building has been so repaired that but little remains but the old timbers and inside woodwork that made up the framework of the structure.

One can scarcely imagine that this old mill has stood so many years or that it has witnessed so many exciting scenes. It stood through the shedding of revolutionary blood. It has looked upon the warships of England and the Indians creeping through the thick undergrowth of the forest. Today it looks out from the glen upon a city, and still performs its mission, grinding corn in the same old way that it did 261 years ago.

Boiler Room Bulletin

E. B. Ford, the chief engineer of the Harvard power station of the Boston Elevated Railway Company, Cambridge, Mass., has a boiler bulletin which shows at a glance the status of every boiler in the plant.

This bulletin consists of a board in which there are 20 vertical rows of holes. A number of plugs have been prepared and enough are inserted in the different holes to give all the information required about every boiler in the plant.

In the column headed Boiler Parts is a complete list of all the parts of the Babcock & Wilcox boiler. This column could be made to apply to other boilers also. There are 10 boilers and each one has two columns of holes on the board. When a boiler is in operation and it is found that some particular part needs repair, the man in charge puts a plug in the column of the boiler number, and opposite the name of the part needing repair, on the left half of the board. For example, No. 2 boiler is in operation and it is found that the blowoff valve needs repair; the man finding this would plug the column for No. 2 boiler opposite the blowoff line. Then when the boiler is out of operation it may be readily seen what is to be done.

At the right of the board there is also a set of columns for each boiler. On this side a record is kept of the watch, the day of the week and the month that the boiler is either taken off or put on the line. On this side also there is a method by which the chief engineer can notify the watch engineers at what watch day of the week or the day of the month a boiler is to be put on or taken off the line. This is accomplished by plugging the put-on or take-off line.

Referring to the bulletin it is seen that boilers 1, 2, 5, 7, 9 and 10 are in operation but that the blowoff on No. 2 needs attention, and therefore is to be cut out of the line on the third watch on Tuesday, March 7, while Nos. 3 and 8 are to be cut in by the first watch of the same day, after the arch and side walls have been put in good order.

Much has been said from time to time regarding "theory and practice," but the following extract from an address by R. S. Hale, at a recent meeting of the National Electric Light Association, seems to sum up the whole thing in a nutshell:

"A theory is a statement of a case that should consider all the facts, but when it does not, hence the results of using such a theory may be bad. On the other hand, good practice, if it is good practice, takes into consideration all the facts in deciding what to do, even omitting some of them from its statement. Therefore, good practice is better than bad theory; but a correct theory that takes into account all the facts is necessarily the best practice."

Captain Charles H. Manning

One of the most prominent mechanical engineers in New England is Capt. Charles H. Manning. His reputation, however, is not local, for he has been associated with such engineers as Haswell, Isherwood, Kafer, Loring, Melville, Thurston and others, some dead, some living, and is known to hundreds of steam engineers throughout the country.

Captain Manning is the son of Joseph C. Manning and Rebecca Parkman Jarvis (Livermore) Manning. He was born in Baltimore, Md., June 9, 1844. His early education was received in private schools in Baltimore, in the high school of Cambridge, Mass., and in 1860 he entered the Lawrence Scientific School of Harvard University to study civil engineering

In the fall of 1861 he returned to Baltimore, due to business reverses brought on by the war, and became an apprentice in the marine-engine works of Charles Reeder. While there he met many officers of the naval-engineer corps, and as a result he was appointed third assistant engineer of the Navy, February 19, 1863.

His vast knowledge of scientific matters brought him to the attention of Chief Engineer Isherwood, who assigned him to the making of experiments on superheating steam on the "Adelaide" and other vessels. As a consequence, Captain Manning's active service "under fire" was confined to some brief fighting in Hampton Roads. He served on the "Adelaide" for two years, when he left her to join the sloop-of-war "Dacotah," and later served on other vessels of war. In 1870 Captain Manning was assigned to shore duty as an instructor at the Naval Academy, where he remained five years. While serving as instructor, Manning assisted in organizing a course of instructions for cadet engineers at the academy, which in his own estimation and that of others is one of his most valuable achievements.

Captain Manning served as a member of the first Advisory Board, in 1881, which body prescribed the first general characteristics of the warships of what was termed the new navy. Other members of the board were Rear-Admiral John Rogers and Chief Engineers Benjamin F. Isherwood and Charles H. Loring. Captain Manning has the distinction of being the only engineer on the board who had the courage to vote for steel vessels.

Captain Manning was granted a year's leave of absence in 1882, after 12 years of continuous duty. He immediately accepted a position as mechanical engineer of the Amoskeag Manufacturing Company, Manchester, N. H., the largest of the cotton mills in the world. This position he now occupies.

In 1884 Manning was placed on the retired list of the Navy, to the regret of his engineering associates. During the Spanish-American war, when he was 54 years of age, he was again called into active service and was stationed at the naval station at Key West, as chief engineer of repairs of the machinery on warships which gathered there.

The position now held by Captain Manning is of importance and calls for more than ordinary skill. Besides having charge of all the power plants of the company, he is in addition the architect and builder of the new Coolidge mill recently completed. Something of the extent of his duties can be gathered from the following:

To operate the 110 acres of mill area there are 16,488 horsepower of water turbines, 24,800 horsepower of steam engines and 17,500 horsepower of steam turbines. To supply the steam units, and to produce steam for manufacturing purposes, there are installed 65,700 nominal horsepower of boilers. These are all of Captain Manning's design.

Manning was the pioneer in designing and installing in 1885 a 2000-horsepower horizotal water turbine, the first large installation of its kind.

The resourcefulness of Captain Manning has never been questioned. In the fall of 1891, a 30-foot flywheel burst and, being dissatisfied with the metal put into the rim of flywheels at that time, he designed a new 30-foot flywheel, with a face of 108¼ inches and a thickness of 12 inches. This rim was made up of 44 rings of ash. This was doubtless the largest wooden-rim wheel in the world. The wheel is still in operation after a service of 20 years.

In addition to his position with the Amoskeag company, Captain Manning is consulting engineer for several other large mills. He is a past vice-president of the American Society of Mechanical Engineers. He is also a member of the Army and Navy Club of New York, American Society of Naval Engineers, United States Naval Institute, American Society of Naval Architects and Marine Engineers, American Association for the Advancement of Science and the American Society of Cotton Manufacturers.

Captain Manning's career has been brilliant. He is known as a man of sterling qualtities, of a manly and generous nature, one of the men whose friendship is well worth cultivating.

Charles H. Manning, Mechanical Engineer of the Amoskeag Manufacturing Company

Desirable Improvements in Boilers

By F. W. Dean*

Boiler joints, settings, heating surface, factor of safety, elastic limit, vertical boilers, large units and blank flanges on pipes are the topics touched upon by the author.

A few years ago I advocated before the American Society of Mechanical Engineers the adoption by boiler designers of a longitudinal joint having all rivets in double shear and getting all the rivets as near the center line of the joint as practicable. The lap joint is now well understood to be almost the sole cause of boiler-shell explosions, and any joint which gives one-sided resistance to rupture is likely to cause explosions at some time. The form of butt joints commonly used in this country, that is to say, those with narrow outside and wide inside straps, is of that class. A part of the joint is lapped and in that part the rivets are overhung and in single shear. These rivets are poor things for resisting a pull, and the whole joint may be deformed under strain. The result of this is that longitudinal cracks may occur in the joint due to bending by steam pressure, and changes in the bending by changes in the pressure. I think that the ruptures of the joints at Woonsocket and Torrington were hastened, if not caused, by this action. I expect to see this form of butt joint abandoned.

In the paper referred to I advocated a form of butt joint in which both straps were of the same width and all rivets in double shear. The pitch of the outside row was wide, but the outside strap was thick enough to render calking effective. The efficiency of such a joint cannot well be over 85 per cent., and in this respect is hardly satisfactory. Fig. 1 shows a design of a Scotch boiler having joints of this design, made by me for the Deer Island station of the Metropolitan Water and Sewerage Board of Massachusetts.

More recently I have adopted as my regular practice an extension of the same idea, taking the form used on the S. S. "Kaiser Wilhelm der Grosse" some 15 years ago. I understand that this is the form of joint used in Germany quite generally. It is easy to obtain an efficiency of about 92 per cent. with it, and it fulfils every ideal. This form of joint is shown in Fig. 2, which is a design of an 84-inch horizontal return-tubular boiler for 150 pounds of steam, which I made for the Diamond State Fiber Company, of Bridgeport, Montgomery county, Penn. The extra cost of this joint is insignificant. Other features of this design may be interesting; for example, the thinning of the plates at the circular seams so that the double thickness will not exceed well established limits.

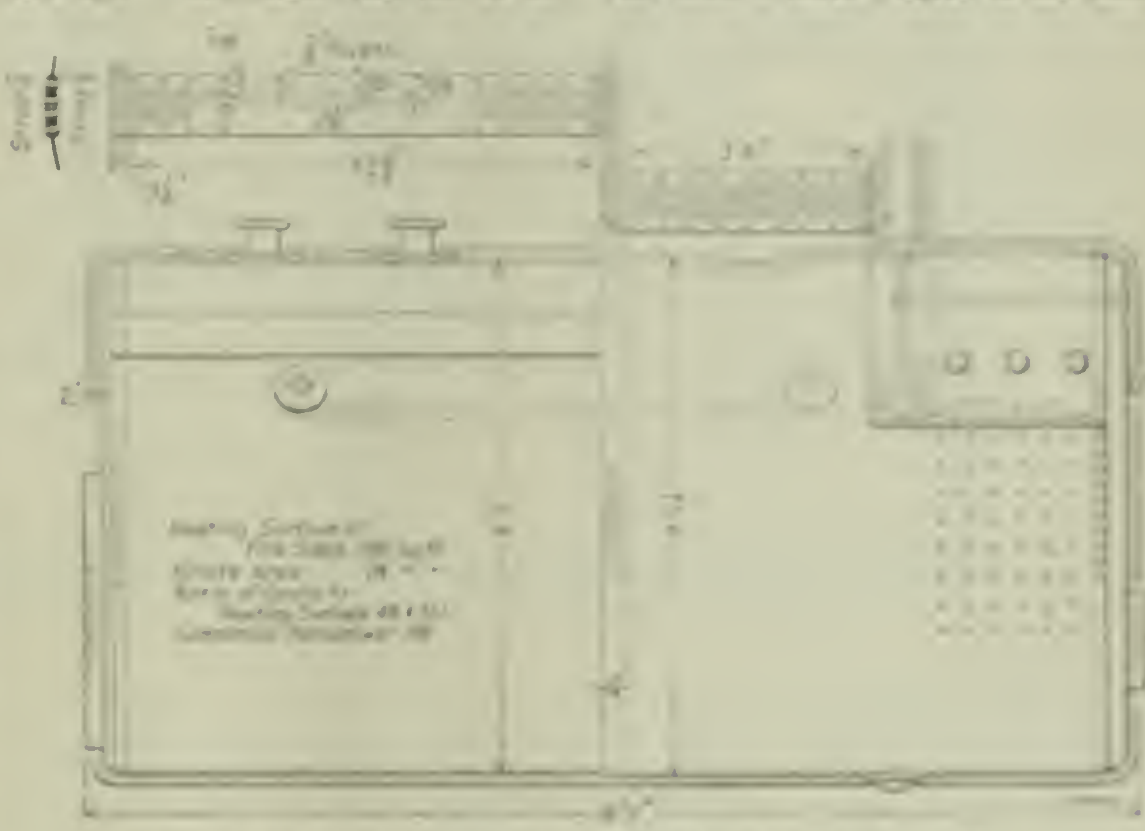


Fig. 1. Method of Riveting 110-horsepower Scotch Boiler

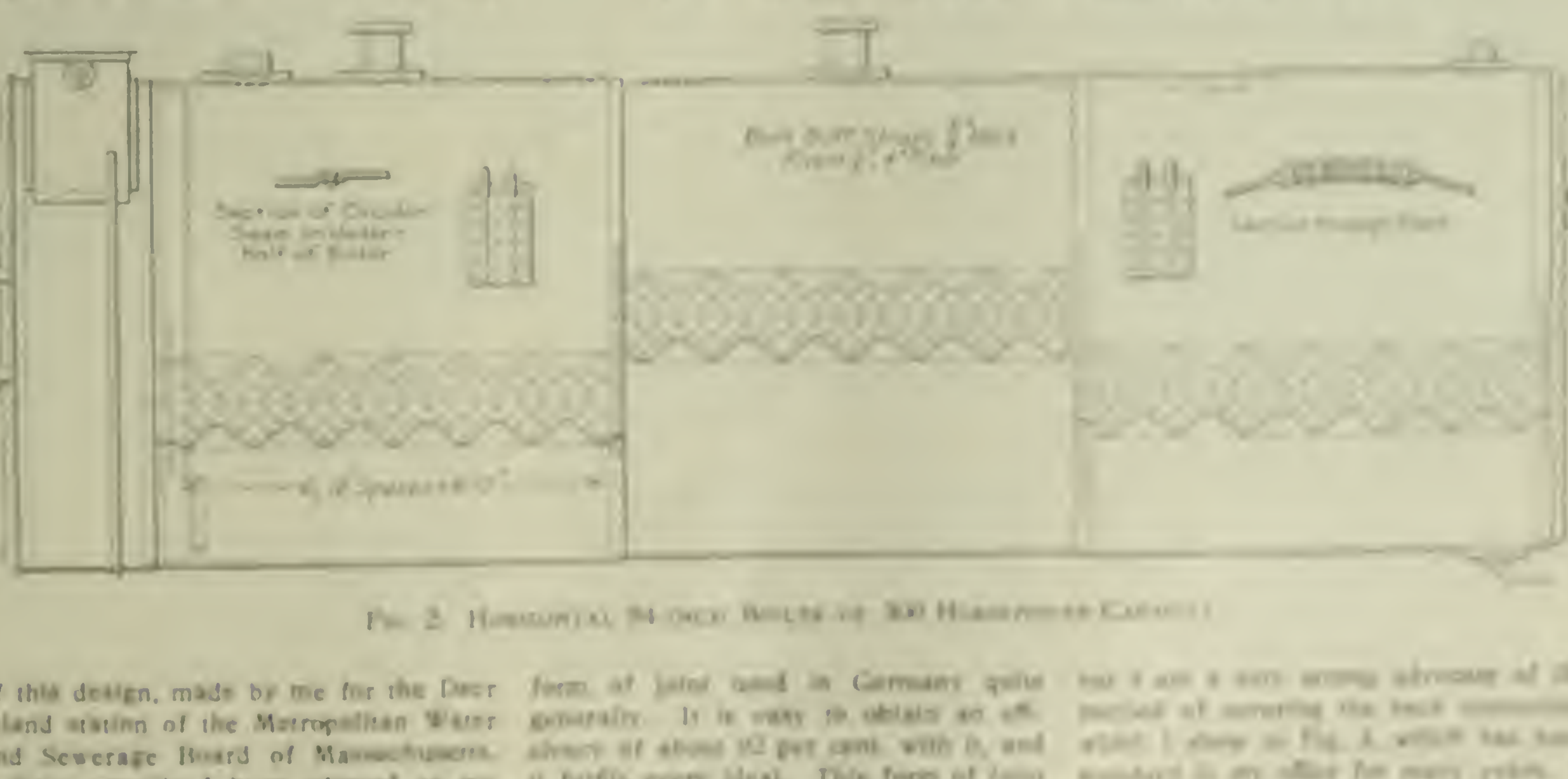


Fig. 2. Horizontal 84-inch Boiler of 300 Horsepower Capacity

Boiler Setting

Recently there were published in Power two articles on the proper method of setting horizontal return-tubular boilers. With these articles I agree in the main, but I am a very strong advocate of the method of securing the back connection which I show in Fig. 3, which has been standard in my office for many years. If

*Mill engineer and architect of Boston.

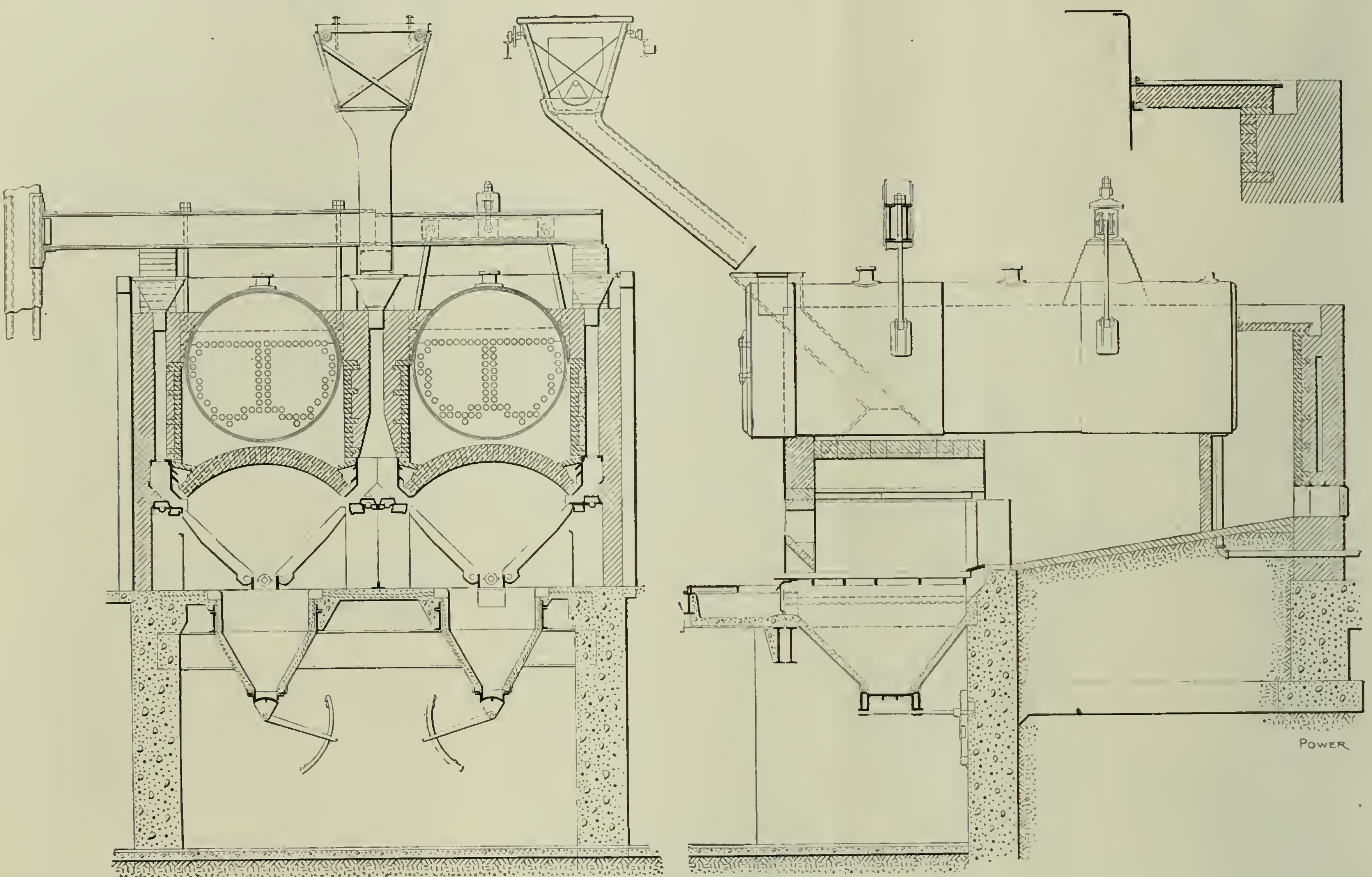


Fig. 3. Illustrating Three-point Suspension and Special Back-arch Construction

consists of some long slabs of firebrick which cover the back connection and slide back and forth over it as the boiler expands and contracts. It is pushed back by the boiler and pulled forward by the angle on the underside of the outer end of the steel plate above the slabs. The steel plate protects the slabs from breakage when walked upon. When boilers are set with this feature the cracking of the walls at the back end is prevented, as there is nothing to push them as the boiler expands.

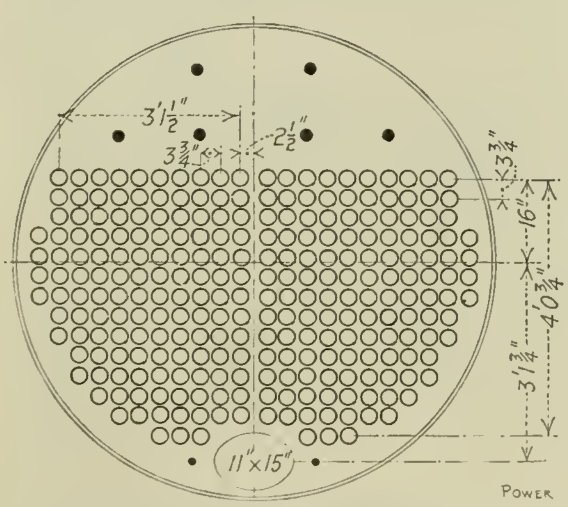


Fig. 5. Tube Layout for 90-inch Horizontal Tubular Boiler

It is my practice to suspend the boilers from above, and I prefer Mr. Woolson's three-point suspension. This and the setting for the Diamond State Fiber Company are shown in Fig. 3.

Vertical Boilers

Many vertical fire-tube boilers have been built having the diameter of the outside shell reduced above the crown sheet by a reversed flanged connection, often called an "ogee." Many of these flanges have cracked circumferentially on account of bellows action caused by changes in pressure and by vertical vibration caused by the opening and closing of the inlet valves of steam engines. An examination of such boilers will often show a vibration coinciding with the revolutions of the engine. It can be said, in fact, that this is the only kind of boiler that breaks in two. The defect has been diminished by making the reversed flange thicker and less flat, and thus reducing the action that has been, by some, thought important in vertical boilers for permitting free expansion of the tubes.

The recent explosion of such a boiler at the Amoskeag mills and the action of the reversed flange in an experimental boiler recently tested to destruction, should serve to open people's eyes to the unsuitability of such a design, especially for high pressures. Such boilers are unquestionably dangerous because they elongate seriously under pressure, make the upper tube plate convex downward, the lower tube plate convex upward and tend to pull the outer tubes out. This is what occurred in the exploded boiler, and although the tubes of that boiler were not beaded, the additional safety caused by beading must make a very narrow margin between safety and danger. The reversed flange can be replaced by a long conical course which will not yield, and which will give whatever advantage is accomplished by a reduction in diameter. Many such boilers have been built and one is shown in Fig. 4.

Quantity of Heating Surface

It is a custom of boilermakers to make too little of the opportunity of getting a great deal of heating surface in horizontal return-tubular boilers. By so doing they make a boiler plant unnecessarily large and expensive.

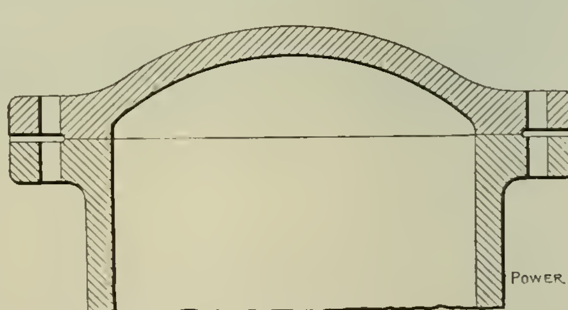


Fig. 6. Preferred Design for Blank Flange

Boilers can have tubes as follows with no resulting disadvantage and with important gains in horsepower and saving of room:

72" boiler, 140–3" tubes, 2033 sq.ft. h.s.(18' tubes)
78" boiler, 166–3" tubes, 2376 sq.ft. h.s.(18' tubes)
84" boiler, 192–3" tubes, 3056 sq.ft. h.s.(20' tubes)
90" boiler, 260–3" tubes, 4016 sq.ft. h.s.(18' tubes)

In the last case (90-inch boiler) the tubes are ¾ inch apart, and very high. These boilers are rated each at 400 horsepower and when run at nearly 800 horsepower they send over dry steam and cause no trouble. There is no reason for being afraid of putting much more heating surface in boilers of this type than is common.

Large Units

There is likewise fear on the part of many persons of making large fire-tube boilers. It has been conclusively shown by several installations that 400-horsepower horizontal return-tubular, and 500-horsepower vertical boilers are satisfactory, and either can be run at double or more their usual rating. There is no limit to the sizes of these types except shipping possibilities. In a large plant there are great advantages in large units as follows:

Smaller number of boilers; smaller number of pipes and valves; smaller buildings; smaller number of men required; greater economy by reduction of losses; less number of chances for explosions and troubles; reduced cost of plants.

These facts are becoming recognized and will be taken advantage of more and more.

For the arrangement of tubes in a 90-inch boiler see Fig. 5.

Factor of Safety

The factor of safety in boiler shells is of less importance than is generally supposed. In 1908 the Massachusetts Board of Boiler Rules increased the factor of safety from 4½ to 5. In my opinion this is a mistake, for boilers never explode because the shell is too thin. Explosions are due to cracking of plates due to causes which do not come from thinness, and it is probable that increasing the thickness intensifies these causes.

Elastic Limit

Some engineers base the factor of safety of boilers upon the elastic limit of the material, and this is the logical way. The value of the strength of a plate lies between zero and the elastic limit, and the difference between the elastic limit and the ultimate strength is so much lumber. It is common to say that the elastic limit of steel plate of boilers shall be not less than one-half of the ultimate strength. If it is one-half, the factor of safety with reference to it is 2½ if it is 5 referred to the ultimate strength. If it can be 2½ referred to one elastic limit, it can be to another, and this clearly establishes the propriety of this principle. Steel can be made by anybody with a high elastic limit and a low ultimate strength, accompanied with all desirable properties. Such steel is very desirable because it will make a strong, thin, light, cheap and more durable boiler than that customarily used. It will be more durable because it is less likely to crack either in making or operating. If I were not prevented by established legal rules I should specify boiler plate to have an elastic limit between 35,000 and 40,000 pounds and an ultimate strength as low as possible, say about 50,000 pounds per square inch.

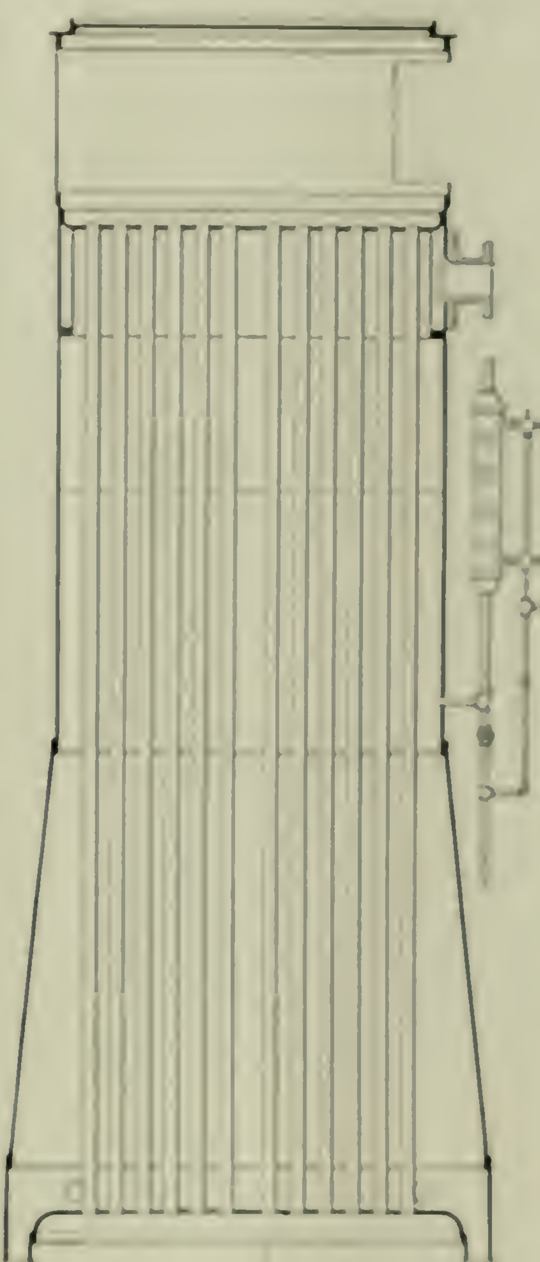


Fig. 6. Vertical Boiler of 175 Horsepower Capacity

Blank Flanges on Pipes

The recent explosion of a blank flange on the end of a large steam pipe at the Amoskeag mills should cause steam engineers to require that these flanges should always be not only very heavy, but made spherical in form inside of the bolt circle. If they are not they are weak unless they are very thick. If they are flat and ribbed they are worse than if they had no ribs, when the ribs are outside, and the ribs are of little value when they are inside. If they are spherical, ribs should not be used. The extra cost of a spherical blank flange is trifling. See Fig. 6.

Smokestacks for Natural Draft

By M. E. [illegible]

To solve the problem of correct dimensions for a proposed stack it is first necessary to approximate as closely as possible the capacity of the plant based on the commercial evaporation. Then if there is the least probability of any increase in the demand for power, make proper allowance for such increase and do not be afraid to err a little in favor of bigness.

After the horsepower capacity of the plant has been determined a simple and easily remembered rule for proportioning the stack is to multiply the number of horsepower by 6. This will give the area of the stack in square inches. Thus, a 500-horsepower plant requires a chimney with an area of 3000 square inches. This would equal a circular stack of about 62 inches diameter. A comparison with stacks already built will show that this figure is approximately correct.

The hight of a chimney is sometimes governed by local conditions, such as the hight of the building to which it is attached or the hight of surrounding buildings. The ratio of hight to diameter may be from 20 to 36 diameters of a circular stack or lengths of one side of a square stack.

One rule establishes the hight of the stack at 25 diameters. This would be correct for some sizes, but would not apply to all. The hight of the larger chimneys must be limited to keep down the cost of construction, and the hight of smaller stacks must be sufficient to give draft enough to maintain the desired rate of combustion. Thus an 8-foot stack multiplied by 20 gives 160 as the proper hight, and a 2-foot chimney multiplied by 36 gives 72 feet as the hight.

Stability or resistance to wind pressure is secured by constructing the base with an outside diameter equal to one-tenth of the hight.

Corrosion is generally due to air which has been absorbed by the feed water and which cannot be removed. Its action is intensified by common salt and by chlorides of magnesia and lime; its action is diminished by suitable additions of soda and of lime. Purified water, in addition to obviating scale, also reduces corrosion. Excesses of soda in boiler compositions attack brass fittings and cause leaky seams.—Ex.

Oil Fuel for Steam Boilers*

By B. R. T. Collins

The possibilities of oil fuel along the Atlantic coast; its advantages and disadvantages and the principles involved in the efficient burning of fuel oil.

In view of the present gradually increasing cost of coal for steam-generating purposes in the Atlantic coast States and especially in New England, the question of a satisfactory and economical substitute naturally arises. Among various possible substitutes crude petroleum and its residual product, commonly known as fuel oil, have attracted more or less attention since the discovery of the Texas oilfields about ten years ago.

Fuel oil is more satisfactory for burning than crude petroleum because practically all of the light and easily ignited products, such as naphtha, gasolene and kerosene, together with any water which the crude oil may contain, have been removed by a process of partial distillation. Hence, while the crude oil is burned in large quantities in the Gulf States and along the Pacific coast with safety under proper precautions, fuel oil, which has a considerably higher flash point and calorific value, can be used for fuel by men of ordinary intelligence with practically the same safety as coal.

The cost of fuel oil in the New England States has been decreasing recently so that at the present time it can be purchased there more cheaply than in the western part of Texas. This is due to the fact that the cost of transporting oil in tank cars to western Texas is greater per barrel than the cost of transporting it to New England in barges and tank steamers.

At present the major portion of the supply of oil for fuel purposes for the north Atlantic States comes from Texas, Louisiana, Oklahoma and Kansas, this group of States producing about 62,000,000 barrels in 1909, or over one-third of the total production of petroleum for the United States in that year, in spite of the fact that California made an increase of over 20 per cent. above her production of petroleum for 1908. During the year 1910 there was an increase to 72,000,000 barrels in the production of crude oil in the States mentioned, as well as a phenomenal increase of 50 per cent. to 77,000,000 barrels in California, thus making the total production for the United States 216,500,000 barrels, or about two-thirds of the total production of crude petroleum for the world. The increase in the production from 1898 to 1910 is shown in the chart.

The interest that fuel users along the Atlantic coast have in California oil may seem at first to be very small, but with the opening of the Panama canal now promised for 1915, a means will be provided for the easy and cheap transportation of California's surplus production to Atlantic coast ports. Furthermore, the strip of country between the mountain ranges and the Paeific ocean in Mexico, Ecuador, Peru and Chile is known to be rich in petroleum, and with the completion of the canal all of this region as far south as Valparaiso, Chile, will be brought nearer to the Atlantic seaboard than the port of Los Angeles, Cal.

It is understood, of course, that the supply of fuel oil at the present time would take care of only a small portion of existing steam plants now using coal, but judging from the fact that the production of crude petroleum in this country increased over threefold during the last ten years, there should be sufficient fuel oil to take care of a gradually increasing class of plants which for various reasons and conditions can use it economically. Included in this class would be:

1. Plants where the cost of handling coal by hand is higher than the average because of local conditions, and where the installation of suitable coal-handling equipment would not be warranted by the saving effected.

2. Plants in which the boilers are fired by hand and more than one fireman is required on each shift.

3. Plants where greater capacity is required than can be obtained with the coal available. With oil, 35 per cent. or more additional capacity can be obtained than with high-grade coal.

4. Plants where the boiler capacity is limited by the capacity of the existing stack or stacks and where it is not desired to install more stack capacity, although more boiler capacity must be obtained. Oil fuel can give this added boiler capacity without increasing the stack capacity, as the stack area required for the same boiler capacity with oil is only about 60 per cent. of that required for coal.

5. Plants where it is necessary to keep smoke below certain fixed limits at all times, due to smoke ordinances.

Oil Analyses

The accompanying table shows comparisons between the calorific value and other properties of crude oil, fuel oil and coal.

Advantages and Disadvantages of Oil Fuel

The advantages of oil fuel may be summarized as follows:

1. Calorific value per pound 30 per cent. higher than that of high-grade coal, less weight of oil being required to give the same heating effect.

2. Space required for storage of oil is less than that for an equal weight of coal.

3. Oil does not deteriorate by storage, as coal does to a greater or less degree.

4. Lower temperature in boiler room.

5. Area of stack 60 per cent. of that required for coal for equal boiler capacity, thus enabling a plant having insufficient draft with coal to have an excess amount with oil, a change from coal to oil making the installation of additional stack capacity unnecessary.

6. Less heat lost up the stack, owing to cleaner condition of tubes and to smaller amount of air which has to pass through furnace for a given calorific capacity of fuel.

7. Higher efficiency due to more perfect combustion with less excess air, more equal distribution of heat in combustion chamber, as doors do not have to be opened and very little soot is deposited on the tubes.

8. Increase in capacity over coal.

9. Heat is easier on the metal surfaces, being better diffused over the entire heating surface of the boiler.

10. Ease with which fire can be regulated from a low to a most intense heat in a short time or entirely extinguished

COMPARISON OF PROPERTIES OF CRUDE OIL AND FUEL OIL

Oil	Field	Carbon, Per Cent.	Hydrogen, Per Cent.	Sulphur, Per Cent.	Oxygen, Per Cent.	Specific Gravity	Flash, Degrees F.	Fire, Degrees F.	B.t.u.	Authority
Crude	Sour Lake, Tex...	...	...	...	...	0.9266	198	.	18,460	Professor Scott, University of Texas
Crude	Beaumont, Tex...	....	....	....	....	0.9179	...	...	18,500	
Crude	Beaumont, Tex...	84.6	10.9	1.63	2.87	0.9240	180	200	19,060	U. S. Naval Liquid Fuel Board
Fuel	Beaumont, Tex...	83.3	12.4	0.50	3.83	0.9260	216	240	19,481	
Crude	Whittier, Cal.....	...	....	....	....	0.9416	...	...	18,513	Professor Blasdale, University of California

*From an address before the Boston section of the American Society of Mechanical Engineers, on April 21. Mr. Collins has been engaged in the burning of oil fuel for the past 17 years.

instantly in case of emergency, such as water dropping out of sight in gage glass, and quickly relighted when the emergency is over. In less than half an hour a boiler can be brought up to 150 pounds steam pressure from cold water, if necessary.

11. Smoke can be entirely eliminated.

12. No cleaning of fires.

13. Much lower cost for handling oil than handling coal.

14. Absence of coal dust and ashes.

15. No firing tools used, consequently, no damage to furnace linings from this source. No clinkers to be removed from grate bars or furnace side walls.

16. Saving in labor of all kinds.

The disadvantages of oil fuel are:

1. Low flash point. Fuel oil should have a flash point not lower than 140 degrees Fahrenheit, and with oil of this quality, handled by men of ordinary intelligence and common sense, there is practically no more danger than with coal.

2. The ordinary underwriters' or city requirements specify that storage tanks for fuel oil be located underground and at least 30 feet from the nearest building. This can generally be complied with in the case of the power plant of the average manufacturing concern, but in the case of a plant in the congested districts of a city it is likely to be prohibitive.

3. With boilers using feed water of considerable scale-making qualities, the cost of repairs is likely to be increased by changing to oil, owing to the intense temperature developed in the furnace.

Principles Involved in Efficient Oil Burning

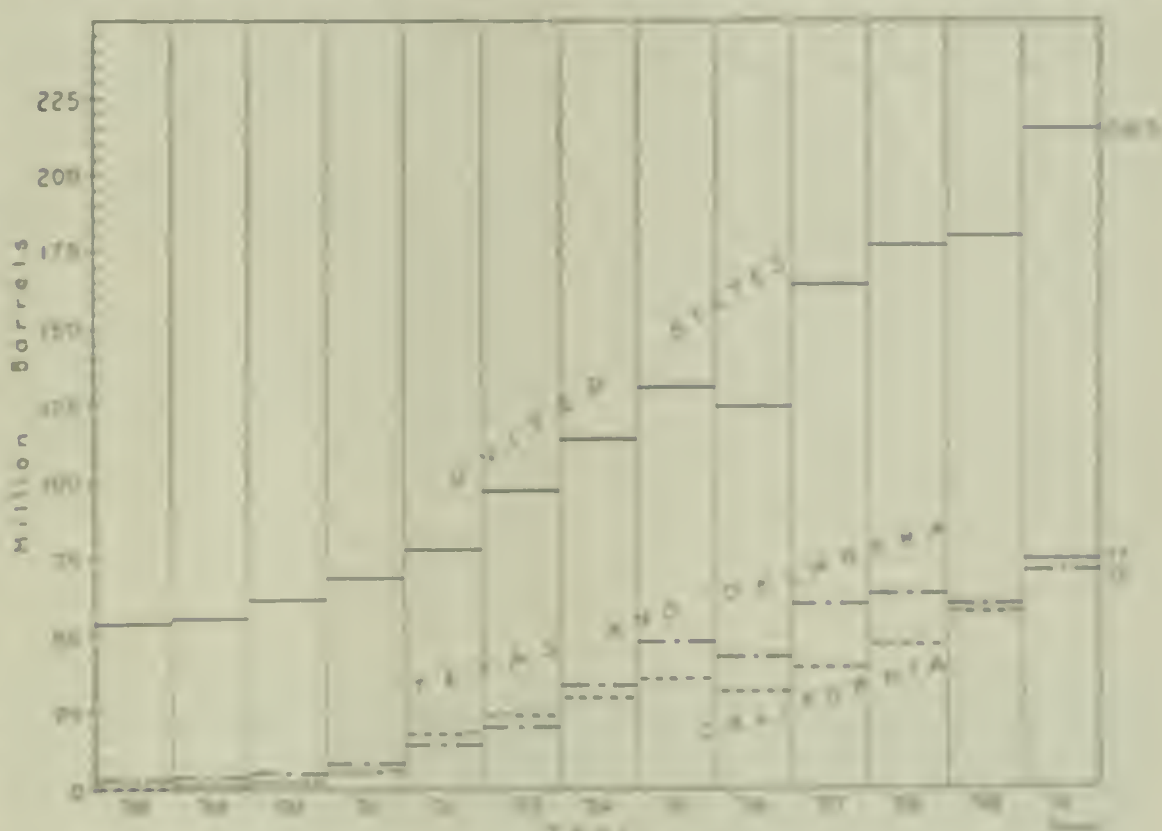
The requirements for the perfect combustion of liquid fuel are as follows: Reduction to a fine spray or complete atomization; bringing it into contact with the proper amount of air; mixture of oil spray and air burned in the furnace of refractory material with room enough to complete combustion before the gases come in contact with the boiler-heating surfaces. The first condition is fulfilled by selecting a proper burner, and the remaining conditions can generally be obtained by making slight changes in, or additions to, the existing furnaces.

As to whether steam or air should be used for atomizing the oil, the decision is usually in favor of steam, because it takes about the same amount of steam to operate the air compressor as it does to atomize the oil at the burner and the additional investment and complication involved with greater possibility of interrupted service is avoided.

Also a flat fan-shaped flame presents a larger surface for heat radiation and uniform distribution of gases than any other shaped flame, and at the same time requires a minimum number of burners per boiler.

Heating of the oil is an aid to economical combustion, and should take place as near the furnace as possible and be carried as high as safety permits, but not so high as to cause the oil to decompose and carbon to be deposited in the supply pipes. If preliminary heating is limited to the temperature of the flash point of the oil used there can be no trouble from these causes.

One of the most important questions in the combustion of liquid fuel is the regulation of the air supply in such a way as to obtain perfect combustion before the gases come in contact with the heating surfaces of the boiler. This can be done with an automatic damper regulator, although its adjustment is rather difficult. It is therefore usually accomplished by hand regulation of the damper when considerable variations in the load take place. This is supplemented by changing the position of the ashpit doors, which are kept closed until a slight tendency to make smoke is noticed in the furnace; or, better, by using an Orsat or continuous CO_2 recorder to determine the position of the damper and the ashpit doors which give best complete combustion under certain constantly recurring conditions.



Production of Oil from 1898 to 1910

Types of Oil Burners

Although thousands of patents have been granted for oil burners or atomizers two general subdivisions of five general classes, as designated by the United States Naval Liquid Fuel Board, cover practically all of the main features of construction. The two general subdivisions are:

Outside mixing: Oil and atomizing agent meet outside the burner.

Inside mixing: Oil and atomizing agent meet inside the burner.

The five general classes included are:

Drooling: Oil oozes out over the steam or air jet.

Atomizing: Oil is swept from the orifice by steam or air jet.

Chamber: Oil mingles with steam or air in the body of the burner and the mixture issuing from the nozzle is broken into minute particles by the expansion of the steam.

Injector: Similar in principle to boiler-feeding injector.

Mechanical spraying: Effected by mechanical means without the use of atomizing agents, such as steam or compressed air.

Method of Installation

In spite of the various principles involved in burner construction, the success of an oil-fuel installation depends not so much upon the type of burner or atomizer used as upon the method of its installation, and the intelligence with which it is operated after the installation is made.

To conform with the underwriters' requirements, storage tanks above the surface of the ground should be placed at least 200 feet from inflammable property and the top of the tanks should be located below the level of the lowest pipe used in connection with the apparatus. When the tanks are located underground they should be outside the building, at least two feet below the surface and 20 feet from any building, with the top of the tanks below the lowest pipe in the building used in connection with the apparatus. Storage tanks should be fitted with vent pipes, [illegible] the level of oil in the tanks, filling pipes, [illegible] for heating the [illegible] water, suction pipes, return or overflow pipes, steam pipes for filling the space in the tanks above oil with steam in case of fire, and suitable manholes for cleaning-out purposes. A suitable strainer should be installed on the suction line between the storage tanks and the oil-pressure pumps. The suction line should slope so that it will drain all oil back to the storage tanks when the pump is stopped and a vent opened. Duplicate oil-pressure pumps should be installed with pump governors and all piping in connection with these pumps should be cross-connected in such a manner that a change can be made from one to the other and repairs made to either without interrupting the service. A suitable oil heater should be installed, so that the exhaust steam from the oil pumps can be utilized to heat the oil before it reaches the burners. A relief valve should also be installed on the discharge line between the pumps and the burners, and provision should be made for removing any condensation from the steam lines to the burners. Automatic regulating devices are desirable for varying the pressure of both the oil and the steam to the burners in accordance with the demand for steam on the boilers.

In a series of tests* on a 604-horsepower Babcock & Wilcox boiler equipped with Hammel burners and furnaces at the Redondo plant of the Pacific Light and Power Company, an efficiency as high as 83.3 per cent. was obtained, and the water evaporated per pound of oil from and at 212 degrees Fahrenheit was 15.81 pounds. The average percentage of CO_2 was 13.2, the excess air 21.2 per cent. and the steam used by the burners 2.15 per cent. The average efficiency for all seven tests, running from 72.7 per cent. up to 195.5 per cent. of rating, was 80.47 per cent., and the average evaporation from and at 212 degrees Fahrenheit was 15.23 pounds.

In tests made at the Ravenswood plant of the New Amsterdam Gas Company, on a 595-horsepower Babcock & Wilcox boiler, equipped with a Peabody furnace and four No. 1 burners, a boiler efficiency of 80.97 was attained, when evaporating 14.61 pounds of water from and at 212 degrees Fahrenheit per pound of oil. The steam used by the burners was 1.54 per cent. of the total steam generated.

Although a fair idea may be obtained of the comparative cost of the two fuels by making certain assumptions in regard to heat values, specific gravity, gain in efficiency, etc., still this will not enable one to figure the saving which could be made by changing from one fuel to the other. The reason for this is that the saving generally depends on other things than the cost of the fuel. The saving in firemen and coal passers, increase in capacity, facilities for fuel storage, advantage of pumping oil over methods of handling coal, elimination of handling ashes, quantity of coal used for banking fires, elimination of smoke and other things, many of which cannot be figured out in advance in dollars and cents, would throw the ultimate cost decidedly in favor of oil. The only way to determine the exact saving is to operate the plant with each fuel for a long enough period to get accurate data on all the items entering into the question.

*The results of these tests are given in the May 9 issue of POWER.

Discussion

D. S. Jacobus: The efficiency results secured in the tests on an oil-burning boiler at Redondo, Cal., represent good practice. Better results, however, than these were secured in tests made on one of the boilers at the same plant preparatory to making a test of the plant. The results of the plant tests, which have already been reported to the society, indicated that a kilowatt-hour was turned out at the switchboard for every 25,000 B.t.u. contained in the fuel oil. In these tests the standard form of Peabody furnace was employed with burners of the outside-mixer type. I intend to submit the results of the tests of the single boiler to the society in connection with an article dealing with boiler and furnace efficiencies.

M. H. Bronsdon: Every test of crude or fuel oil made for me by Professor O'Neill at the University of California showed practically the same calorific value, regardless of its specific gravity or whether or not the gasolene had been removed. The more fluid oils are much less troublesome, requiring much lower pressure to send them through the piping and where the gravity is 17 degrees Baumé or lighter at 60 degrees Fahrenheit they require no warming during the pumping process.

Where oil is used for fuel, perfect combustion may be obtained under all conditions of load with proper installation excepting when the fires are first lighted and the brickwork is comparatively cold. The labor charge is much lower with oil fuel than hand-fired coal, for with oil fuel one fireman can readily care for the fires under 5000 or more horsepower of boilers, provided the boilers are on the same floor level and equipped with feed-water controllers.

Boiler settings and boiler tubes will last much longer with oil than with coal, provided the tubes are kept clean. The flame from the burners should not under any circumstances be allowed to impinge upon the boiler tubes. Extra large combustion chambers below the tubes are especially desirable.

The impression should not be given that by changing from coal to oil fuel the capacity of any boiler plant can be increased from 35 to 50 per cent. In a boiler plant with sufficient draft to burn large quantities of coal, or where the evaporation can be made to exceed, say, seven pounds of water per square foot of heating surface, fuel oil will not increase the capacity 35 to 50 per cent.

Every item and condition of boiler-plant operation favors the use of oil fuel, the price of the oil being the only factor regulating the economical results to be obtained. Its use is clean, safe, reliable and responsive, the only laborious work being that of changing and cleaning the burners and piping. Proper cleaning vats should be provided in a suitable place, as fuel oil is very sticky and odorous.

Experience leads me to favor burners of the type known as "outside mixers," that is, where the oil and steam mix just beyond the tip of the burner. Carbon seldom causes trouble with burners of this type, even where the oil is quite hot before it reaches the burner. There seems to be no practical difference in the efficiency, however, in the use of either "inside-" or "outside-mixer" burners.

When properly installed, there is no danger from storing or using oil fuel. One important requirement is that the tank should be well ventilated to allow the escape of any gas that forms and no flame should be allowed to approach the uncovered storage tank.

In a well designed and carefully operated boiler plant using coal for fuel, where the efficiency is approximately 75 per cent. or better, the use of fuel oil will not change the efficiency materially. In a plant which operates from 20 to 24 hours per day, the standby losses, of course, will be lower with oil than with coal for fuel, due to the fact that there are no banked fires to be maintained under spare boilers, some of which are of use only during the peak-load conditions. Any gain in efficiency is not due simply to the use of oil fuel instead of coal, but rather to better conditions which are maintained with less effort on the part of the operatives, such as the removal of soot from the tubes, cleaner back connections and the fact that the fireman is not fatigued by his labors, but can without any particular effort see that perfect combustion is maintained. The CO_2 recorder becomes a valuable instrument in a boiler room using oil for fuel.

Professor Robinson: It would seem to me that the place where the use of fuel oil would have its greatest economic advantage, would be on steam vessels. There the saving in weight, volume and labor would have a much greater value than on shore. This would make it possible for the steamships to pay a higher price for oil than installations on land. Such being the case, it would seem to have small chance to compete with coal in New England until such time as it shall have been demonstrated that the supply is sufficient to take care of the steamships and leave a surplus for the land plants.

R. C. Monteagle: The question was asked whether there were any vessels running in New England that were burning oil. I do not know of any at present. The "Harvard" and "Yale" were two good examples; they are now on the Pacific coast. When they came out first they were fitted to burn coal and the running time between Boston and New York was 15 or 16 hours, and they almost invariably took over that time. After running a year they changed over to oil fuel, and thereafter had no trouble in making the trip on running time. I was going to ask Mr. Collins if he could not get some more data about the amount of water in fuel oil, as I understand all fuel oil contains a certain percentage of water. In the case of one of the vessels referred to, I happen to know that due to water in the oil in one particular instance, it caused the flame to go out, and as the fireman did not go the rounds properly, the oil kept flowing into the corrugated furnace and overflowed under the fire-room floor. When he finally discovered that the flame was out he stuck a torch into the furnace and immediately there was a puff and fire. If the vessel had not been built of steel it might have been a total loss.

In reply to several individual questions, Mr. Collins stated that the steam required for the oil pumps was about 1.5 per cent. of the total steam generated; this added to that required for atomizing made a little over 3 per cent. As to the presence of water, this is very apt to be present in crude oil, but fuel oil should be free from it. Furthermore, if two or more burners are used, and a slug of water extinguishes the flame in one, the flame from the other will relight it. Referring to the case cited by Mr. Monteagle, Mr. Collins pointed this out as proof that only reliable men should be employed in fire room when oil is used as fuel.

Some Ingenious Engine Room Kinks

By R. O. Warren

Most power plants contain interesting features, some of which would escape the casual glance because their simplicity detracts from their real merit. During a recent visit to the power plants of the Amoskeag mills, Manchester, N. H., the writer saw several devices which were of interest.

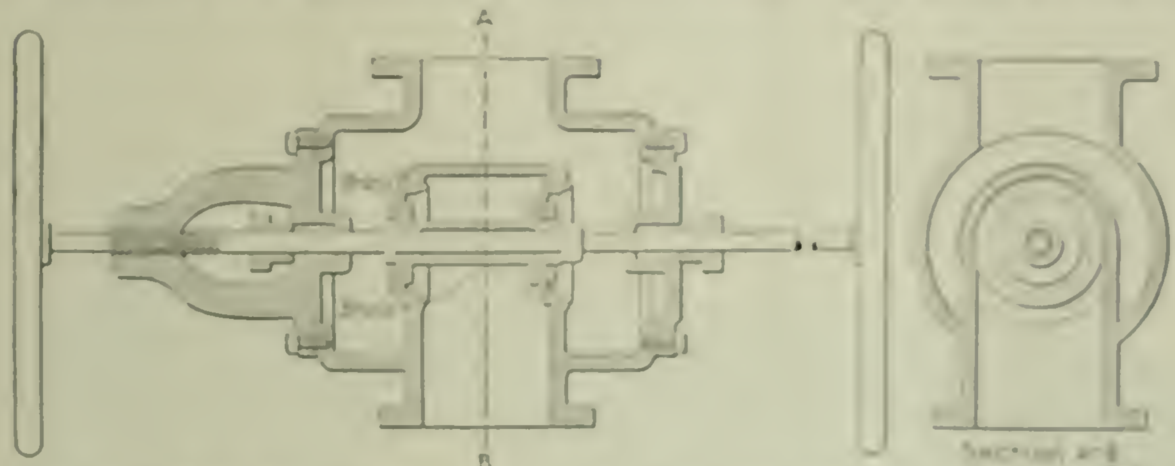


Fig. 1. Sectional Views of Double-wheel-and-stem Throttle Valve

Perhaps one of the most important was a double-stem, double-wheel poppet throttle valve, one of which is used on each reciprocating engine throughout the works. A sectional view of one of these valves is shown in Fig. 1. It consists of the main body containing two double brass seats against which the double poppet-valve disks seat. In addition to this feature the valve stem is made with an extension, as shown. This valve stem passes through the sleeve to which the brass valve disks are secured, each by four [illegible]-inch tap bolts. One end of the sleeve fits against a collar on the valve stem; the other faces against a nut. Both ends of the valve stem pass through a stuffing box, but only one end of the stem is threaded.

The chief advantage of this valve is that the engineer can shut down the engine from either side of the cylinder, a most convenient arrangement in case of a runaway engine. Fig. 2 shows one of these valves in the steam pipe of one of the large reciprocating engines. This illustration also shows an arrangement used to prevent pipe vibration. Before this device had been put in place the pipe vibration was so severe that leakage continually occurred at the joint formed at the straightway valve shown in the vertical pipe.

Fig. 2. Double Throttle Valve and Pipe Brace

Details of the arrangement are shown in Fig. 3. It consists of two saddles, each fitting on each section of vertical pipe, and a distance piece which snugly fits into the hollow place in each saddle. The saddles and distance piece are kept in place by means of two stayrods which are drawn together by two turnbuckles. Each rod is bent around the pipe as shown; the turnbuckles are midway between the two vertical pipes.

While passing an almost empty coal-storage bin, a method of ventilating the coal was observed, which is illustrated in Fig. 4. The bin contains several rows of upright beams, as shown. On two sides of each upright there are fitted saw-tooth projections, each projection forming an air space leading to the main flue, which extends from the bottom to the top of the upright supports.

When the storage bin is full of fuel, the gases and heat generated will escape through the numerous air vents to the top of the building. In this manner spontaneous combustion is prevented to a certain extent. There is one disadvantage; if the coal should once get on fire the ventilating vents would produce an excellent draft and add to the difficulty in subduing the fire.

An interesting method of heating and ventilating the Coolidge mill, the latest addition to the Amoskeag mills, is shown in Fig. 5. The heating apparatus consists of seven old Manning boilers, each 5 feet in diameter and 16 feet 6 inches long, and five larger boilers of the same make, each 6 feet 6⅜ inches in diameter and 19 feet 5½ inches long. These boilers are all placed in a horizontal position and rest on brick piers placed at each end of each boiler. Exhaust steam is carried through a tunnel from an adjacent mill to these boilers, and surrounds the tubes on the outside. The boilers are separated at the end next to the air passage leading to the fans by brick headers, so that the air cannot bypass between the boilers.

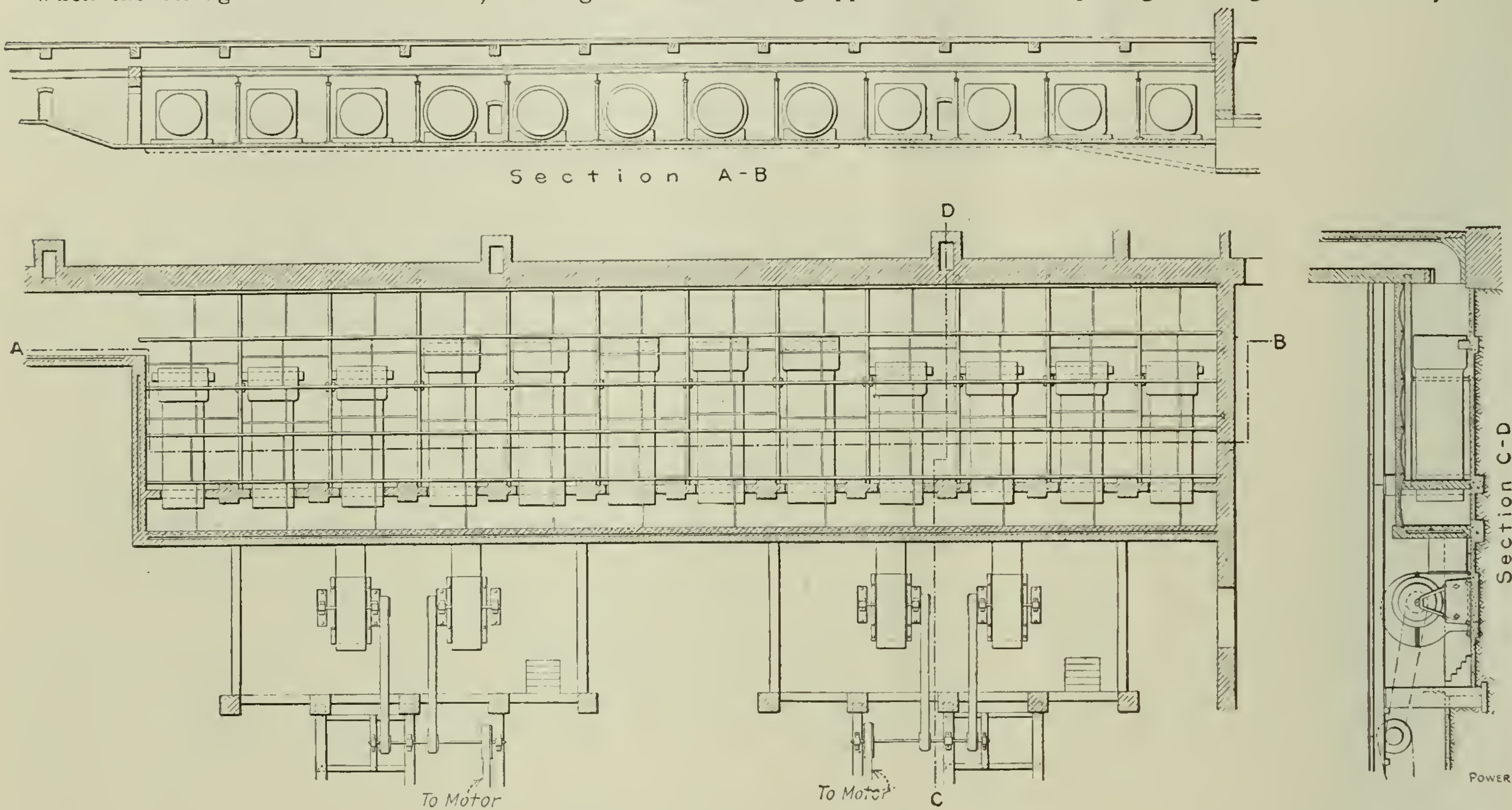


Fig. 5. Arrangement of Heating Boilers and Air Fans

Fig. 4. Showing Construction of Ventilating Chutes

Extending along the front end of the boiler is an air duct which is 8 feet 10 inches high and 4 feet wide. At the rear end of the boiler, connection is made with an air duct which is 5 feet high and 40 inches wide. This air duct runs up to the Coolidge mill, in the basement of which the hot room is located. Another branch leads to a neighboring mill. Two 6-foot fans, placed outside of the wall surrounding the boiler, supply the air for heating and ventilating; each is driven by a 60-horsepower motor. These fans force the air into the air duct at the front end of the boiler and the air passes through the boiler tubes to the other end, where it is allowed to surround the outside shell of the boilers, thus coming in contact with every part of the heating surface of the boiler shell and tubes. The air when thoroughly heated passes to the various rooms in the mills.

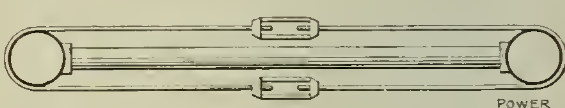


Fig. 3. Details of Saddles and Stayrod Arrangement

By means of this system two large mills are heated indirectly by exhaust steam with very little piping and no radiators. The help that would be necessary to keep them in proper condition is therefore eliminated.

These devices have been put in under the direction of Charles H. Manning, mechanical engineer of the company.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Automatic Starting Attachment for an Exciter

An exciter unit that is somewhat out of the ordinary is in operation in the power plant of the Lynn Gas and Electric Company at Lynn, Mass. The unit consists of a 125-volt General Electric dynamo of 75 kilowatts capacity driven by a Curtis turbine at a speed of 2400 revolutions per minute; the steam pressure is 150 pounds per square inch. The special feature of the outfit is an arrangement for starting the unit automatically when the running exciters reach their load limit.

A general view of this unit is shown in Fig. 1. The constructional details of the automatic attachment are shown in Fig. 2; this is a steam-control valve consisting chiefly of a Waters governor with the springs, ball weights, pulleys and gears removed, the only part utilized being the valve body, valve and stem. The valve is inserted in the steam-pipe line upside down and is fitted with a bypass adjusted so that when the main valve is closed a small volume of steam flows through the bypass to the intake end of the turbine; the condensed steam is permitted to drain from the turbine casing through the drip valves, which are always open. This arrangement keeps the steam end of the turbine hot and ready for immediate use. Bolted to the flange of the control-valve body is an L-shaped piece of flat iron *A*, to which a thin piece of wood is attached and this supports an electromagnet *U*, which is energized from the exciter busbars on the switchboard. Attached to the member of the governor which contains the bearing through which the valve stem passes is a U-shaped piece of iron to which the lever *L* is pivoted at *M*. A slot *N* is cut in the lever in which the pin *O* can slide; this pin passes through the valve stem.

A piece of soft steel of the same width as the magnet core and forming an armature for the magnet is attached to the handle, as shown at *P*, and a 28-pound lead weight *Q* is hung on the end of the valve stem. So long as current at the normal pressure of 125 volts passes through the magnet coil, the magnet holds the lever *L* in the position shown, in which position the valve is closed and the turbine inoperative. When the exciter voltage drops seven volts, a relay opens the circuit through the magnet coil and the magnet, being deenergized, is, of course, unable to hold the lever up against the downward pull of the weight *Q*; the latter drops, pulling the lever down and opening the valve, thereby starting the turbine. The rapid descent of the valve stem is prevented by means of the dashpot shown in the sketch. The handle *L* is for closing the control valve, of course, when the turbine is to be shut down.

Fig. 1. Exciter Unit with Automatic Control

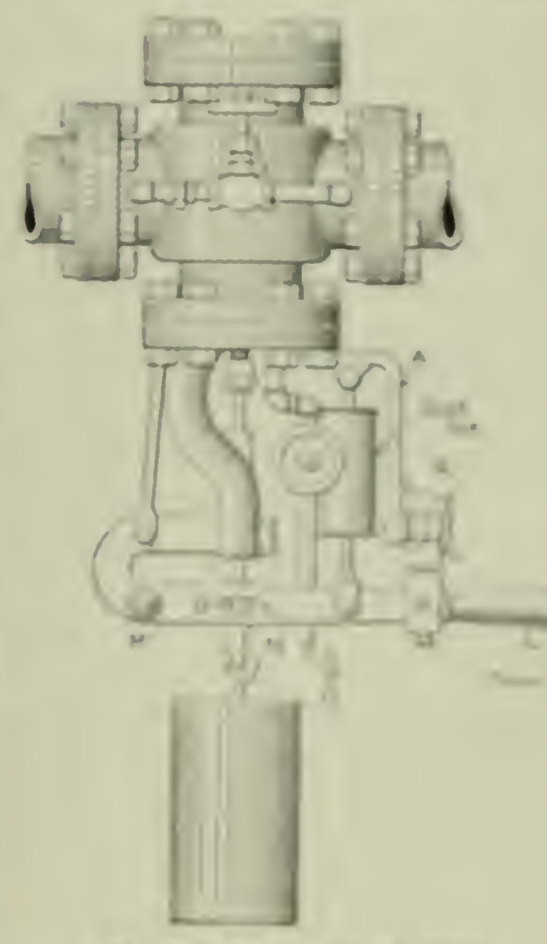


Fig. 2. Automatic Starter

Fig. 3 is a diagram of the master circuit in which the magnet *U* is the one shown in Fig. 2. Normally, when the exciter is not needed, the switch *T* is held closed by the solenoid *S* which is also energized from the exciter busbars. A drop of seven volts weakens the solenoid to such an extent that its plunger drops and opens the switch *T*, thereby "killing" the magnet *U* which has been holding the steam valve of the turbine closed, as described.

The switch *T* has three blades but the middle one is independent of the other two when they are closed. When the handle is pulled, however, it closes all three contacts. The middle blade, when closed, short-circuits the resistor *R* and this strengthens the solenoid *S* sufficiently to enable it to lift the plunger and close the switch *T*. When this has been accomplished, the middle blade is pulled out, leaving the resistor *R* in series with the solenoid *S*, in which condition the latter will just hold up its plunger at normal exciter voltage. The middle blade

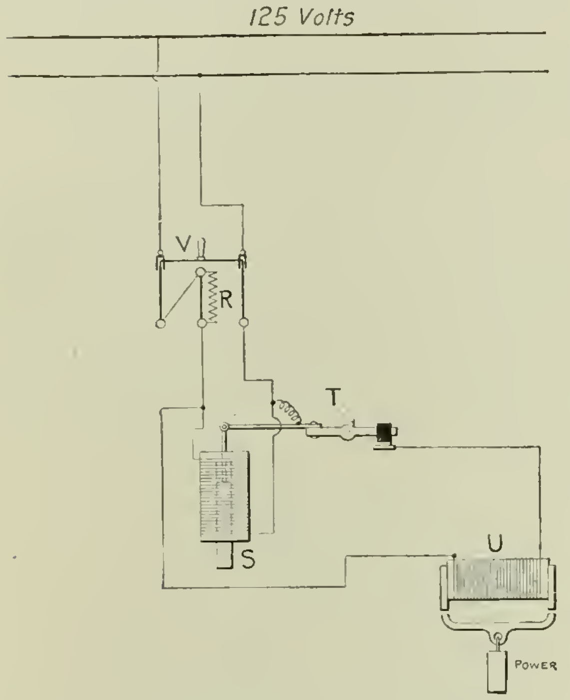


FIG. 3. MASTER CIRCUIT DIAGRAM

of the switch *V*, therefore, serves merely to reset the switch *T* from the switchboard.

An East Indian Postgraduate Technical School

Mr. Tata's Research Institute in Mysore has at last been completed and will begin work next July. Dr. Morris Travers, director of the institute, has issued the following statement:

"The annual guaranteed income of the institute is about 270,000 rupees (about $86,000) which sum should be able to maintain six departments of work. The work at the beginning, however, will be limited to four departments, namely, general, organic and applied chemistry, and electrical technology, these being considered by the council to be of the greatest importance to Indian arts and industries and not provided for in the other post-graduate institutions in the country. Graduates of a recognized university or a similar institution will be admitted as students. The institute does not charge any fees for tuition, though it does not offer any scholarships. The council has decided that the other two departments are to be devoted to pure and applied science, in some branch, but is not in a position to make a definite announcement on this subject."

The institute owes its existence and its magnitude to the princely donation of Mr. Tata and the generosity of the Mysore state. The work has taken about ten years. It aims to provide an institution where technical and scientific research work of a higher order can be undertaken on a large scale in its laboratories and where the students can have a practical insight into such work.

Small Station Switchboards

By Guion Thompson

It is almost universal practice in small plants to display as much switchboard as circumstances render possible. The switchboards are bulky and by some are considered unsightly; also more of a plaything than a necessity. The wiring and apparatus are usually crowded in a mass on the back in order to avoid getting the board too large from the point of view of switchboard advocates. To those who do not admire them, this mass of wiring and apparatus appears inconsistent with the form of energy being handled and seems a departure from the usual rules of spacing and other precautionary methods practised in other branches of the art. The appearance of a generator room is better without a switchboard, as has been demonstrated in the large stations where the boards are placed on galleries. The largest and latest stations are working toward elimination altogether, which appears to be much more in keeping with thorough station efficiency.

The switchboard is only a development of our old-fashioned admiration of mechanism to be manipulated and with which to awe the uninitiated. The apparatus mounted on a switchboard is refined down to the last notch of size and delicacy, all of which tends to detract from its efficiency, as of all the parts of a station equipment the control should be rugged and reliable to the highest degree. A remote-control board may appear complicated, but it is based on simple principles the applications of which do not need to be shaved down to the last degree of delicate construction in order to reduce space and attain convenience. The switch gear and main circuit connections are rugged and of open construction, easily accessible and yet removed from accidental interference by reason of their isolated situation.

The expense of remote-control equipment is considered excessive in small plants but there is no reason why it should cost more than the ordinary switchboard in any station that contains more than a small generator circuit-breaker, switch and voltmeter. For example, in a small plant of two 500-kilowatt water-driven three-phase generators with six outgoing feeders and requiring one attendant on watch, the generator room should contain only the generators, exciters, wheel governors and attendant's desk. The desk should be so placed that while sitting thereat the attendant has full view of the room. The required generator and feeder indicating instruments should be mounted on a small panel along the back of the desk about eight or ten inches high and on the top of the desk, with a clear space in the center, should be the finger switches controlling the main switch gear in the basement, wire tower or other protected location, as conditions may indicate.

Current for the control circuits may be obtained from the exciter busbars and, if it is thought necessary, a small storage battery may also be provided for such use, though there does not seem to be any real need for it because it is quite practical that all switch gear should be inoperative and open when the plant is shut down. All ammeters, voltmeters, wattmeters, etc., should be connected to their operating circuits through transformers and absolutely no main wiring should enter the desk. Wherever the main wiring, switches, etc., are located, they, of course, need not be ornamental but of rugged construction, and wiring connections should be of similar character and generously spaced for easy access and handling.

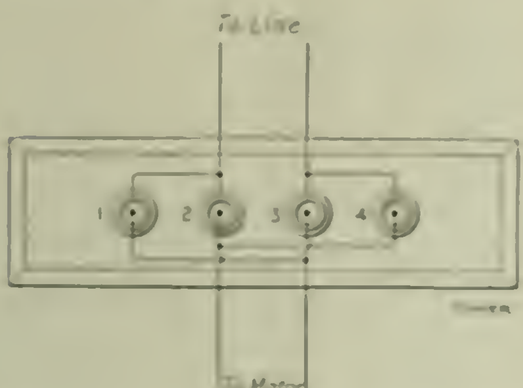
Switch gear, lightning arresters, etc., should be regularly inspected and kept in first-class condition but the station attendant should not be the one to make this inspection. The monotony of continual contact with his surroundings tends to render him oblivious to increase of wear and irregular operation of minor parts; inspection should be made by the superintendent. We know that very few switchboards in small plants are ever inspected beyond a casual glance at the mess at the back and a remark to the operator that he had "better remove that stick," or piece of waste or some other stray object. The first real evidence of anything out of order is usually a display of pyrotechnics and the operator is censured because he is there all the time and ought to know what is going on behind the board as well as in front. With the remote control he has no responsibility for the maintenance of the switchboard and the superintendent, who has, is given an opportunity to perform his duty and to have repairs made without danger of fireworks or shutting down the plant.

In substituting remote control for the old form of switchboard many changes suggest themselves in the methods of treating details. For instance, generator ammeters, wattmeters and field resistors are all local to their respective machines and in a small station it seems consistent and feasible to mount each set of instruments on a pedestal near the machine to which they are connected. The place for the resistor in the field circuit of a machine is adjacent to that machine, with either mechanical or electrical control at the desk. Voltmeters and feeder instruments should be at the desk, with the exception of recording instruments, the proper location of which is the switch room. With a diagram of the main circuits under a glass in the center of the desk the operator can always have a grasp of feeder conditions as changes or additions occur from time to time. The advantage of having the operator familiar with the system outside the station can scarcely be exaggerated.

LETTERS

Substitute for a Double-throw Switch

After installing a 5-horsepower direct-current motor for driving a crab winch through a friction clutch, we found that the weight of the line would not run the winch backward after throwing out the clutch, so we decided to make the motor reversible. Having on hand neither a double-throw switch nor the material from which to construct one, we resorted to the arrangement indicated in the accompanying sketch.



SUBSTITUTE FOR A DOUBLE-THROW SWITCH

We mounted four incandescent-lamp receptacles on a board and connected them as shown. Then we short-circuited the terminals of two ordinary attachment plugs with pieces of No. 12 copper wire and screwed them into the different receptacles according to the direction of rotation required. With the plugs in Nos. 2 and 3 the motor runs one way and with them in Nos. 1 and 4 it reverses.

This arrangement works so satisfactorily that we have decided to leave it in use instead of putting in a switch.

W. S. YOUNG.

Cherokee, Iowa.

An Extension Brush Holder

We have a 150-kilowatt alternator of the compound-wound type and the brushes on the rectifying commutator had always given considerable trouble by sparking and cutting away. They are woven-wire brushes and had to be bent as shown in Fig. 1. As they wore down near the bend we could not get tension enough on them to hold them down on the commutator; then the sparking increased, and the more they sparked the worse they would cut. Besides, the flashing caused a flickering at the lamps due to the variation in voltage. In order to get around the difficulty, I made up a full set of extra brush holders, each consisting of a simple block with two slots through it and two set screws, as shown in Fig. 2. This holder was mounted on the end of a short brush which was set in the regular holder, and a working brush of regular length was clamped in the diagonal slot. The complete arrangement is shown in Fig. 3. This enables

FIG. 1. THE REGULAR BRUSH

FIG. 2. AUXILIARY HOLDER

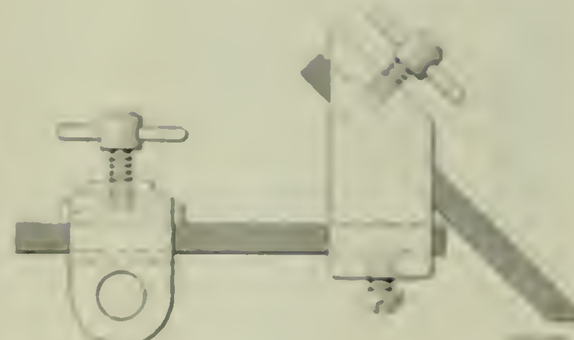


FIG. 3. APPLICATION OF AUXILIARY BRUSH HOLDER

us to keep the spring tension constant and to use up nearly all of the working brush.

E. M. GILBERT.

Nelsonville, O.

Starting a Large Motor Supplied by a Small Alternator

A factory was newly equipped with three-phase induction motor drive, the power to be furnished by the central station of the city. All the motors started their required load without difficulty except one of 50 horsepower. The customer tried in every way he knew to get this motor started but with no success. It was consequently declared defective and I was sent to locate the trouble. A thorough examination of the motor disclosed no defect except a ground in the rotor squirrel cage, and I knew that this would not necessarily interfere with the operation of the motor. The fuses, transformers and the inside wiring to the motor were found to be in perfect condition. The voltage of the circuit was tested and found to be normal.

Then we decided to give the motor another trial, but before doing this we connected lamps across the three phases in order to find out if there was an abnormal drop in voltage at the time of starting. With two or three men at the belt to aid the motor, the compensator switch was thrown in. The motor hummed, made a feeble effort to start, and the test lights showed extremely low voltage on the line. As the torque of an induction motor varies as the square of the applied voltage, one-half of the normal voltage would give only one-fourth of the normal torque, so it was now no wonder to me that the motor refused to pick up its load.

We inspected the line leading from the power house and found it was large enough to carry the current without any appreciable drop in voltage, and I felt sure that they were not running the voltage down at the central station while the motor was being started. Upon investigation at the power house we found that the current was supplied by a 100-kilowatt alternator, and observing the voltmeter on the switchboard while the motor was given another trial start showed that the heavy lagging current taken by the relatively large motor weakened the alternator field and reduced the e.m.f. to about half the normal voltage.

As a makeshift we tried running the voltage up while the motor was being started; it was run up to 15 per cent. above normal and when the motor hit the line we immediately cut all the resistance out of both the alternator and exciter field rheostats. The busbar voltage was thereby held about normal and the motor speeded up with its load with the greatest ease. This method had to be used in starting this motor until a larger generator was installed.

G. J. KETWILLER.

Anniston, Ala.

The portion of the feed pipe in the boiler should be suspended by short wires from the braces and not be allowed to rest upon or across the tubes. Tubes are sometimes cut through by the continual movement of the feed pipe upon them, due to the pulsations of the feed pump. The pipe should be put together in sections so that it may be removed and cleaned.—ED.

When the belt has become oil soaked and will not stay on the pulleys, a good method of cleaning it is as follows: Coil the belt loosely in a tub of sufficient size, and cover with whiting. Be sure that the whiting gets in between the coils of the belt, and it will be only a short time before the whiting will absorb the oil from the leather. It will then only need to be wiped clean to be ready for further service.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Running a Gasolene Engine with Kerosene

By M. W. Pullen

It is well known that for a hydrocarbon engine to run properly it is necessary that the fuel be finely atomized (preferably vaporized) and thoroughly mixed with the intake air. With gasolene engines and some forms of kerosene and crude-oil engines the problem of obtaining the proper mixture has been solved in a number of ways which are quite satisfactory. With a kerosene engine, vaporization of the fuel is much more difficult than in the case of the gasolene engine, because kerosene is not as volatile as gasolene. If, then, an attempt be made to use kerosene as fuel for an engine normally adapted for gasolene, trouble is likely to arise from failure to vaporize the kerosene.

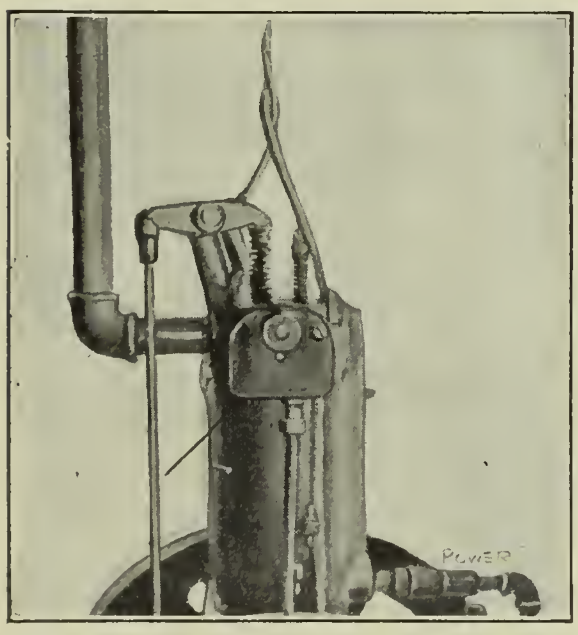


Fig. 1. Gasolene Feeder

This trouble was very noticeable in the case of a small engine which was supposed to be properly equipped to burn kerosene. The engine was fitted with an atomizing mixer very much like that used by the manufacturer for gasolene. Fig. 1 shows the atomizer used for gasolene on the type of engine under discussion; the arrow points to the air-intake opening. Fig. 2 shows a vertical section (not to exact scale) of the device taken at right angles to the needle valve and Fig. 3 a vertical section partly in the plane of the needle-valve axis. It is clear that as the intake air is drawn into the cylinder it sucks a certain amount of fuel through the small nozzle and the two mingle in the short passageway to the cylinder.

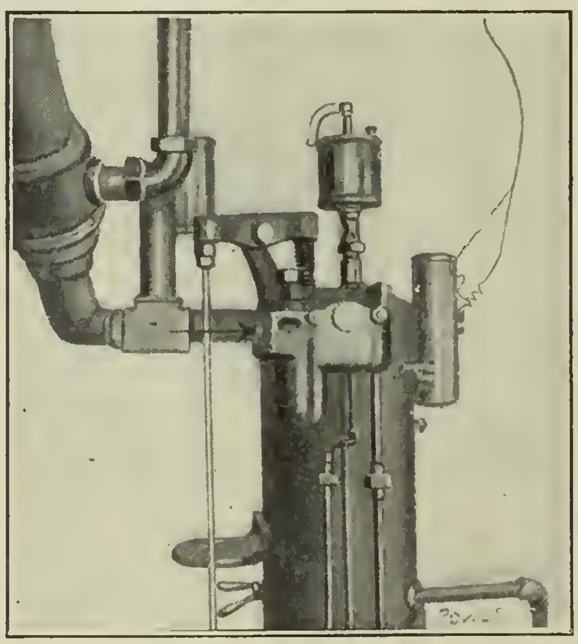


Fig. 4. Kerosene Feeder

Fig. 4 shows the atomizer that is used for kerosene. The similarity in appearance of the two is quite marked, the kerosene device differing only in having the retort at the left. The intake opening is located somewhat differently, however, as indicated by the arrow. The retort, which is the only essential difference between the two types of atomizer, is arranged to be heated with a blow torch in case it is desired to start the engine on kerosene. In this case the large sight-feed oil cup shown just above the needle valve is screwed into an opening directly over the retort; this opening is indicated in the sectional view of Fig. 5. The function of the sight-feed cup is explained later. The portion of the kerosene atomizer which is not shown in Fig. 5 is exactly like the corresponding part of the atomizer represented in Figs. 2 and 3. Vent holes are provided for the escape of the hot gases of the blow torch from the jacket space *J* but they do not show in Fig. 5; one may be seen near the top of the retort in Fig. 4.

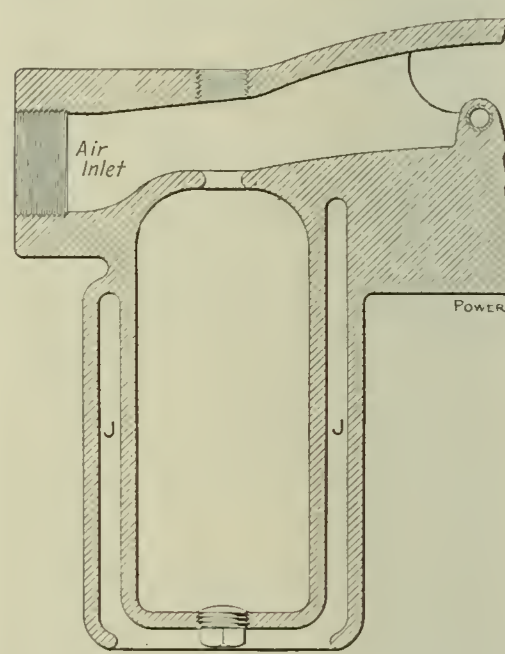


Fig. 5. Section of Kerosene Vaporizer

To start the engine with kerosene, the sight-feed cup is filled with the fuel and the retort is heated at the bottom. When it is hot enough, the cup is opened and the kerosene drops down into the retort, where it is vaporized. The kerosene vapor rises into the air passage and mixes with the air drawn into the cylinder by the suction stroke of the piston and the ordinary cycle of operation

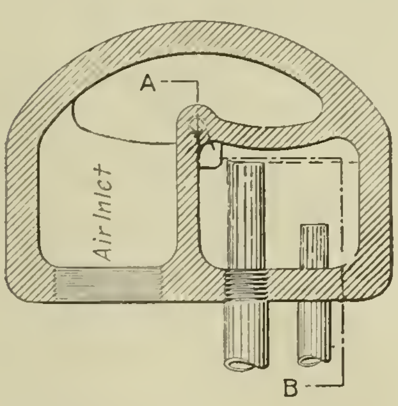


Fig. 2

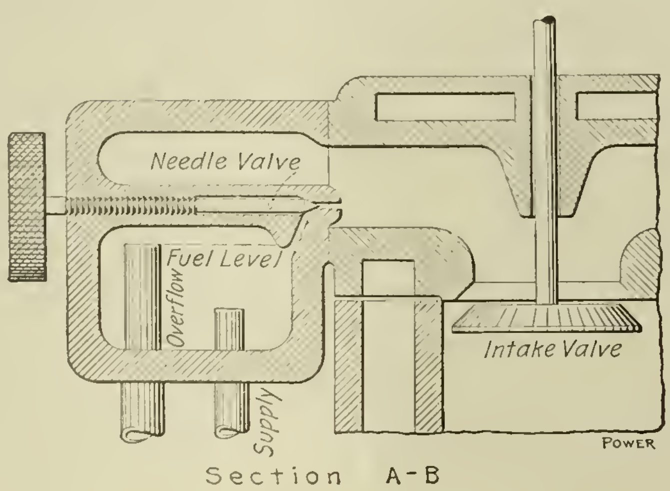


Fig. 3

Sections of Gasolene Feeder

started. After the start the needle valve is opened, the oil cup shut off and the kerosene is thereafter fed to the engine in exactly the same way that gasolene is fed in the gasolene atomizer. The retort, of course, goes out of use until another start is made.

If there is gasolene at hand the sight-feed cup may be mounted in the position shown in Fig. 4 and the engine started by allowing gasolene to feed from the cup into the air passage of the atomizer, whence it is swept up by the air and forms an inefficient mixture but one good enough for starting. After the engine has run for a few minutes, the gasolene is shut off and the needle valve opened; regular operation on kerosene follows. This latter method of starting is much handier than the former, and if it be used the retort is unnecessary, a simple gasolene atomizer being sufficient as far as running is concerned. No provision is made for vaporizing the kerosene; it is simply atomized by the nozzle.

The engine with the kerosene (retort) feeder gave trouble almost from the time

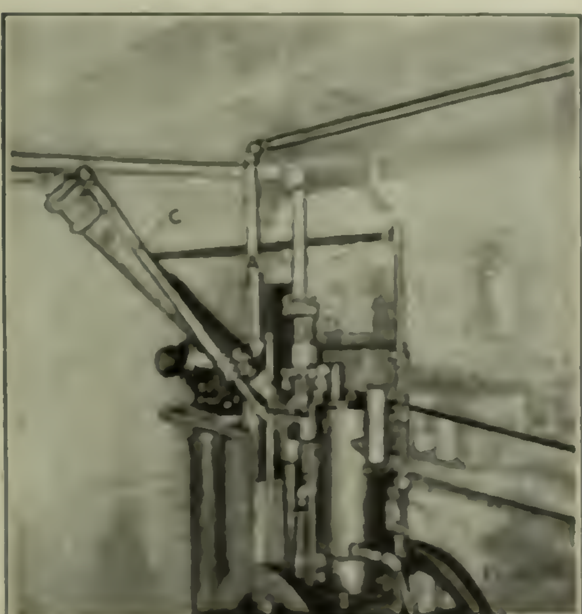


FIG. 6. INTAKE-AIR HEATER

it was put into operation. It used a great deal more fuel than it should, even when the needle valve was regulated to give the least amount of fuel that would enable the engine to run smoothly.

The second trouble was in lubrication. The engine, as will be noted, is vertical with a closed crank case, being oiled by the splash system. The hight of the oil in the crank case was noted daily and each time it was necessary to *draw off* oil instead of adding more; the amount drawn off was greater than the amount added by the oil cup which was supposed to keep up the supply. Then, again, the oil worked out through the main bearings and getting on the flywheels it spattered two streaks on the floor and ceiling of the room.

The cause of the lubrication trouble was not discovered for some time. However, it became necessary to draw the oil all off about a month after the engine was set up, and the oil was saved with the idea of using it again. It was noticed that it had a peculiar appearance, was very thin, and did not feel very smooth between the fingers. A close examination showed that it was a mixture of cylinder oil and kerosene, mostly kerosene.

From this discovery it became evident that the kerosene was not being fully burned and that some of the unburned part of it worked down into the crank case; perhaps a good share of it went out through the exhaust port.

In Fig. 6 is shown the remedy adopted. A jacket of 3-inch pipe fittings was put on the exhaust riser, which is of 1½-inch standard iron pipe, and the intake air was led through it. The air comes from out-of-doors through the small vertical pipe *A*, entering the bottom of the heater *B*. The air then rises along the hot exhaust pipe and out at the top by way of the pipe *C*, which leads down to the atomizer. The heated air serves to help vaporize the kerosene.

It is now necessary to add oil to the supply in the crank case and, what is more important, the kerosene tank does not have to be replenished nearly as often as before with the same engine load. No exact data as to the saving can be given, but it is estimated that with the heated air only about three-quarters as much fuel is used as when the engine was supplied with cold air.

Steam Engineers for Gas Power Plants

BY CHARLES O. HAMILTON

"Whom have you picked out to take charge of your power plant?" is the way I generally bring up the matter of attendance in going into details with a gas-engine buyer. I am not likely to say "engineer"; it's mighty apt to start something.

After explaining the need for attendance and the buyer understands the matter, it is only natural for him to say, "How will my present steam engineer answer?" This is a most natural suggestion. Why not the present engineer?

Unfortunately, the engineer himself in many cases has made his selection as the gas engineer a bad move for his employer. The reasons may be many, but foremost is the prejudice that he has cultivated for the gas engine. He would be out of harmony with gas power; until he had weaned himself from his first love and formed an attachment for the new power he could not hope to succeed. The chances are that he has opposed the purchase of the gas plant and his personal feeling prejudices the builder against trusting him to operate the engine.

Even though he had taken a broad-minded position, advising fairly on such points as were put up to him during negotiations, there might be still many things which would make his selection as operator of the plant seem inadvisable. Chief among these objections is usually the fact that unless he has been more progressive than the average engineer he has not equipped himself with any knowledge of gas-engine operation, having assumed that if he should ever be called upon to operate such a plant his knowledge of steam engines would enable him to step in and make good immediately. He is apt to scorn A, B, C instructions and the need of his making-over that is requisite to change from steam- to gas-engine operation.

A good steam engineer has a great many points to recommend him. He is not afraid of the noise and the moving parts of an engine, whereas a man of other training would be timid until he became used to the surroundings. His training has made him thoughtful and watchful of details; he does not forget to do the little things. He has self-reliance and presence of mind in an emergency—a most valuable asset. He knows the plant, knows the ins and outs of everything, probably having installed or renewed a good part of it if long in his position. To have been a successful steam engineer he must have been of good habits. He must have been something of a mechanic in order to keep his plant in shape.

Every one of these things counts in his favor as a gas-engine operator, but if he is prejudiced against gas power or has been so indifferent that he has made no study of its peculiarities, the favorable points will not suffice to make him eligible.

Steam engines and gas engines are both machines for converting heat into mechanical energy. But aside from this function there is mighty little similarity. They are decidedly unlike in operation. Conditions in the steam cylinder are materially different from those in the gas cylinder because steam differs, of course, from flame. Steam exerts a fairly even continuous pressure on the working parts; gas pressure starts with an explosion and diminishes rapidly; it is also intermittent. Lubrication, packing, valve conditions, are entirely different. Even the bearings require different handling and adjustment. The control of the fuel and ignition have no correspondent at all in handling steam.

The steam engineer served a long time to learn steam-engine operation. The gas engineer, to be equally proficient, must serve and study too.

The ordinary steam man usually begins his gas-engine apprenticeship by far underestimating his need for special knowledge and training, and is inclined to feel that changing to gas power is a step downward. The fact that he has been "it" in the old plant often leads to a resentful, obstinate, overwise bearing in receiving instruction regarding the eration of the gas engine. Starting up looks so easy in the hands of the erecting engineer that he assumes there is nothing to it. He despises suggestions of a routine, preparing to start and stop.

When anything goes wrong, he will hark back to his old plant and when he cannot figure it out he blames the gas engine. He will make about as ridiculous mistakes in his new work as an inexperienced man would make with steam—mistakes he would laugh at in a steam engineer, yet he does not see the joke when we laugh at his bungling with the gas engine.

When we find an old steam engineer who is wise enough to know that he does not know about gas power and really wishes to learn, there we find an ideal candidate for a gas engineer.

The gas engineer in Europe must make his engine perform well up to its possibilities or lose his standing as a mechanic. It is so in this country with steam engineers, and eventually it will be so with gas-engine operators.

There is another feature that steam men do not always like. The medium-sized gas plant, say, of 20 to 200 horsepower, using natural gas, city gas or gasolene, will not require over two hours' time out of the eight, nine, ten or eleven hours which the operator puts in. (In this time estimate I am considering a plant where the engine is belted to a line shaft.) If a suction-gas producer is used, another hour will be sufficient to care for that. Consequently, the gas engineer must occupy himself for the greater part of the day with other work.

Here, again, we are apt to find the steam man with his hair rubbed the wrong way. Where there is any auxiliary machinery, such as dynamos, pumps, compressors or a heating system, to take up his time he is satisfied, but when the spare time must be put in at some regular work, like running a lathe or other production machine, he is apt to buck, and rather naturally, because this usually forces him to learn two trades, gas engineering and machine-tool operation. Under such circumstances, the steam engineer is at a disadvantage compared with a man taken from some machine in the shop, who willingly masters the gas engine as a side line to running his regular machine. But there are hundreds of industrial establishments in which working at a distinct trade in addition to running the power plant is not necessary. Only the ordinary kind of mechanical work, such as the care of belts, shafting, hangers, etc., is required. Here the steam man ought to shine if he would take the proper interest in gas power.

There is a growing demand for competent men in this line of work. We know it from the continual efforts made by engine buyers to hire our field men and experts away from us to take charge of their power plants.

What I have written here is not intended as an argument for or against the steam engineer in the gas plant. It is intended merely to tell some facts which I know to exist, some facts that are not always quite apparent to the people who buy engines and those who run them.

I do not know that the average steam engineer wants to take hold of a gas plant such as might be bought to replace his steam plant, but if he knew the possibilities for more money—and that is what most of us work for—I should think he would be anxious to do so. My experience indicates that the man who can successfully operate a gas-power plant and make himself of real service in his spare time will easily earn at least 25 per cent. more money, with shorter hours and cleaner work, than he could get in the average steam plant of the same horsepower. Perhaps he would not get it at the start, but why should he expect it? He is learning a new trade then.

Essential Factors in Making Producer Gas

Bulletin No. 7, just issued by the Bureau of Mines, describes the results of some interesting investigations, made by J. K. Clement, L. H. Adams and C. N. Haskins, of the processes that take place in a gas producer. One of the chief objects of the work was to determine the effect of temperature upon the proportion of carbon monoxide obtained. In experiments made by Mr. Clement at the Norfolk plant of the United States Geological Survey, it had been found that the temperature in the generator varied greatly in different parts of the fuel bed. In order to ascertain the conditions of temperature most favorable to efficient operation it became necessary to determine the temperature required for the formation of carbon monoxide and hydrogen.

The investigations described in the bulletin demonstrated that a very high temperature is necessary for the maximum production of carbon monoxide from carbon dioxide and carbon. Other conditions, however, are against operating the decomposition zone of the fuel bed at extremely high temperatures—much above 1300 degrees Centigrade (about 2400 Fahrenheit). A very hot fuel bed means that the gases will leave the generator at a high temperature and thereby lower the efficiency of the producer unless the heat of the gases could be used for generating steam or preheating the air blast. High temperatures also favor clinkering. In the application of the results of these experiments to commercial producers and furnaces it will be necessary, of course, to consider the other questions which are involved.

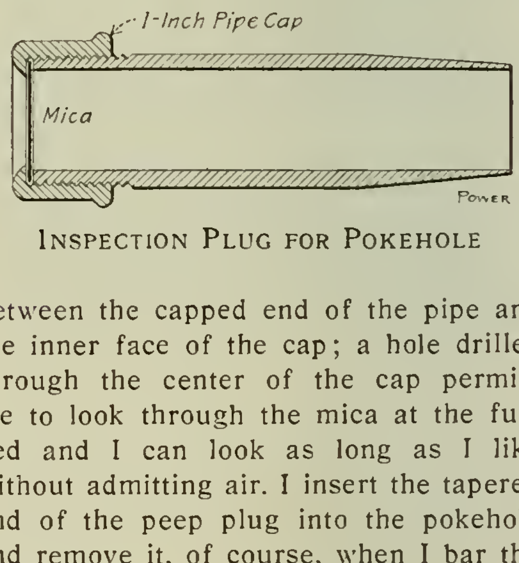
The investigations also demonstrated that the higher the velocity of the gas through the fuel bed and the thinner the bed, the smaller will be the percentage of carbon monoxide formed; also, the greater the supply of air to a given depth of bed, the smaller will be the percentage of this gas formed.

The use of large amounts of steam is inconsistent with the realization of high temperature, and is, therefore, to be avoided. Moreover, on account of the large percentage of carbon dioxide that is formed when a relatively large quantity of steam is used, it is doubtful if a real gain in efficiency is obtained.

CORRESPONDENCE

An Airtight Peephole

For a long time I followed the common practice in the operation of gas producers of using the opened pokeholes as peepholes for inspecting the condition of the fuel bed, wishing all the time that some other way could be devised. Finally I hit upon the simple arrangement illustrated by the accompanying sketch and now I never need to open a pokehole to the air except for actually poking the bed. The arrangement shown consists of a piece of 1-inch pipe 6 inches long, capped at one end and slightly tapered at the other, with two sheets of mica clamped



INSPECTION PLUG FOR POKEHOLE

between the capped end of the pipe and the inner face of the cap; a hole drilled through the center of the cap permits me to look through the mica at the fuel bed and I can look as long as I like without admitting air. I insert the tapered end of the peep plug into the pokehole and remove it, of course, when I bar the fuel bed.

N. A. LEE.

Hawley, Minn.

A 63-ton shafting has recently been placed in the engine room of the Sharp Manufacturing Company's mills in New Bedford, Mass. To move the huge piece of metal from its bed on a flat car to its position in the engine room required the work of ten men and two large steam road rollers for two days. A cylinder weighing 29 tons had previously been placed in position.

Just because you do not get a raise in pay every few months is no sign that you are not appreciated. Things might have been worse. You might have got fired.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Inspirator Troubles

Some years ago I had trouble with an inspirator. The conditions under which it worked were severe and different from what the device was designed to work under. It received its water supply under a head of about 45 pounds; the water pipe was the common supply for two power pumps, and the steam supply came from a main that supplied two air pumps and a duplex steam pump.

As long as the steam pressure would be kept up to 140 or 150 pounds per square inch, the inspirator would work properly, but as soon as the pressure dropped, as it would through the night, trouble would be experienced. In starting the inspirator, it would only run a few minutes and then break. The trouble was with the water supply. The inspirator was made to lift water, and when doing so works satisfactorily with widely varying steam pressure.

With the inspirator connected to a water supply under pressure, the valve on the suction pipe should be throttled until just the right amount of water is admitted; otherwise the inspirator may break. In starting up under such a condition the steam should be turned on first; then open up the water-supply valve a little and draw over the starting lever, for, when lifting the water, it can easily be determined if there is too much or too little. It is a matter of rather nice adjustment, depending on the steam and water pressure, but after a few trials one can judge the right amount of opening the suction valve needs.

H. X. Gehrt.

North Cambridge, Mass.

Flywheel Worked Loose

One morning, after I had started a 12x12-inch automatic high-speed engine, my attention was arrested by a loud grating noise. When the governor "came out" the noise stopped, but it was succeeded by a rapid pounding. I shut down and as the governor "went in" the pounding ceased and the grating began.

I found that the governor was rubbing against the eccentric oil guard, which was caused by a loose and shifting flywheel. I could think of no easy way to shift the wheel back to place, so I tightened the set screws in the hub and started up again. This time there was no pounding and the engine ran very well all day. The wheel was about ½ inch out of position on the shaft and this drew the eccentric out of line with the valve rod. Putting the wheel back into position was a difficult matter, for it was a side-crank engine and the flywheel and armature were so close to the main and outboard bearings that there was not enough room for the usual make of jacks.

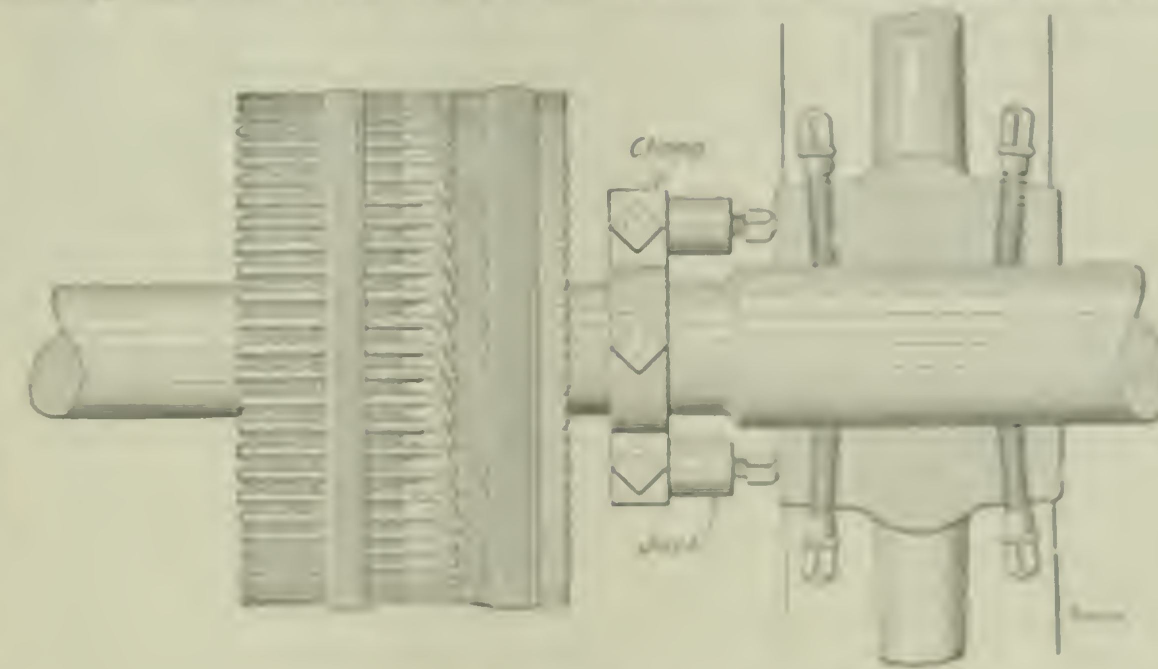
During the day I made two jacks by sawing a 2½-inch cast-iron bar in 3-inch lengths. I drilled and tapped them for a ⅝-inch set screw, shown in the accompanying illustration. I also made a clamp to fasten to the shaft. The clamp contained two set screws which were to be used for gripping the shaft after the clamp bolts had been tightened as much as possible. With the clamp in position on the shaft, the base of each jack was placed against the clamp ends and the heads of the set screws were placed against the hub of the flywheel. I then loosened the set screws in the wheel hub and with a small monkey wrench began to screw out on the jacks. Presently the wheel began to move and in a few minutes it was back in place.

I then took some putty and plastered it all around the shaft close to the hub and after removing one set screw out of the hub I poured in a solution of sal-ammoniac and water and allowed it to stand until the next morning. The clamp and jacks were then removed, the engine was started up and no trouble has been experienced since.

The object of using sal ammoniac was to rust the wheel and shaft together.

J. England.

New Haven, Conn.



Jacks Used to Force Flywheel Into Place

Some Power Cost Figures

Some interesting figures on the cost of producing power in a plant which sells its exhaust steam for heating during the winter months have recently been reported. These figures refer to the plant of the Wells Power Company, of Milwaukee, Wis., the power plant of which is an outgrowth of a small isolated plant installed to furnish power and heating for several neighboring buildings in the center of the business section of the city, and at the present time furnishes power and exhaust steam for heating to customers within an area of 2½ square miles.

When the original isolated plant was outgrown a new plant was built to be operated in parallel with the former, each plant being situated in the basement of a mercantile block. The old plant had a capacity of 550 kilowatts and 900 boiler horsepower. The new plant at present contains 1000 kilowatts in generators and 1524 horsepower of boilers, and there is provision for eventually more than doubling this capacity.

During the year ending July 1, 1910, the total generated output was 1,561,410 kilowatt-hours, of which 1,275,400 kilowatt-hours were sold to outside consumers, the remainder being used through the company's buildings. Based on the kilowatt-hours sold, the total earnings were $0.097 per kilowatt-hour, divided into $0.056, earned by the sale of electrical power, and $0.026 credited to heating; the remaining amount represents miscellaneous income. Against this earning the total expense charged, which includes depreciation and taxes, amounted to $0.075, giving a net profit of $0.022 per kilowatt-hour.

In order to furnish a real basis for comparison with isolated plants and central stations, it is more logical to take the figures for kilowatt-hours generated rather than the amount sold. On this basis the figure for total earning per kilowatt-hour are $0.079 against a total expense of $0.062.

In considering these results allowance must be made for the fact that, owing to the location of the plant and the impossibility of obtaining the large quantities of water necessary for condensing without undue expense, it is necessary to operate this plant noncondensing in the summer time as well as during the winter when exhaust steam is used for heating. If it were possible to run condensing during the warm weather, the total expense figures would undoubtedly be materially lessened.

H. M. Wilcox.

Boston, Mass.

Smoke Preventers

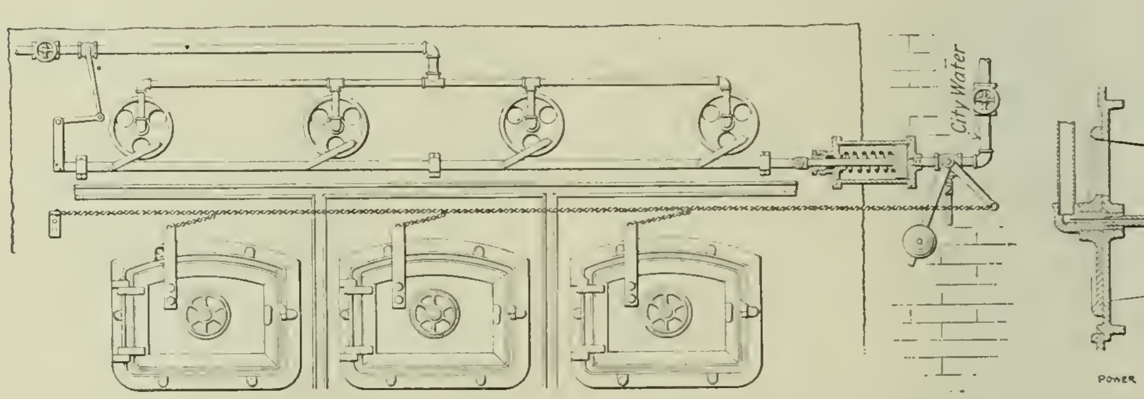
I carried out several experiments some years ago with a so called smoke preventer, the principle of which was to admit steam and air over the fire while the volatile gases were being distilled. The fronts of our boilers were badly cracked. The doors were each 24 inches wide by 20 inches high, and considerable air was admitted when firing and cleaning the fires, causing a serious reduction in steam pressure as the load carried was very heavy.

Patterns were made and a new front with three doors each 18x14 inches was cast and put on one of the boilers. After this was done it was noticed that the stack of the boiler with the remodeled front smoked for a longer period after each firing than the boilers with the old-style front, which was believed to be due to the new front being tight and shutting out the air over the fire.

It was then decided to put on a steam-jet smoke consumer, which was done by piping steam to the inside front wall. A ¾-inch supply pipe fed the ½-inch branch pipes, which were fitted with nozzles made with a very thin, wide opening, in order to spread the steam over the entire fire. This device was tried on one of the old-style fronts, steam being turned on as soon as the doors were closed after each firing. On trial it was found that with the jet on and doors closed the black smoke was reduced to nearly one-half of what it was without the jet, and still better stack results were obtained with the fire door slightly open; the coal consumption was also increased and the feed valve was opened about one turn more to make up for the increased evaporation, due to a hotter fire with better draft rather than more complete combustion.

As this device depended upon the fireman for operation, it would either be left on all the time or not turned on at all.

These results lead to a second experiment on a larger scale with a more complete and automatic device, which is shown in the illustration and was applied to the new front. It consisted of four draft plates 7 inches in diameter, fastened to the boiler front, through which holes were drilled to correspond to the openings in the plates. A hole equal to the area of the opening in each plate was also made through the front brickwork and pitched slightly downward, so that the air and steam would tend to strike the bridge-wall about 2 feet over the fire. Superheated steam was admitted through the ⅛-inch nozzle placed through the center of each plate, which also acted as a bearing on which the plate could revolve.



Control of Steam Jet As Attached to the Front of the Boiler Setting

The draft plates and the butterfly valve in the steam line were operated by a cylinder 4 inches in diameter by 8 inches in length, and closed by a heavy spring on one side of the piston in the cylinder. Water under city pressure was admitted to the cylinder through a three-way valve which was opened as the chain was pulled when opening the fire door; when the door was closed, the three-way valve was closed by a weight and the water gradually drained out of the cylinder through a ¼-inch pet cock.

Steam was superheated by means of 12 feet of ¾-inch pipe placed crosswise of the boiler over the tubes. Both steam and air were gradually shut off by the action of the spring in the cylinder, and could be regulated to close in from 1 to 10 minutes, the duration of the steam blast being determined by trial, the idea being to diminish the amount of steam and air as the volume of volatile gas was decreased. A globe valve was placed in the steam and water lines in order to make changes and cut out at cleaning times.

This boiler was tested in comparison with another boiler fired alone and on another stack. Smoke was greatly decreased over that coming from the other stack without the jet, and better results were gained by having the fire doors open about 2 inches for three minutes after firing and also by firing alternately one-half of the grate at a time, which led to the conclusion that the plates were too small.

I had no CO_2 recorder, so I do not know whether the percentage of CO_2 was increased or not by the use of the "consumer," but, in every case when the device was turned on, the water tender gave the feed valve an extra turn open, and also several more barrow loads of coal were used per day, which led me to believe that the capacity of the boiler was increased, and the clinker was more brittle and easier to get out.

In order to observe the decrease in smoke, the device was left closed until the dense, black smoke was rolling out of the top of the stack, and then put on, the result being that the smoke instantly changed to light gray, and, if the steam jet was shut off again, black smoke would again issue from the stack.

These boilers were worked at full capacity and on a very poor draft. The coal was bituminous run-of-mine, containing about 13,500 B.t.u. and 15 per cent. ash; therefore, it was necessary to fire very light and often, or about every 5 minutes, using not over four small scoops at each alternate firing. In this plant is also another battery of water-tube boilers with the same kind and size of grate, but set in a dutch-oven furnace, the arch being 8 feet long and about 4 feet high in the center. Firing the same amount of coal in the same manner in this type of furnace gave a much cleaner stack than was possible with either the steam jet alone or combination of air and steam with the ordinary furnace.

I believe that the "smoke consumer" shown herewith, properly designed and set in a dutch-oven furnace, will not only produce a clean stack, but will increase the capacity of the boiler and give a high per cent. of CO_2 and better combustion.

The results obtained with the different types of furnaces and methods of firing are given herewith, and in each case the boiler was run at full capacity and fired in the same manner and by the same fireman.

The figures correspond to the numbers used in the Ringelmann smoke chart:

Boiler and furnace	Average Per Cent. of Time for Each Condition					
	No. 5	No. 4	No. 3	No. 2	No. 1	Clear
Sterling boiler, dutch-oven furnace, no jet or air over fire, No. 5 boiler	5	15	25	10	25	20
"Smoke consumer," Fig. 2, in operation on No. 4 boiler	10	15	20	20	25	10
Boiler with smoke consumer cut out	25	30	10	5	0	0
Boiler No. 3 with steam jet, Fig. 1, cut in, old front	20	20	20	20	15	5
Boiler No. 3 with steam jet cut out, old front	40	25	25	10	0	0

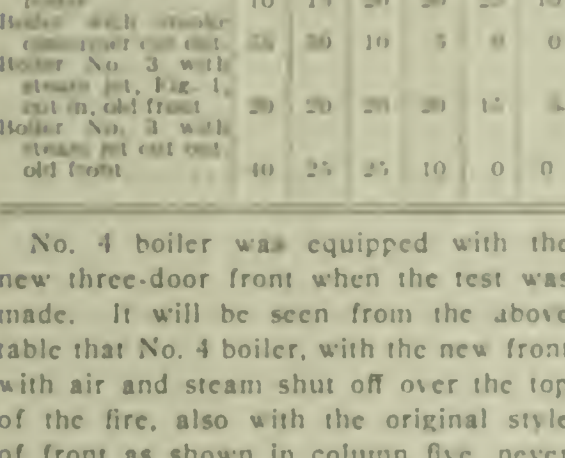
No. 4 boiler was equipped with the new three-door front when the test was made. It will be seen from the above table that No. 4 boiler, with the new front with air and steam shut off over the top of the fire, also with the original style of front as shown in column five, never showed a clean stack.

J. C. Hawkins.

Hyattsville, Md.

Regrinding a Safety Valve

It was necessary to grind a pop-safety valve so I began to think up a convenient method of turning the valve, which was not made fast to the stem and was threaded for a 1¼-inch pipe in the center.



Valve-grinding Device

I, therefore, made the tool shown in the illustration. The square shank end was cut from an old bit and a short piece of 1¼-inch pipe shrunk on the round end. A thread was then cut on the end of the pipe and a 1¼x1½-inch bushing was screwed on it. The whole was then screwed into the valve.

A bit brace was used to turn the valve disk on its seat. The valve was then readily ground in.

This tool will often come in handy as any size of bushing may be used.

Howard R. Taylor.

Norwich, Conn.

Babbitting Bearings

Most all of the so called anti-friction metals are composed of an alloy of two or more metals, such as copper, tin, antimony, bismuth and lead. Babbitt metal, however, has come to mean a metal containing any part of these metals, the base being chiefly lead.

Twenty-four parts of antimony and 76 parts of lead appear to be the proper mixture of the two metals, because 24 parts of antimony seems to be the maximum amount that will unite with lead to form a complete alloy. Considerable care is necessary in preparing these alloys because the melting temperatures of the component metals are so different.

Most engineers are aware that old babbitt metal after having been used and remelted a number of times loses its fluidity and becomes more and more pasty the more it is used until it will not make a sharp, smooth casting. This is due to the rapid vaporization of the more volatile metals and the oxidation of other metals of which the babbitt may be composed. When babbitt metal has reached this condition it is practically worthless but it can be restored to its normal fluidity, to a certain extent, by the addition of a small amount of lead. Pieces of old type metal would be more beneficial than lead as, owing to its composition, it not only restores the normal fluidity, but will improve the quality of the babbitt in general.

There are numerous ways of babbitting a box or journal. One very good way is to level and line up the shaft by putting small cubes of wood under it in such a position that they may be taken out after the babbitt has been poured, thus leaving small pockets for the oil under the shaft. These pockets will get full of oil and in case the journal begins to heat, due to a stoppage of the oil feed, etc., the oil from these pockets will work up to the bearing and thereby protect it from any very serious damage.

A good way for babbitting bearing for small shafts is to wrap common writing paper around the shaft and fasten it with coarse twine. The babbitt will run more smoothly by coming in contact with the paper covering than when coming against the cold surface of the shaft, although the shaft may have the chill removed by means of a blow torch before pouring the babbitt. The paper and cord method is preferable as the thickness of the paper will compensate for the slight shrinkage of the metal so that it will not be necessary to do as much scraping as would otherwise be the case.

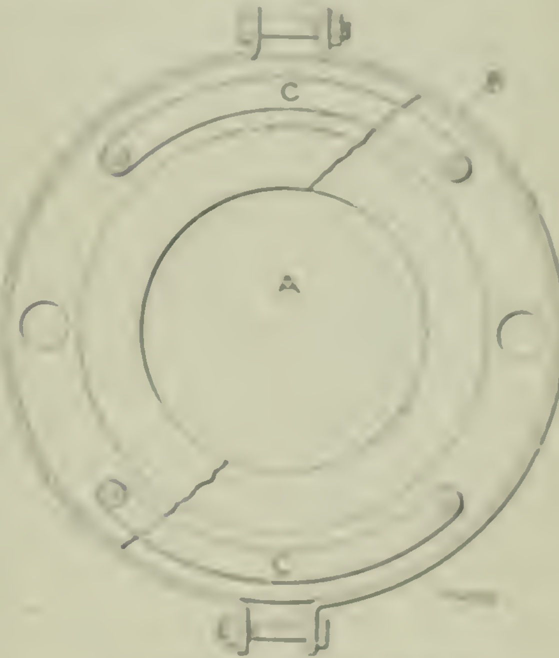
If the twine is properly wound around the shaft, care being taken not to allow the twine to extend to the end of the box, but leaving it terminate in a complete circle about ½ inch from the end of the bearing, the oil will not run out at either end of the bearing. The ends of the bearing must be filled with something to prevent the metal from running out while pouring. This may be done by placing a pasteboard washer on the shaft up close to the end of the bearing and packing all small interstices with putty or soft clay paste. Then the bearing may be poured and a good bearing obtained.

Charles H. Taylor.

Bridgeport, Conn.

Repairing a Broken Pump Gland

A 12 and 8 by 14-inch pump of the pot-valve center-packed type had a cracked gland, as shown at *A* in the illustration. As a new gland could not be



Repaired Pump Gland

procured within two weeks, and as the pump had to be ready for the line for the peak load, I made the repairs as follows:

I got some ⅜x1-inch stock and made a strap to go around the outside of the flange, as shown at *B*. By drawing up on the bolts the gland was held together. Then I made two clamps, as shown at *C*, out of some ⅜x¾-inch stock, and drilled a 1⅛-inch hole in each end so that the clamps would fit over the studs. These clamps were fitted to the top and bottom studs, which enabled setting up the packing and prevented leakage.

When packing pumps of this type, care should be taken that all the old packing is taken out and that the plunger is central in the stuffing box. If the plunger sags and there is more clearance at the top, a tack screw put under the plunger or rod, whichever it may be, will equalize the clearance around the plunger in the stuffing box.

I find that by soaking the packing in oil over night and putting it in both short it gives better results and wears better.

J. Robert

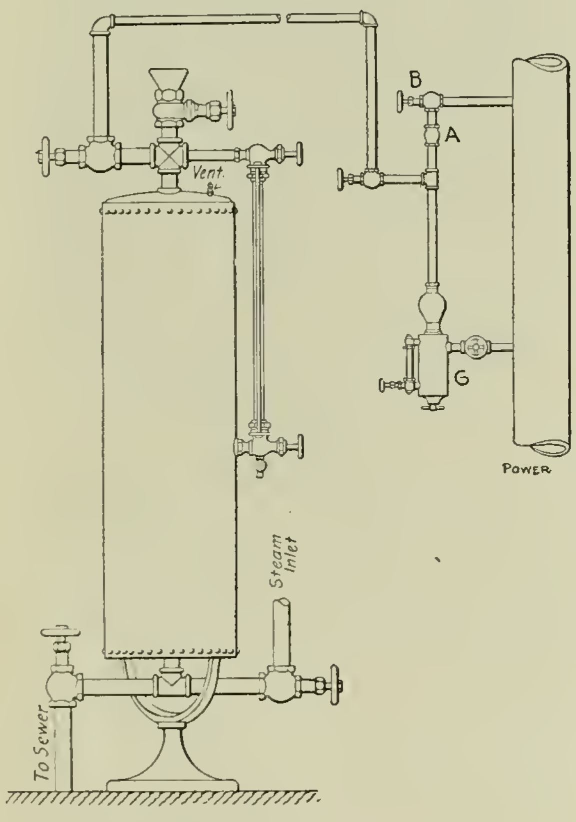
Cambridge, Mass.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

A System of Lubrication

About three years ago I rigged up an oiling system in the plant where I am employed similar to the one described by Charles P. Weaver in the March 28 number of POWER. I connected the system up as described by Mr. Weaver with the addition of a check valve in the oil pipe close to the reservoir, which prevents any oil from returning to the reservoir when pressure is off. I provided a funnel similar to that shown in Mr. Weaver's sketch, through which to fill the reservoir. My reservoir contains enough oil to last six



MR. WEAVER'S OIL RESERVOIR

weeks, at the end of which time I find that I have quite a job refilling the reservoir.

As every engineer knows, cold cylinder oil has cold molasses beaten to a frazzle when it comes to slowness, and in handling any quantity of it he is quite likely to get his hands and clothing soiled, besides consuming a lot of time. To avoid this annoyance I ran a 1¼-inch pipe from the top of the reservoir to the oil barrel, entering the barrel at the bung and extending the pipe to about one inch above the bottom of the barrel. I put a union in this pipe 3 inches above the barrel and a globe valve just over the union, so that an empty barrel can be easily removed and a full one substituted. The oil barrel is set on skids about one foot higher than the bottom of the oil reservoir.

When the reservoir needs refilling I simply close the steam or water inlet to the reservoir, open the outlet to the sewer and open the two valves in the pipe between the reservoir and the oil barrel. The water runs out at the bottom of the reservoir and pulls the oil out from the barrel, filling the reservoir with oil as fast as the water runs out. We do not have to handle the oil at any time. The pipe from the barrel to the reservoir should be filled with water or oil to start the outfit, which is simply a siphon. If no air is allowed to get into this pipe it always works; but to fill the tank quickly when the plant is running, I have a ½-inch pipe running from the bottom of the reservoir to my condenser, with a valve close to the condenser. This pumps the water from the reservoir and fills it with oil in a very short time.

W. T. PIPER.

No. Andover, Mass.

The Point of View

The front-page editorial of the April 18 issue of POWER gives a good suggestion to engineers as to how they might make their work more interesting. A man can do much better work when he takes a genuine pleasure in what he is doing than when only working to put in time so as to be able to draw a salary. However, the engineer is not always to blame, for while there are men who would not do the right thing no matter how fairly they are treated, there are some men who would be of use if they were rightly handled.

Take, for example, the young man commencing to learn the business and suppose he gets into some plant where the chief engineer is a man who thinks that everybody is trying to get his job and therefore is afraid to teach the young man anything of real value. Then there comes the time when the engineer is in need of an assistant. The young man does not get the job, for he has not been trained properly for it. So he is told that he does not know anything and never will know anything. How does he feel? How would any man, with a spark of pride, feel? Would he not be pretty much discouraged? A man treated like this may never rise above an ordinary helper. He has been spoiled at the outset. If any of the firm should inquire about him, the chief will say he is no good, so they fire the boy and hire somebody else. If it had been the case of a machine which had cost a hundred dollars or so, there would have been an investigation to fix the blame.

In my opinion, the average man who starts out to learn a trade has, if not the right view, the right spirit, and it is up to the man he is working for to develop him so that he may be valuable to others and himself. The beginner often believes that every man is an expert in his line and that each one is doing his best; but how rudely he is "brought to earth" when he finds that 90 per cent. of his fellow workers are just mediocre workmen.

Some years ago, I read an editorial in an engineering paper on the statement of an engineer who refuted the fact that an employer did not buy proper supplies for his plant. At the time it had not been my opportunity to see much of the methods employed in steam plants, so I thought this editorial unusual; now I know better. Anybody with experience knows that firms that buy the best supplies on the market are in the minority. I know of a plant belonging to one of the largest corporations in New England which buys a cheap grade of packing intended for 75 pounds pressure and uses it on superheated steam at 135 pounds. The chief can get nothing better. This tends to spoil his "point of view" somewhat.

As it is true that the engineer often considers his work a dull, monotonous drudgery, it is also very true that he is not wholly to blame. The layman is looking from a wrong "point of view" which cannot take in all the things that the engineer sees. If a fireman should call himself an "industrial chemist" in the hearing of some employers and some chief engineers, no matter how good a workman he may be, they will say that he is crazy and will fire him out of the plant. If he happens to be a young man, it will alter his "point of view" somewhat.

I claim that many engineers would take great pleasure in their work if they were allowed to do so by their employers. It will be found that those who are the most successful are those who are appreciated by their employers. This gives them added confidence and an opportunity to expand and develop in knowledge.

G. H. KIMBALL.

East Dedham, Mass.

Constant Receiver Pressure

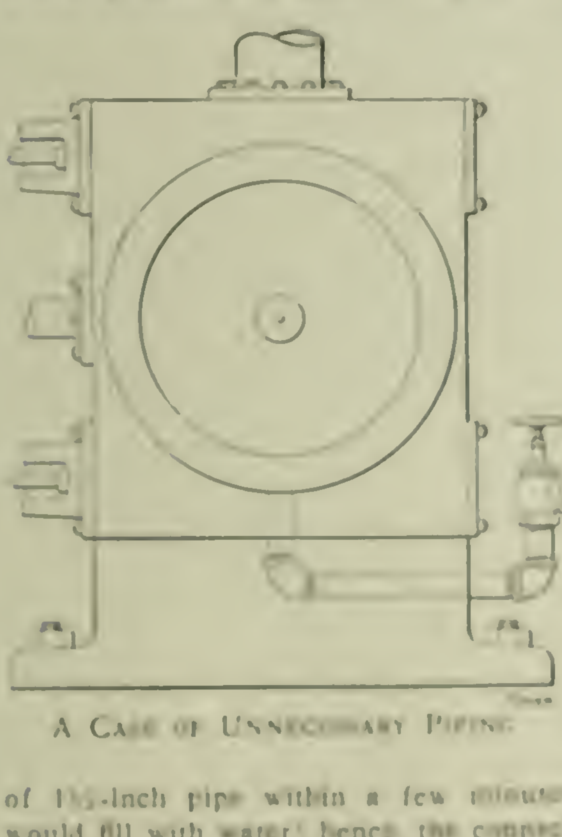
W. R. Beard, in the March 28 issue, gives it as his opinion that the cylinders of a compound engine should each do the same amount of work, and that it is better to maintain a constant receiver pressure under all loads.

In my opinion the receiver pressure should be such that the governor will revolve in its highest plane regardless of whether one cylinder does more work than the other or not. The engineer's problem is to keep the wheels turning with as little coal as possible, and it goes without saying that with the shortest cutoff in the high-pressure cylinder the steam consumption will be least.

Exeter, N. H. L. JOHNSON.

Unnecessary Clearance Loss

Under the above heading in POWER of April 25, S. Kirlin writes of the extravagant steam consumption of a four-valve engine equipped with relief valves and connected as shown in the accompanying illustration. I fail to see how this would affect the economy. The 3 feet



A CASE OF UNNECESSARY PIPING

of $1\frac{1}{2}$-inch pipe within a few minutes would fill with water; hence, the connection would add nothing to the clearance space, excepting the little space cleared after excessive pressure has opened the relief valve.

I take exception to Mr. Kirlin's method for two reasons: First, in a four-valve engine it could not be placed near enough to the end of the cylinder, if tapped into the bottom, to do any good during the period of compression, when it is most needed; second, it is likely to give trouble by leakage at the connections, after being used a few years.

I would much prefer to have relief valves tapped directly into the counterbore, through the side of the cylinder. This custom is adopted by most engine builders and gives universal satisfaction. If Mr. Kirlin placed his relief valves in an inverted position underneath the cylinder, he would find adjusting and repairing a disagreeable job, unless the cylinder was overhung and placed some distance above the floor.

GEORGE R. WILLIAMS.

Findlay, O.

Will an Isolated Plant Pay?

There has lately been much discussion of the above query in the columns of POWER. As I have had some experience with the encroachment of the central station upon the field of the operating engineer, I will add my quota to the general debate. Personally I am of the opinion that even diminutive isolated plants pay; and where they do not compare favorably with purchased power, I believe the fault to lie in the ignorance and stupidity of the attendant engineers. Some years ago I was hired to care for a 25-kilowatt motor which the central station had installed to supplant a little 20-horsepower Atlas slide-valve engine. The old engineer was afraid of electric power, and the superintendent of the mill was blissfully ignorant as to its simplicity and imagined that he had to have an experienced central-station man to operate the machine, which, by the way, was an old Edison bipolar motor, whose only apparent imperfection was a tendency of the commutator and the adjacent bearing to heat up. It ran, otherwise, very nicely; and the power soon became popular with management and operatives alike.

But early one morning the motor stopped; something was wrong with the transmission lines; and over the telephone came the cheering news that the power would be shut off for the rest of the day. Now the mill was behind with its orders, and a delay of even one hour's duration would be seriously felt. If all prospective patrons of power stations could have heard our manager's vehement denouncement of the service that day, it would not now be necessary to propound the above interrogatory caption.

To change from the motor to the engine took some little time, for additions had to be spliced to the main belt, and several pulleys had to be changed; but I was elated at the prospect of running the little engine, though I had up till then never seen it in service. They said that she had a habit of lying down on her job, but I was confident that I had located and eliminated its "book worm," for, while working with it when it lay idle, I had discovered the eccentric advanced so far that the port was over half open for lead. And my suppositions as to the performance of the engine were verified; it bore its load as steadily as the motor had carried it, and at a less expense. I am unable at this late date to give comparative costs of operation in detail, but I do remember well that the saving for the first month was $[illegible], for it was the means of bestowing upon me my first case of swelled head in engineering.

But the point I started in to illustrate and impress upon the reader is that the central station could never have endangered the engineer's job in this mill, had the engineer himself been competent. Hairs may be split as to the proper method of balancing charges, interest, etc., but it should not be forgotten that the engineer is the man who is responsible for the largest items of expense—such items as cannot be juggled by the central-station experts. If a plant is already installed in a building and the engineer loses his job through the crowding out of the central station, I am of the opinion that he deserves losing it. An excellent idea for those who would fight against the encroachments of the central station would be to unite into a society, and vote to levy assessments for the support of experts, whose duty it shall be to visit such plants as are threatened, and make sure that the encroachment is not warranted by the incompetency of the operating engineer.

C. HUGHES.

Saxonville, Mass.

Holly System for Draining Manifold

In answer to the question asked by Mr. Bopp as to the practicability of the Holly system for draining a manifold collecting drips from separators, reheaters, etc., I wish to say that the Holly system will work if Mr. Bopp will connect a $1\frac{1}{4}$-inch equalizing pipe from the header to the receiving tank or manifold, if it is large enough to be used as a receiver.

The riser should be $1\frac{1}{2}$- or 2-inch pipe, depending on the amount of condensation, and the separating tank should be 35 feet above the water line of the boilers. A check valve should also be placed at each boiler in the return line. The turns in the riser should be made by long bends and all valves should be gate or straight way. The vent pipe from the separating tank should be ½-inch with a good valve near the lower end and should connect with the exhaust pipe or heater. At the present time I am in charge as engineer in a plant using the Holly system under conditions similar to those outlined by Mr. Bopp.

J. C. H[illegible].

Hyattsville, Md.

Binding "Power"

I am much interested in the methods used by many in binding copies of POWER. This is how I do it. I got my idea from our daily report-sheet file. One day while in the superintendent's office I saw several catalogs which were made up of loose sheets and bulletins placed in substantial covers and held together by two pins or keys passing through the covers and through the holes in the back margin of the leaves. I found several sizes. Some, however, were just the size for such papers as POWER, *Practical Engineer, American Machinist* and other magazines of like dimensions. I selected a set of covers to fit POWER. Before binding the papers, I removed the covers, binding wires and advertising matter. Then I took the pages of reading matter out of each issue that I most desired to save, and punched holes in the back margin, using a templet and belt punch. I put them in place and then tightly bound them down.

As the book was made up of several magazines, I could not use the page numbers as printed, but numbered them from 1 to 700, which was the size of my file. An index was made of the names of the articles and their page numbers, and they were grouped under such heads as New Power Plants, Boiler Management, Boiler Tests and Testing Apparatus, Pumps, Condensers and Connections, Engine Design and Theory, Engine Management, Power Plant Management and Economical Operation, and Gas Engines. Some articles which contained matter coming under more than one head were listed under two or three heads. The list was then typewritten and pasted inside the front cover. The cost of this file was nothing except a little time. It is easily worth $5, perhaps more. A slip of paper pasted on the front cover gives the dates of the first and last number the file includes. My file covers six months.

One objection to binding the whole magazine is that where several papers are taken, there are often articles which are nearly the same, so that the file contains much duplicate matter. Such a method makes a bulky file and handling for reference difficult. I file only those articles which present a new thought or new phase of a subject or one that is of especial interest. Selections from several magazines makes quite a large volume. After reading the articles, I mark those I wish to save and mark their classification. Then when I am ready to do the binding I take the paper apart and remove the pages marked. These loose-leaf binders can be bought for a nominal sum, but I would advise going to the superintendent first. While there are very few dull pages between the covers of such magazines as POWER, *Electrical World, Practical Engineer* and others of the same nature, I do not like to waste time looking through several bulky volumes to find something on a certain subject.

J. CASE.

Hyattsville, Md.

Belt Lacing

In the February 28 number, Thomas Clark asks for information on belt lacing, and as there have not been many replies, I submit the following for his consideration:

Some of the sketches and descriptive material below I have written up in the past, and some of the illustrations shown I have copied from sketches found in a power-plant office in this city. None of the methods shown are considered fancy lacing, but for durability and efficiency they are all right.

The lacing shown in Fig. 1 is known as the hinge joint. It is all right to use on small pulleys at high speeds. Heavier work demands a joint of which Fig. 2 is an example. In making the joint shown in Fig. 2, lace the outside holes first; the pulley side of the belt will show four short and three long straight lines. Fig. 3 is a good all-round joint; the lacing is started at *A A* and finishes at *E E*.

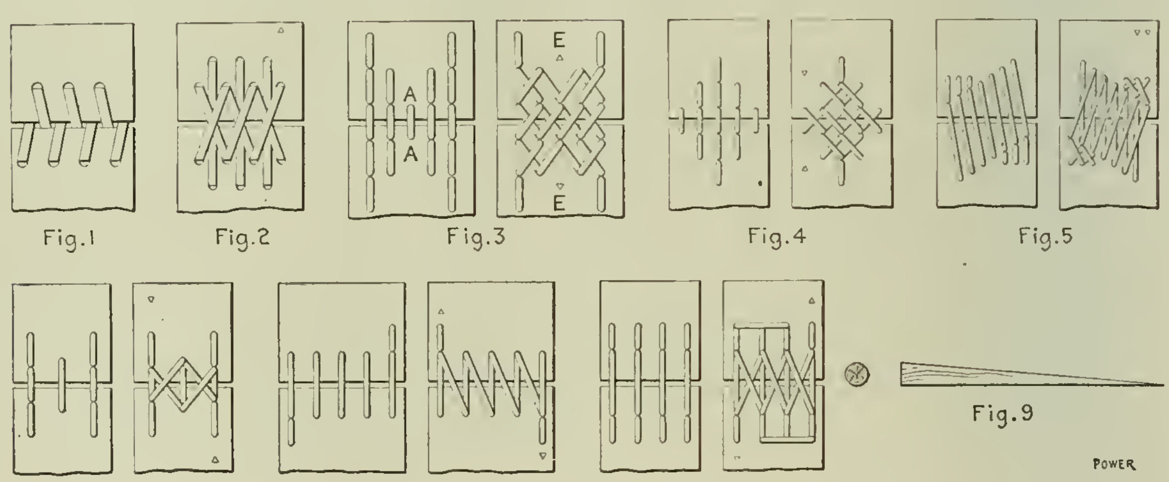


Fig. 1 Fig. 2 Fig. 3 Fig. 4 Fig. 5 Fig. 6 Fig. 7 Fig. 8 Fig. 9

Fig. 4 is often used and Fig. 5 is generally used on quarter-turn work. For small belts running at average speeds, use the method shown in Fig. 6. Figs. 7 and 8 are methods used for light and heavy work.

Fig. 9 is a valuable tool to have on hand when lacing belts. If the lace hole is too tight, it is an easy matter to insert the point of the tool in the hole and start the lace through, and if the tool is used carefully, it will not injure the belt.

Belt ends should be cut off squarely and the holes punched exactly opposite each other; the first row on one end should be opposite the first row on the other end, and so on. Many prefer to cement belt ends instead of lacing, but this has the disadvantage of rendering the taking up of stretch or slack a difficult matter.

JAMES E. NOBLE.

Toronto, Can.

Stopping a Pound

C. B. Smith's article in the April 25 issue on the reduction of lead and compression, induces me to tell how I increased the output and decreased the coal consumption.

Some time back I was employed in a plant which had one 26x48-inch single-eccentric noncondensing Corliss engine running 90 revolutions per minute. I was told when I took charge that the engine was very much overloaded and that it had a very loud pound but that I was not to let that worry me as there had been two men from the factory trying to locate the cause but had gone away in disgust.

The boilers carried 125 pounds of steam and whenever the steam went below 115 pounds the engine would hook up and the feed from the mill would have to be removed until 125 pounds could be maintained. The engine is five years old and has had two new crank pins.

I applied my indicator and found that the compression started when the piston had made two-thirds of the stroke, which carried it up to about 75 pounds. I cut the compression down one-half but still the pound was not affected. It could be heard for a block around. I had several indicator experts come out to take cards and they all claimed that the conditions could not be improved.

I noticed that the higher the boiler pressure the louder the knock, but still I thought the indicator showed a good admission line. I decided something must be done, so I gave my steam valve enough lap to let the piston travel about one inch before the valves opened. This stopped the pound instantly and the engine began to run as smooth as any engine in the city. The load that it previously carried with 125 pounds of steam can be carried nicely now with 100 pounds. Today the engine pulls the same load with a one-quarter cutoff that a three-eighths cutoff would not handle when I took charge. Thus by removing the compression the engine developed considerably more power.

J. W. DICKSON.

Memphis, Tenn.

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Some Argument Figures

When a central-station man undertakes to prove that an isolated plant has really no excuse for existence, or an isolated-plant man starts in on an exposition of central-station iniquities, or a gas-engine man presents a few "representative" comparisons with steam, or a—well, when figures are dug up by anybody in support a commercial contention those figures nearly always have a weird, unnatural aspect. The old, old characteristic of zealotry comes right to the front with forefeet stuck deep in the sand and hind feet combatively elevated. Sometimes, of course, the figurer has a forlorn hope to defend and his plight seems to demand heroic measures, but in many cases the bare, unbolstered truth is ample and would be infinitely more effective than a strained version.

An instance of the latter sort of "case" is printed in a recent number of the National Electric Light Association *Bulletin*. A storage-battery man, obviously with a view to presenting an invulnerable argument for the electric truck as against the gasolene truck, puts the cost of charging the battery at one cent per kilowatt-hour. Now, although that figure may be correct for the specific truck and generating plant to which he referred, we all know perfectly well not only that one cent per kilowatt-hour is not a representative figure but that there are not a dozen charging stations in the entire country that can generate their energy at that cost, let alone sell it for that. Where, then, is the sense in quoting this rate in a letter purporting to present a general comparison? The electric truck has so many real advantages over the gasolene-motor truck for use within the radius of any city in this country and the operating costs of the two are so nearly alike that a discussion of the latter is a waste of time and a forced favorable showing for the electric is more harmful than otherwise.

An amusing manifestation of inconsistency was made recently by our esteemed contemporary, the *Electrical Review and Western Electrician*. In an effort to show that isolated-plant costs are higher than central-station rates, the *Review* said editorially that a certain isolated plant powered by three gas engines of forty horsepower each showed the woefully high operating cost of something like three or four cents per kilowatt-hour. Some of the figures on which this contention was based were absurdly high and unrepresentative, but the amusing feature of the case is that the *Review's* editorial assertions and assumptions were completely refuted by the report of a producer-gas-power central station published in the same issue with the editorial. Although the isolated plant of one hundred and twenty horsepower could not get its cost below three cents, the central station, which was of only eighty horsepower capacity, easily showed less than two cents per kilowatt-hour!

The explanation is simple. The fixed charges and fuel cost ascribed to the isolated plant were abnormally high, whereas the fixed charges for the central-station plant were too low and the costs of administration, of transmitting power to the consumer and of keeping lines in condition were ignored.

An Uphill Fight

It is always desirable to know the actual cost of power being delivered from any plant. The advantages to be derived from this knowledge are too obvious to require explanation. It is frequently the lack of this information in convenient form which enables the central station to take over the plant and reduce the importance of the installation to one required merely for heating.

On the other hand, many a winning fight has been conducted using well arranged operating records as an argument, the significance of which the owner could not fail to appreciate. When the matter is one merely of dollars and cents, it is not so very difficult for the well informed engineer to carry the fight into the enemy's country and present his side of the case with some show of success.

There is another feature in this controversy, however, against which the operating engineer finds himself well nigh powerless to contend. This is one of high finance and does not relate to the actual money involved in any equal situation, but has more to do with the influences which control the different concerns requiring power. Moneyed men have affiliations which are not apparent on the surface; they play billiards at the same club, they go hunting and fishing together and have associations which result in mutual benefit to their concerns and which influence them to make decisions than is the outsider would indicate poor business judgment.

There is a group of buildings in the business district of a Western city, all taking central-station current and paying from five to eleven cents per kilowatt-hour. The chief engineer of this property, a capable man, has repeatedly brought to the attention of the owner that concentrating the several different heating plants necessary to take care of these buildings and generating current at a central point, using the exhaust steam for heating, would result in a net saving of twenty thousand dollars a year, but this has had no effect.

It would seem to the ordinary individual that the owner, although already a multimillionaire, could afford to take the trouble to pick up this extra money. It may easily be possible, however, that he can well afford to pay twenty thousand dollars a year for the privilege of sitting in the same game with the financial powers that be, the benefits of this being far greater (to him) than any petty saving which might accrue from changes recommended in his power department.

Against this sort of competition the operating engineer is working under a serious handicap. It illustrates the necessity of being wide awake in every respect and emphasizes the importance of having every scrap of available information at hand, ready to use at the proper time.

If the engineer knows, he has a chance. If he does not know, he is lost.

Slovenly Language and Salary

As we have said before, it is neither necessary nor to be expected that an engineer shall be a shining literary light or even a polished writer or speaker. It *is* important, however, that engineers should use language which means what they intend it to mean and refrain from inflicting upon more careful people a mongrel jargon unworthy of the intellect of a scavenger's assistant. Electrical engineers and artisans appear to be more reckless in this respect than other technicians. A common specimen of inaccuracy is the use of the word "kilowatt" alone when "kilowatt-hour" is meant. This is not inelegant, of course; it is merely an indication of either ignorance or carelessness. A kilowatt is very far from being a kilowatt-hour; it has to exist exactly sixty minutes before it represents a kilowatt-hour. It is highly probable that every reader of POWER knows that simple fact. It is almost as probable that many of them would unhesitatingly say that the cost of "current" is so many cents "per kilowatt," which is absolutely devoid of intrinsic meaning. Such a statement is usually understood by those familiar with the sloppy habit of speech, but that is no excuse for it. Current is neither power nor energy and power is not energy and has no value until it is combined with time to make energy. A similar carelessness characterizes references to horsepower, the word being used alone when "horsepower-hour" is meant.

The haphazard use of the word "field" is another common cause of confusion and mental irritation. In electrical engineering the word has exactly one meaning, no more. A field magnet is not a "field"; neither is a magnet coil, nor is a yoke ring, nor yet the exciting current. Nevertheless, all of these are frequently referred to as the "field" by men who either ought to or do know better. Both of these editorial pages could be filled with such citations.

Now there is no direct relation between exactness of speech and earning power, except in literary work. But there is a very strong indirect relation in all other kinds of skilled work. A man who is careful in one respect is very likely to be careful in others and, although it is not at all probable that the mere avoidance of the class of errors just referred to will produce an immediate increase in salary, it is almost certain that cultivating the habit of accuracy—not hair splitting—will ultimately increase one's value to his employer. A certain electrical engineer has a knowledge of his particular branch of the science that should enable him to earn a very large salary. The fact is, however, that he is so slovenly in the application of his knowledge that other men who have less are drawing larger salaries because of their greater accuracy. The inaccuracy of this man is reflected in his every utterance; "power" is always "current" with him; "reactance" is "self-induction," and everything about a machine except the armature and bearings is referred to indiscriminately as the "field"—and so on, down the whole list.

Absurdities of a School of Finance

The school of finance and commerce attached to one of our large universities requires neither scientific nor engineering knowledge from its students at entrance and does not teach either of these branches in its courses. It is, therefore, astonishing that last December the school required each student to separately select a manufacturing plant and make a series of reports thereon.

The first report was to be a careful study of the power plant, its installation, cost of production and cost of distribution, involving a number of drawings and a careful discussion of the suitability of the power equipment for the particular plant, comparing it with other possible sources of power.

This was to be followed by a second report dealing with the raw material, its storage and handling. A third report was to relate to superintendence, organization, management, labor payment and inspection, the students to suggest improvements and give reasons therefor. A discussion upon storing, shipping and selling the finished product was next in order, and, finally, a report was to be made upon "cost keeping."

The average student taking this course has no conception of foot-pounds; he could not define a horsepower, and would be unable to distinguish between boiler, engine and electrical horsepowers. He has probably never heard of a B.t.u. and knows absolutely nothing about the burning of fuel and the cost of power production. He has never installed a power plant; knows nothing of its power, and has not had sufficient experience to estimate depreciation. Yet his teacher, advancing these tasks, believes these facts can be obtained by merely "observing" and asking a few judicious questions.

How can an untrained mind observe fuel costs, capital costs, repairs, etc.? These are not elements of observation, but matters of experience and operation. Moreover, to whom shall the student address "a few judicious questions"? If he obtains any information at all, is he sure that his information is correct, and how can he check it? As to cost keeping, even though he has access to the books and accounts of a particular plant, it would require many weeks for him to go over the vouchers, for, say, the past year, and ascertain whether or not the accounts were properly and correctly kept. Yet this student is to advise as to the adaptability of the system of bookkeeping and to make suggestions as to improvements.

Such a course is incongruous and serves as a testimonial to the impracticability of those responsible for it. If certain schools would confine their efforts to the fields which they can legitimately cover and not attempt things out of their sphere, technical education would be better served and there would be fewer instances of its being subjected to ridicule by the practical man.

If a man tried to sell a 1000-horsepower Corliss engine for five hundred dollars, any of us would naturally ask him what was the matter with it. Why do not all of us do that when another man offers to sell cylinder oil at eleven cents a gallon?

When you reach the conclusion that you are too big for your job, it is a safe plan to take a vote and see how nearly unanimous that opinion is before you shake the dust of that job off your feet and tackle a bigger one.

After all is said and done, do you really believe there is any good excuse for a modern dynamo or motor to spark at the brushes? We don't.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Bucket Pump Defined

What is a bucket pump?

B. P. D.

A bucket pump is one in which the water passes through the piston as in the common house pump or as in the vertical single-acting jet-condenser air pump.

Vacuum in Simple and Compound Engines

Which requires the higher vacuum, a simple or a compound engine?

S. C. E.

There is no difference in the requirements except as regards economical operation, but it is customary to carry a higher vacuum with a compound than with a simple engine, as it is believed that it is more economical not to employ so high a vacuum in simple engines on account of the difference of temperature between the entering and the exhaust steam in the simple engine, which is much greater than in the low-pressure cylinder of the compound engine and nullifies the gain of a reduced back pressure by initial condensation.

Flared Tube Ends

Why are the tube ends of water-tube boilers flared instead of being beaded?

L. H. F.

Tubes are flared because it is easier, cheaper and just as effective as beading for the purpose intended.

Variation in Air Pump Piston Speed

Why does the piston of an air pump start off fast and slow down near the end of the stroke?

P. C. V.

In the independent steam-operated direct-acting air pump the cylinder at the beginning of the stroke contains a little water and also air at the pressure existing in the condenser. At the beginning of the stroke the piston meets with little resistance and, until the air is compressed to nearly atmospheric pressure, the motion of the piston is rapid. As the pressure in the cylinder rises the speed is reduced and is slowest as the water and the air are being forced out through the discharge valves.

Hydrostatic Test and Yield Point

If the bursting pressure of a boiler shell is 600 pounds per square inch and the yield point is one-half the tensile strength, what hydrostatic pressure would it be safe to apply? What is the rule for finding the yield point?

H. T. P.

If the bursting pressure is 600 pounds per square inch and the yield point is at one-half the tensile strength, then yielding will begin at 300 pounds pressure per square inch. With a factor of safety of five, the working pressure will be 120 pounds, and the hydrostatic test pressure applied 50 per cent. above the working pressure, or 180 pounds, 120 pounds below the yield point, is presumably safe. There is no rule for determining the yield point or elastic limit as it is called. It can only be determined by experiment.

Steam and Air Pressure

If a 4-inch air pipe should be connected to a 4-inch steam pipe with 110 pounds pressure in the air pipe and 100 pounds pressure in the steam pipe, what would happen?

J. J. H.

The air, if the pressure were kept at the original pressure, would force the steam back to the boiler whence it came and increase its pressure to that of the air unless relieved by the blowing of the safety valve.

High-speed Engine Valve Setting

If the valve on a high-speed automatic engine is out of adjustment, how may it be reset?

E. C. M.

In most high-speed automatic engines the only valve setting the engineer can do is that of adjusting the length of the valve stem. The valves are set by lead, which means that the lead is made right for each end of the cylinder. Usually a little more is given on the head than on the crank end.

Gas-engine Efficiency

What is the heat efficiency of a producer-gas engine of a few hundred horsepower?

W. T. McN.

From about 22 to about 27 per cent., according to size and condition.

Steam Table Difference

In the last edition of "Kent's Pocketbook" the value for the latent heat of steam at 212 degrees Fahrenheit is given, in a table compiled by Marks & Davis, as 970.4 B.t.u. The value of 966 is the one I have seen most frequently used. Which is the correct value? Which value is used in engineering work where accuracy is desired?

C. D. H.

Recent investigation has shown that the total heat of saturated steam as given in the old tables was too low, and both the Marks-Davis and the Peabody tables have been revised in accordance with the new values. The Marks-Davis tables are used in this office. Peabody's new value for the latent heat of steam at 212 degrees is 969.7, the difference between this value and that given in the Marks-Davis tables is largely due to the fact that Professor Peabody uses for the value of the B.t.u. the amount of heat necessary to raise a pound of water one degree at 62 degrees, while Professors Marks and Davis use the average amount of heat required to change a pound of water one degree through the entire range from 32 to 212.

The Best Size of Wire

How can I determine the best size of wire to use in a long power circuit?

C. T. McK.

From the purely mathematical point of view, the greatest economy is obtained when the value of the energy lost in the line annually is equal to the interest and depreciation charges against the cost of the line. There are practical considerations, however, which cannot be ignored. If the drop in the line is excessive, the voltage regulation at the far end will not be satisfactory, induction motors will not operate properly and it will be difficult to attain satisfactory results from incandescent lamps because of the variations in candlepower. If the line is an addition to an existing system, the question of regulation takes first place; if it is a question of laying out a new transmission line or building the feeder system of a new plant, maximum operating economy comes first, because the matter of regulation in such cases can usually be provided for by means of special apparatus. The interest and depreciation on such apparatus should be added to that on the line in figuring the maximum economy conditions.

Refrigeration Department

Principles and operation of ice making and refrigerating plant and machinery

Capacity of Ammonia Compressors

By F. E. Matthews

Since the efficiency of ammonia compressors is subject to wide variations, both through diversity of design and diversity of operating conditions to which the same machine is often subjected, the efficiency of the individual compressor should be determined under its own operating conditions. This can be accomplished most accurately by determining the quantity of refrigerating fluid actually passing through the system and comparing this amount with the apparent amount computed from the displacement of the compressor.

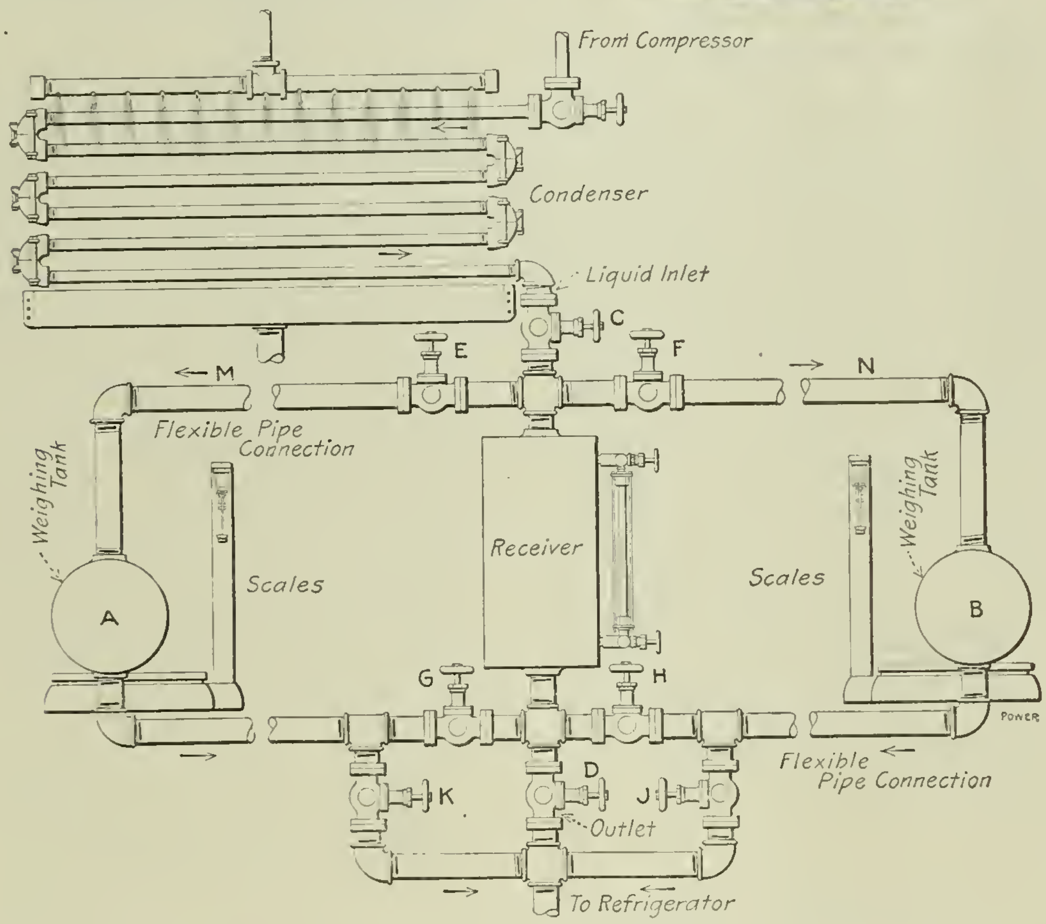


Fig. 1. Arrangement of Piping for Weighing Ammonia

The best way for determining the amount of liquid refrigerant is to weigh it. Fig. 1 represents a condenser, a pair of weighing tanks and their connections. For testing, crosses are inserted in the inlet and outlet lines, and valves and additional pipes are attached as indicated. When using the weighing tanks, the outlet valve *D* is closed or blanked off and, as the valves in the new connections are closed, the liquid refrigerant collects in the receiver. The weighing tank *A* is filled by opening valves *E* and *G*, after which valve *G* is closed and the gross weight of the tank and its contents is determined. The weight of the refrigerant is then found by subtracting the net weight of the tank and the liquid in the bottom connections. While the liquid in tank *A* is being weighed, tank *B* is supplying the cooler through valve *J*. Alternate filling and emptying of the two tanks allow the operation of the plant to proceed without interruption. When employing this method for weighing the refrigerating liquid, it is necessary that the pipes connecting with the weighing tanks be sufficiently long to insure flexibility to the system. The liquid level should never be allowed to rise to the pipes *M* and *N*, as any liquid other than that vertically over the drums will not be weighed correctly.

Assume that a test has been conducted under standard conditions and it has been determined that *X* pounds of anhydrous ammonia are evaporated per hour. The number of heat units required to cool a pound of the liquid is

$$S\ (t_1 - t_2) = 1\ (90 - 0) = 90\ B.t.u.$$

The heat units available from the evaporation of one pound of ammonia are

$$R_{B.P.} - S\,(t_1 - t_2) = 555.5 - 90 = 465.5\ B.t.u.$$

The amount of anhydrous ammonia required per ton per minute is

$$\frac{200}{R_{B.P.} - S(t_1 - t_2)} = \frac{200}{465.5} = 0.42964\ pound$$

which is equivalent to 25.778 pounds per hour or 618.7 pounds per day of 24 hours; where

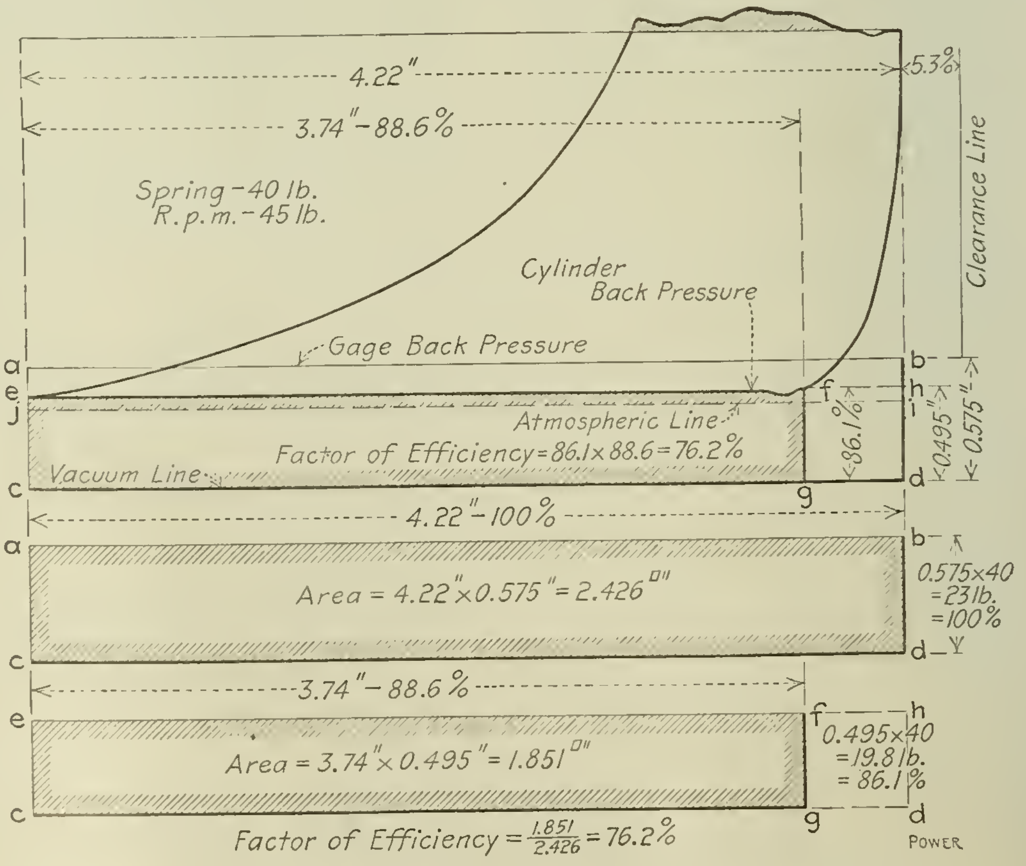


Fig. 2. Graphical Method for Determining Efficiency

[illegible]

S = Specific heat of liquid ammonia;
t_1 = Temperature of the liquid ammonia;
t_2 = Temperature of the ammonia vapor corresponding to a back pressure of 15.67 pounds gage;
$h\,p\,l$ = Latent heat of vaporization of ammonia at back pressure, in this case zero degrees Fahrenheit;
200 = Number of heat units per minute corresponding to one ton of refrigeration per 24 hours.

If, for example, it is found by test that 3000 pounds of liquid ammonia per hour pass through a refrigerating system, the compression unit of which is a 10x18-inch double-acting compressor running at 45 revolutions per minute under standard conditions, the cooling effect produced is found to be

$$\frac{3000}{25.[illegible]} = 116.17 \text{ tons}$$

The capacity apparently developed is computed from the displacement per minute of the compressor piston. This is represented by the expression

$$D = \frac{\frac{\pi}{4} \times d^2 \times l \times 2 \times [illegible]}{1728}$$

$$D = \frac{0.7854 \times [illegible] \times [illegible] \times 2 \times 45 \times [illegible]}{1728}$$

$$= 163.13 \text{ cubic feet}$$

per minute, where

D = Piston displacement in cubic feet per minute;
d = Diameter of piston in inches;
l = Length of stroke in inches.

The cooling effect per cubic foot of ammonia gas passed through the compressor is found from the expression

$$C = \frac{h\,p\,l - S\,(t_1 - t_2)}{V}$$

$$C = \frac{[illegible] - [illegible]\,([illegible] - [illegible])}{[illegible]} = [illegible] \text{ B.t.u.}$$

where,

C = Cooling effect per cubic foot of ammonia;
V = Volume of one pound of the ammonia gas passing through the compressor, cubic feet.

Hence the apparent tonnage capacity is

$$\frac{D \times C}{200} = \frac{163.13 \times [illegible]}{200} = [illegible] \text{ tons}$$

Obviously, the efficiency of the compressor can be approximated by dividing the probable cooling effect, as determined by calculation based on the properties of the liquid, by the tonnage computed from the apparent displacement per minute in cubic feet, as calculated from the dimensions of the compressor, hence,

$$E = \frac{[illegible]}{[illegible]} = [illegible] \text{ per cent.}$$

In the majority of cases the tonnage capacity of the system is required with reasonably close accuracy, but it is often impracticable to weigh the ammonia. In such cases a somewhat less accurate estimate of the efficiency of the compressor can be made with the assistance of an indicator. For all practical purposes the weight of ammonia gas may be considered proportional to its absolute pressure, and within narrow limits the amount of refrigeration represented by a cubic foot of ammonia gas will likewise be proportional to its absolute pressure. From this it follows that anything tending to reduce either the number of cubic feet of gas that a compressor handles or lower the pressure at which it is handled, proportionately reduces the capacity of the compressor. Graphically this is illustrated and the actual amount of the reduction in capacity is determined as follows:

Having taken an indicator diagram, such as that shown in Fig. 2, draw the lines *a b* and *c d* representing, respectively, the actual back pressure in the suction pipe, as indicated by a gage, and the line of absolute vacuum. Next, determine *f*, the point at which the suction valve first opens to admit cold gas to the compressor cylinder. This point is the intersection of the admission line *e f* and the reëxpansion line forming the heel of the diagram. Draw a vertical line *f g* through this point and other vertical lines *e c* and *b d* through the ends of the diagram. These horizontal and vertical lines form two rectangles. The larger one *a b d c* incloses a smaller one *e h d c* which, in turn, is made up of two still smaller rectangles *e f g c* and *f h d g*.

In the case under consideration the cylinder back-pressure line *a b* scales 4.6 pounds above the atmospheric line *j i*, making the absolute back pressure within the cylinder approximately 19.6 pounds. The observed suction pressure in the suction line is 8 pounds gage or approximately 23 pounds absolute, of which the 19.6 pounds is 86 per cent. This means that on account of the fall in back pressure, in passing through the suction valves and pits in entering the compressor cylinder, each cubic foot of gas represents only 86 per cent. as much ammonia by weight, as it would had no resistance been encountered and the cylinder back pressure had been 23 pounds, the same as in the suction line.

The diagram shows that the compressor from which it was taken had excessive clearance. Due to the reëxpansion of the high-pressure gases remaining in the clearance spaces, the opening of the suction valve is delayed until the piston has reached point *f* in the suction stroke. Cold returning ammonia gas can enter the compressor cylinder only during the time the piston is passing from *f* to the end of its stroke. The full length

TABLE 2. DISPLACEMENT *D* IN CUBIC FEET PER FOOT OF PISTON TRAVEL FOR VARIOUS-SIZED CYLINDERS.

Cubic Feet per Inch of Piston Travel.					Cubic Feet per Foot of Piston Travel.				
Diameter, Inches and Fractions of Inch.	0 Inch.	¼ Inch.	½ Inch.	¾ Inch.	Diameter, Inches and Fractions of Inch.	0 Inch.	¼ Inch.	½ Inch.	¾ Inch.
1 ...	0.00045	0.00071	0.00102	0.00139	1 ..	0.00540	0.00852	0.01224	0.01668
2 ...	0.00182	0.00230	0.00284	0.00344	2 ..	0.02184	0.02766	0.03408	0.04128
3 ...	0.00409	0.00480	0.00557	0.00639	3 ..	0.04908	0.05760	0.06684	0.07668
4 ...	0.00727	0.00821	0.00920	0.01025	4 ..	0.08724	0.09852	0.11040	0.12300
5 ...	0.01136	0.01253	0.01375	0.01503	5 ..	0.13632	0.15036	0.16500	0.18036
6 ...	0.01636	0.01775	0.01920	0.02071	6 ..	0.19636	0.21300	0.23040	0.24852
7 ...	0.02227	0.02389	0.02557	0.02730	7 ..	0.26724	0.28668	0.30684	0.32760
8 ...	0.02909	0.03094	0.03284	0.03480	8 ..	0.34908	0.37128	0.39408	0.41760
7 ...	0.03682	0.03889	0.04102	0.04321	9 ..	0.44184	0.46668	0.49224	0.51852
10 ...	0.04545	0.04775	0.05011	0.05252	10 ..	0.54540	0.57300	0.60132	0.53024
11 ...	0.05500	0.05752	0.06011	0.06275	11 ..	0.66060	0.69024	0.72132	0.75300
12 ..	0.06545	0.06821	0.07102	0.07389	12 ..	0.78540	0.81850	0.85224	0.88668
13 ...	0.07681	0.07980	0.08283	0.08593	13 ..	0.92172	0.95760	0.99396	1.03116
14 ...	0.08908	0.09229	0.09556	0.09888	14 ..	1.0689	1.10748	1.14672	1.18556
15 ...	0.10226	0.10570	0.10920	0.11275	15 ..	1.2271	1.26840	1.31040	1.35300
16 ...	0.11636	0.12002	0.12374	0.12752	16 ..	1.3963	1.44024	1.48488	1.53021
17 ...	0.13135	0.13525	0.13919	0.14320	17 ..	1.5762	1.62300	1.67028	1.71840
18 ...	0.14726	0.15138	0.15556	0.15979	18 ..	1.7671	1.81650	1.86672	1.91748
19 ...	0.16408	0.16843	0.17283	0.17729	19 ..	1.9689	2.02116	2.07396	2.12748
20 ...	0.18181	0.18638	0.19101	0.19570	20 ..	2.1817	2.13656	2.29212	2.34840
21 ...	0.20044	0.20524	0.21010	0.21501	21 ..	2.4053	2.46288	2.52120	2.58012
22 ...	0.21998	0.22501	0.23010	0.23524	22 ..	2.6397	2.70072	2.76120	2.82280
23 ...	0.24044	0.24569	0.25100	0.25637	23 ..	2.8852	2.94828	3.01200	3.07644
24 ...	0.26180	0.26728	0.27282	0.27842	24 ..	3.1416	3.20736	3.27364	3.34104
25 ...	0.28407	0.28978	0.29555	0.30137	25 ..	3.4088	3.47736	3.54666	3.61644
26 ...	0.30725	0.31319	0.31918	0.32523	26 ..	3.6870	3.75828	3.83016	3.90276
27 ...	0.33134	0.33750	0.34373	0.35000	27 ..	3.9760	4.05000	4.12476	4.20000
28 ...	0.35634	0.36273	0.36918	0.37568	28 ..	4.2760	4.35276	4.43016	4.50816
29 ...	0.38225	0.38886	0.39554	0.40227	29 ..	4.5870	4.66632	4.74648	4.82524
30 ...	0.40906	0.41591	0.42281	0.42977	31 ..	4.9081	4.99092	5.07372	5.15724

TABLE 3. CUBIC FEET *F* AND POUNDS *P* OF AMMONIA PER TON OF REFRIGERATION PER 24 HOURS.

W = Weight per cubic foot. BP = Back pressure.			Head Pressure, Condenser or Gage Pressure and Corresponding Temperature.											
			100 Pounds. 63.5 degrees	110 Pounds. 68 degrees	120 Pounds. 72.6 degrees	130 Pounds. 77.4 degrees	140 Pounds. 80.3 degrees	150 Pounds. 83.8 degrees	160 Pounds. 87.4 degrees	170 Pounds. 90.8 degrees	180 Pounds. 93.8 degrees	190 Pounds. 96.9 degrees	200 Pounds. 100 degrees	Temperature, Degrees Fahrenheit.
W	0.0556	P	0.4159	0.4199	0.4240	0.4284	0.4310	0.4343	0.4376	0.4408	0.4440	0.4470	0.4501	—28.5
BP	0	F	7.482	7.551	7.626	7.703	7.761	7.812	7.870	7.929	7.986	8.041	8.095	
W	0.0133	P	0.4122	0.4160	0.4202	0.4243	9.4271	0.4308	0.4335	0.4366	0.4397	0.4437	0.4458	—17.5
BP	5	F	5.636	5.675	5.732	5.790	5.826	5.878	5.914	5.970	5.999	6.039	6.081	
W	0.0910	P	0.4093	0.4130	0.4171	0.4204	0.4237	0.4271	0.4302	0.4332	0.4363	0.4392	0.4423	— 8.5
BP	10	F	4.502	4.543	4.587	4.625	4.662	4.698	4.733	4.766	4.799	4.833	4.865	
W	0.1083	P	0.4068	0.4106	0.4145	0.4186	0.4211	0.4244	0.4276	0.4288	0.4336	0.4365	0.4394	— 1
BP	15	F	3.756	3.791	3.827	3.866	3.889	3.918	3.948	3.975	4.003	4.030	4.058	
W	0.1258	P	0.4040	0.4077	0.4116	0.4158	0.4182	0.4214	0.4245	0.4275	0.4304	0.4333	0.4362	5.66
BP	20	F	3.211	3.241	3.272	3.305	3.324	3.350	3.375	3.398	3.422	3.444	3.467	
W	0.1429	P	0.4025	0.4062	0.4102	0.4140	0.4167	0.4198	0.4229	0.4258	0.4287	0.4316	0.4345	11.5
BP	25	F	2.819	2.843	2 870	2.898	2.916	2.938	2.959	2.980	3.000	3.020	3.040	
W	0.1600	P	0.4013	0.4049	0.4088	0.4128	0.4152	9.4184	0.4213	0.4243	0.4273	0.4300	0.4329	16.8
BP	30	F	2.507	2.530	2.555	2.580	2.600	2.615	2.633	2.653	2.671	2 687	2.706	
W	0.1766	P	0.3991	0.4028	0.4066	0.4105	0.4130	0.4161	0.4188	0.4220	0.4249	0.4277	0.4305	21.7
BP	35	F	2.260	2.280	2.302	2.925	2.338	2.356	2.373	2.390	2.406	2.422	2.443	
W	0.1941	P	0.3984	0.4020	0.4058	0.4098	0.4122	0.4153	0.4183	0.4211	0.4240	0.4269	0.4296	26.1
BP	40	F	2.052	2.071	2.090	2.111	2.123	2.139	2.155	2.175	2.185	2,200	2.214	

$$F = \frac{144 \times 2000}{W\,[1440\,R_{B.P.} - S\,(t_1 - t_2)]}$$

$$P = \frac{144 \times 2000}{1440\,R_{B.P.} - S\,(t_1 - t_2)}$$

of the diagram represents the full stroke of the piston and a displacement of 100 per cent. of the full volume of the cylinder. In this case, however, 11.4 per cent. of the volume is occupied by reexpanding hot gas which reduces the amount of cold gas that can enter the compressor to 88.6 per cent. In other words, the actual displacement of the compressor in cubic feet is only 88.6 per cent. of the apparent displacement, based on the cylinder dimensions only.

Now, the 88.6 per cent. of the gas discharged weighs only 86.1 per cent. as much as indicated by the pressure gage on the suction line, so that the number of pounds of ammonia actually discharged by the compressor was only 88.6 × 86.1 per cent. of what would be discharged by a compressor in which there is no clearance or resistance offered to the gas in passing through the suction valves.

Graphically, the length *a b* of the large rectangle *a b d c* represents the compressor cylinder volume, and the hight *b d* the absolute suction-gas pressure in the return line outside the compressor. The product of *a b* and *b d*, or cubic feet and weight per cubic foot—since the weight of a gas depends upon the absolute pressure—represents the apparent displacement per stroke in pounds.

The length *e f* of the small rectangle *e f g c* represents that part of the compressor-cylinder volume filled by the cold gas; and the hight *g f*, the absolute suction pressure within the cylinder. The product of *e f* and *g f* represents the *actual* displacement per stroke in pounds, or the apparent displacement minus the reëxpanded hot gas represented by the rectangle *f h d g*.

The displacement efficiency of the compressor is represented by the ratio of the area of the small to the large rectangle and will be found to be numerically equal to 70.2 per cent, regardless of the units employed in measuring the areas.

$$\frac{4.74 \times 0.405}{4.[illegible] \times 0.475} = \frac{1.851}{2.4[illegible]} = 76.2 \text{ per cent.}$$

or using pounds to per cent.

$$\frac{[illegible] \times 88.6}{[illegible] \times 100} = 76.2 \text{ per cent.}$$

The apparent number of cubic feet of ammonia gas discharged per minute by a 19x38-inch double-acting compressor running at 45 revolutions per minute has already been found to be 501.15. If it is found, by the indicator-diagram method just described, that the displacement efficiency is 70.2 per cent., the actual number of cubic feet discharged will be

0.762 × 501.15 = 427.50 *cubic feet*

which, multiplied by the number of British thermal units of refrigeration represented in each cubic foot of ammonia gas actually displaced gives the total cooling effect of the machine expressed in British thermal units per minute. This quantity divided by 200 reduces the capacity to tons per 24 hours. Under standard conditions the number of British thermal units per cubic foot was found above to be 51.50, and, under standard conditions, the tonnage capacity of the compressor under consideration when operating at the determined efficiency of 70.2 per cent. is

$$\frac{501.15 \times 0.762 \times 51.50}{200} = 1[illegible] \text{ tons}$$

per 24 hours.

To expedite the figuring of capacities, not only under standard but also under other conditions, the accompanying tables of constants have been derived. To determine the tonnage capacity of a double-acting compressor of any size operating at any piston speed and under various conditions of head and back pressure it is necessary only to substitute appropriate values from these tables in the following equations.

Since 200 B.t.u. per minute is the equivalent of one ton per 24 hours, the tonnage capacity *T* of a compressor will be equal to the number of cubic feet of gas *D* actually displaced per minute multiplied by the number of British thermal units of cooling effect *H* available per cubic foot of gas actually displaced, divided by 200. But the actual displacement is equal to the apparent displacement *D* (figured from the dimensions and speed of the machine) multiplied by *E*, the displacement efficiency of the compressor, which may be assumed either from knowledge of the design, calculated from the indicator diagrams or determined by weighing the liquid refrigerant according to the method already described. Expressed as an equation, this becomes

$$T = \frac{DHE}{200}$$

or since $\frac{200}{H}$ represents the cubic feet required per ton

$$T = \frac{DE}{\text{cubic feet required per ton}}$$

but

$$D = \frac{[illegible]}{[illegible]} = [illegible]$$

$$\text{[illegible] piston speed [illegible]}$$

from which the displacement can be computed readily when the diameter of the cylinder and the piston speed are known. The piston speed of a double-acting compressor of a given length of stroke, when operating at a given number of revolutions per minute, may be determined directly from Table 1.

It is also obvious that the apparent displacement is equal to the displacement per foot of piston travel multiplied by the number of feet of piston travel per minute. Table 2 gives this displacement per foot of piston travel, and Table 3 the number of cubic feet of ammonia that must be actually displaced per minute by the compressor to produce refrigeration at the rate of one ton per 24 hours.

Example: The capacity of a 19x38-inch double-acting compressor of 78.15 per cent. displacement efficiency operating at 45 revolutions per minute under 180 pounds head and 10 pounds back pressure is

$$T = \frac{\left(\begin{array}{c}\textit{Piston speed from}\\ \textit{Table 1} = 285\\ \textit{feet per minute}\end{array}\right) \times \left(\begin{array}{c}\textit{Apparent displacement}\\ \textit{per foot of piston}\\ \textit{travel from Table 2}\\ = 1.[illegible]\ \textit{cubic feet}\end{array}\right) \times \left(\begin{array}{c}\textit{Displacement efficiency of compressor} = [illegible]\end{array}\right)}{\textit{Cubic feet per minute per ton per 24 hours from Table 3} = [illegible]} = [illegible] \text{ tons}$$

A Case of Frosting

Of two vertical single-acting inclosed-crank-case ammonia compressors, one gives trouble by frosting all over the base of the crank case and water jacket; the other does not frost. A [illegible]-inch pipe with a valve connects the base of the compressor that frosts to the suction line. The valve is left open to prevent the accumulation of pressure in the crank case which forces the oil out through the shaft stuffing box. If the boxes run tight enough to prevent this, it heats. The frost melts off when the valve is closed. What causes the trouble? Does the high-pressure gas get by the piston into the base?

It would appear that liquid ammonia is entering the base of the frosting compressor through the pipe connecting the base to the suction line. This would happen if the connection is made into the bottom of the suction line and the system is so operated that the latter is covered heavily with frost at the point where the connection is made. A small amount of liquid ammonia is sufficient to keep the base of a machine frosted over for a long time, as the absorption of heat through the heavy cast-iron walls is slow and the coating of frost offers still further resistance.

The necessity of running with the valve in the connecting line open is probably due to leakage of high-pressure gas by the piston into the base.

A new set of piston rings carefully fitted might help some, but the better remedy is to so place the equalizing pipe from the base to the suction that any liquid running at the bottom of the pipe cannot drop into the base of the machine. The equalizing pipe is absolutely necessary.

It may be that the suction line to the other compressor is so located that the liquid cannot reach it. If the equalizing line to the second compressor is attached in the same way, the liquid would also drop into the base of this compressor and cause frosting.

New Power House Equipment

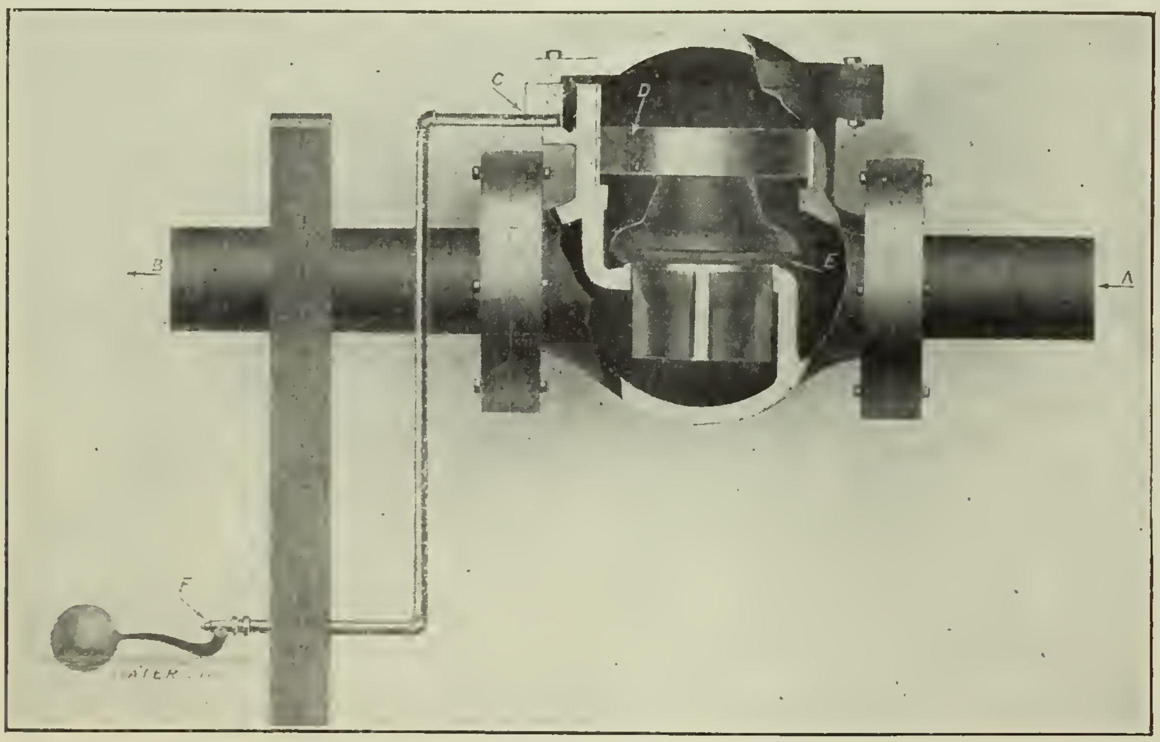
What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

"Hydromatic" Water Valve

The "Hydromatic" water valve consists of a cast-iron body, a cast-iron cover plate and a brass plunger which is made in two parts. The lower part is screwed into the upper and holds a rubber ring *E*—or where required for hot water, a lead ring—which seats in the valve body, making a tight shutoff when the plunger is down.

The brass plunger travels in a brass bushing, and is fitted into it with a piston fit, requiring no packing. Small tapered holes *D* are drilled into the top of the plunger with a capacity for building up head pressure according to the size of the valve. Into the head of the valve above the plunger is tapped a ¼-inch hole, and from this a ¼-inch pipe leads to a pilot valve *F*, at the water level. This valve is controlled by the operation of a seamless-copper 5-inch float.

When the water in a tank reaches the required hight shown by the location of the pilot valve, the elevation of the float closes the valve and shuts off the vent through the ¼-inch pipe. A head pressure is thereby built up through holes in the top of the plunger, strong enough to force the plunger down and shut off the flow of water through the valve. As water is withdrawn from the tank, permitting the float to drop, the pilot valve *F* is opened and the head pressure on the plunger is released just enough to permit the flow of water to restore sufficiently the required level in the tank. The water entering at *A* and passing between the rubber ring and valve seat, passes down around the ribbed valve to the outlet.



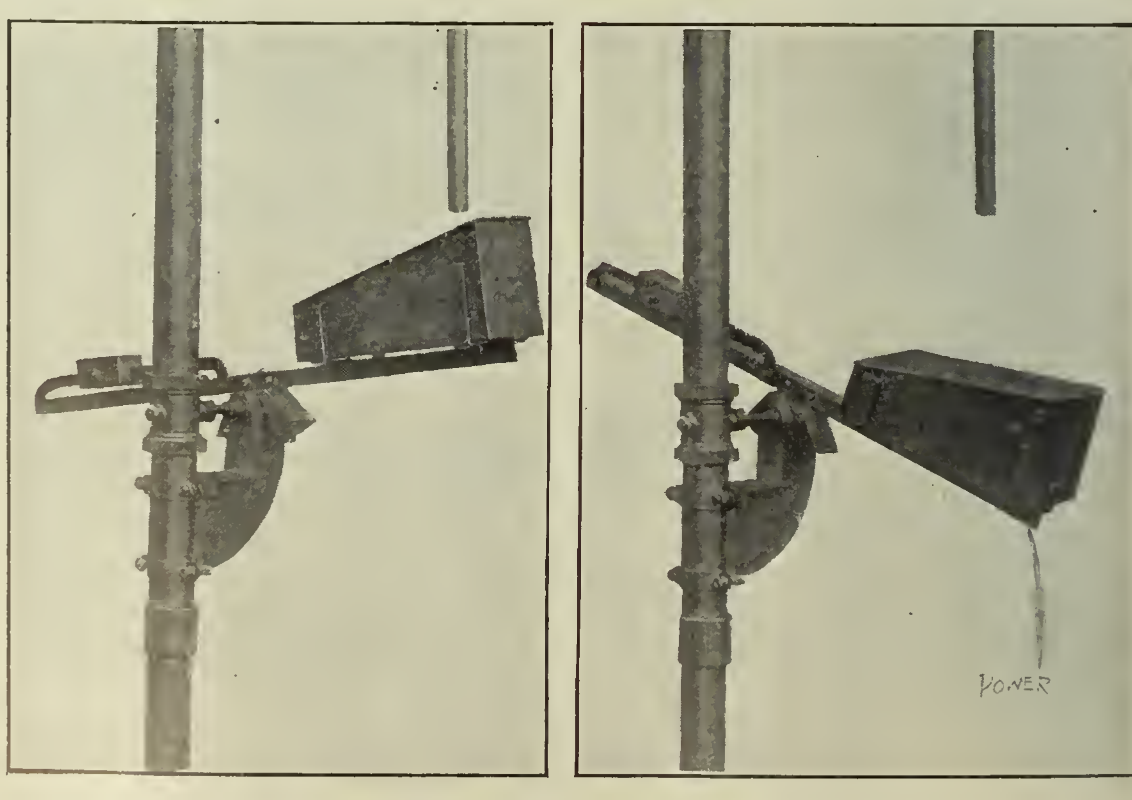
Showing Details of the Hydromatic Water Valve

The valve is very sensitive in its action and permits a small inflow of water or a large inflow of the total capacity of the intake pipe, according to the amount of water withdrawn from the tank.

This valve can be used for maintaining water level in tanks, vats, laundry tubs, cisterns, open feed-water heaters, water towers and for a quick opening or closing of a large water main. This may be accomplished by closing the valve in the ¼-inch pipe, which instantly shuts off the flow of water in the main pipe; the opening of the valve in the ¼-inch pipe instantly starts the flow of water. The shutoff valve in this ¼-inch pipe may be placed any distance from the hydromatic value, as long as the hight of the ¼-inch pipe above the hydromatic valve does not create a water pressure per square inch greater than that exerted by water in the main pipe. This device is manufactured by the Cleveland Steel Tool Company, Cleveland, O.

Miller Automatic Water Controller

This device has been designed to economically handle the distilled water in an ice plant and assists in making pure ice, free from oil and the objectionable red core. The device is illustrated and its action described herewith. A small amount of waste water from the skimmer fills the pan, causing it to drop down a few inches and rotate the valve stem, thus opening the valve.



Showing Automatic Water Controller in Two Positions

A shaft is made to slip on over the end of the valve stem (locked there by a pin and slot), and also serves as a pivot on which the rocker arm rotates. On one end of the rocker arm is an adjustable weight and on the other end a small pan with a hole in the bottom near the outer end. This allows the water to flow from the reboiler into the storage tank.

After the water in the reboiler has been lowered an inch or so, the pan returns to its normal position by the action of the counterweight.

This closes the valve, which remains closed until the reboiler is again full and goes to skimming, thus causing the hot distilled water to stay in the cooling coil long enough to get the full benefit of the cooling water. The process is repeated every few minutes.

The device is free from complicated mechanism and can be installed anywhere between the reboiler and the storage tank and keeps the water sweet and the ice clear.

It is manufactured by L. G. Miller & Sons, 237 Gordon street, Jackson, Tenn.

Bradford Automatic Valves

The principle upon which these valves operate is perhaps most clearly shown in the section of the nonreturn boiler stop valve, Fig. 1. Upon a spider fixed in the valve passage is carried a hollow stationary piston. Upon this piston slides freely a cylinder carrying the valve. The space inside the piston is connected to the boiler side of the valve seat through the port shown, and a small screw valve, the chisled head of which is accessible from the outside of the valve body, is provided to control the passage. The valve is not attached to the valve stem, the flattened end of which simply bears upon the top of the cylinder upon the valve disk.

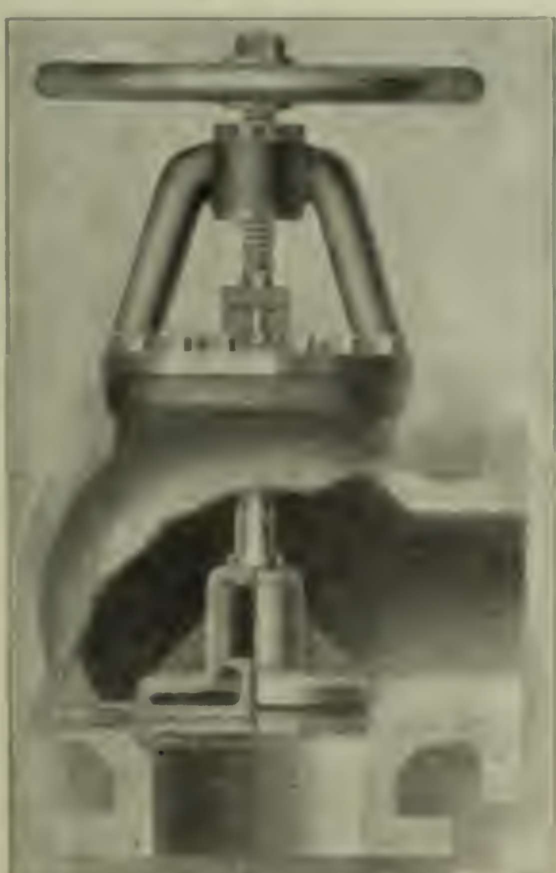


FIG. 1. BRADFORD AUTOMATIC NONRETURN BOILER STOP VALVE

When the stem is withdrawn the full boiler pressure inside the piston causes the valve disk to follow the stem upward, opening the passage for the flow of steam upward through the valve and into the main. Should the flow be reversed, as in case of an accident to the boiler, the valve will be carried to its seat by the backward flow, but will be prevented from slamming by the cushioning action of the steam in the cylinder, which, escaping slowly through the controlled passage, allows the valve to settle quietly to its seat.

In Fig. 2 is shown a protector valve, used to shut off automatically the flow

FIG. 2. BRADFORD PROTECTOR VALVE

of steam from a boiler or battery of boilers in case of a break in the main beyond. The valve is normally held open by the system of compound levers, but in case the velocity of the steam exceeds the normal by a predetermined amount, about 2000 feet per minute for the usual case, the force of its impingement upon the saucer-shaped attachment hung to the valve disk will carry that disk to its seat. The pressure upon the top of the disk will be reduced by the expansion of the steam in the cylinder, and the controlled entrance of steam to this chamber will allow the valve to seat quietly. The same principle is shown applied in a combined atmospheric-relief and back-pressure valve in Fig. 3. Here steam at the low pressure, or air in the case of an atmospheric relief, is admitted to the cylinder and by expansion holds the valve from slamming in the case of closing or by its compression in the case of sudden opening, and by its resistance to change of volume prevents chattering at any phase of the valve's operation.

In addition to the controlling feature the compensating chamber forms a central guide of ample area for the valve disk, even when used in a horizontal position. The chamber is bronze lined, and the seat is of government bronze and

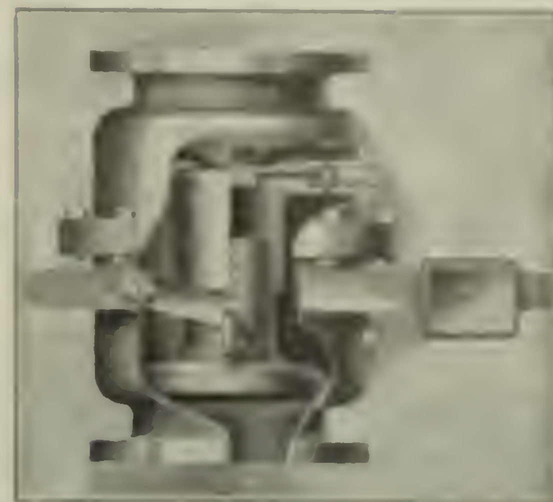


FIG. 3. COMBINED ATMOSPHERIC RELIEF AND BACK-PRESSURE VALVE

interchangeable. They are made by the Jno. B. Perkins Company, 141 Milk street, Boston, Mass.

Perolin Boiler Compound

This boiler compound has no chemical action on the water, but works its way through the cracks in the scale and along the metal of a boiler until the scale drops off and the boiler metal is coated with a film of the compound, to which, it is stated, no scale-forming sediment of any kind can cling.

The compound does not dissolve the scale, but only removes it from the iron so that it can be blown out through the blowoff or washed out when cleaning boilers. It also holds the scale-forming sediment in solution.

Water does not contain the same scale-forming sediment throughout the year, but continually changes with the season, climate and locality, but iron throughout the world is always the same. Therefore, there is a constant, known quantity with which to deal and the manufacturers have, it is said, developed a compound which is drawn to the heated iron and which mechanically removes the old scale and prevents the formation of new scale.

The compound is in the form of a thick liquid, and can be easily fed into the boiler either into the suction line or directly into the hotwell, and fed to the boiler by an injector or pump.

This compound is manufactured by the Eagle Oil and Supply Company, 104 Broad street, Boston, Mass.

Quite a few steam plants have gone out of business, but the general scheme is still working day and night.

Institute of Operating Engineers in Chicago

Since the first of the year there has been in process of formation a Chicago branch of the Institute of Operating Engineers. Monthly meetings have been held in the rooms of the Western Society of Engineers and the movement is now well under way. At the last meeting, which was held May 2, it was decided that there would be no further monthly meetings until the fall, when a vigorous campaign will be conducted and a systematic course of lectures arranged for, all having a bearing on the problems which the operating engineer must solve in his everyday work.

The Chicago organization will be known as the T. J. Waters branch. Mr. Waters was a prominent operating engineer of Chicago and was for many years chief engineer of the Board of Education. He made a special study of heating and ventilating problems and his work in this connection received honorable mention at the Paris Exposition.

Officers have been chosen as follows: P. J. Fleming, branch chairman; W. L. Jackson, lecturer on plant operation; I. J. Bent, lecturer on educational subjects; O. Monnett, secretary-treasurer. Address of the secretary, 1214 People's Gas building, Chicago.

Heating Boiler Explosion Kills Two

Two men were killed and one injured, probably fatally, when a low-pressure sectional boiler exploded in the basement of the supply house of the Union Electric Light and Power Company, St. Louis, Mo., May 4, at about 9 o'clock at night.

The men had gone to the subcellar to get some wire and, according to the advices received, found that the boiler was highly overheated, due to lack of water. One of the men opened a valve in the water-supply pipe and when the cold water struck the cast-metal sections an explosion followed.

The low water was caused by some derangement of the return pipes of the heating system. The night watchman discovered that the water of the return tank of the system was overflowing, instead of returning to the boiler.

Details regarding the exact nature of the stoppage of water have not been obtainable at this writing.

Remains of Heating Boiler Which Killed Two Men

The Electrical Engineers' Pacific Coast Meeting

The Pacific Coast meeting of the American Institute of Electrical Engineers was held at the Hotel Alexandria, Los Angeles, Cal., on April 25 to 29 inclusive. Seven business sessions were conducted at which the various papers arranged for by the committees were presented and discussed.

On Tuesday afternoon an excursion was made to Redondo beach, where the party inspected the power plant of the Pacific Light and Power Corporation. On Wednesday a trip was taken to Pasadena and up Mount Lowe over the spectacular trolley route. On Friday an all-day trip was made to the Mill Creek power plant of the Southern California Edison Company, about eight miles from Mentone in San Bernardino county. A purely pleasure trip was made on Saturday to Catalina Island, starting from Los Angeles at 9:50 a.m. About 300 members and guests were registered.

PERSONAL

George W. Stetson, New England agent for various manufacturers of power-plant equipment, is now located in the Oliver building, room 510, Boston, Mass.

Fred S. Hickey, formerly with the Anchor Packing Company, has associated himself with the Dearborn Drug and Chemical Works, as salesman for their feed-water treatment and lubricants, in the loop district of Chicago.

On the evening of May 3, Col. E. D. Meier, president of the American Society of Mechanical Engineers, addressed a joint dinner of the local members of that society and the Providence Association of Mechanical Engineers at the West Side Club. These two organizations have recently affiliated and Colonel Meier's address was based upon this action.

Prof. F. R. Hutton, who is now president of the Industrial Safety Association, also addressed the meeting, speaking on safety appliances.

W. M. White, formerly of the I. P. Morris Company, of Philadelphia, has become associated with the Allis-Chalmers Company as manager and chief engineer of the hydraulic-turbine department. During the past ten years, Mr. White has been closely in touch with hydraulic-turbine development in this country and for the past five years has had entire charge of the designing for the I. P. Morris Company, in which position he has designed the hydraulic machinery for some of the largest installations in the country. These include such notable plants as that of the Hydraulic Power Company and the Toronto Power Company, of Niagara Falls, the Great Western Power Company, of California, the Washington Power Company, of Spokane, Wash., and the Shawinigan Falls Power Company, of Montreal, Can. Mr. White also designed some of the large centrifugal pumps for the New Orleans drainage system and those that supply the water for the city of Duluth.

POWER

NEW YORK, MAY 23, 1911

ON several occasions this page has been devoted to attempts to impress upon the engineer the necessity for keeping complete operating and cost records.

If our preaching has borne some fruit, we are gratified, but we do not intend to stop at that; we intend to keep right on as long as there is a chance of getting converts to the cause.

Complete records serve a twofold purpose: they show wherein improvements can be made, and they represent the facts in *black* and *white* by which the engineer can disprove the claims of the central-station solicitor.

If it is found to be costing more to generate power than it should, then there is something wrong with the equipment or the operation; otherwise the class of service is such as to legitimately belong to the central station field. Whatever the cause the records show where it is located, and the owner knows exactly where he stands.

While assuming this attitude, we are not insensible to the fact that many engineers are seriously handicapped through lack of the proper facilities for making and keeping complete plant records. This is strikingly shown in the following incident, which is perhaps typical of many others:

The engineer of a small plant put in a requisition for a recording wattmeter, and in the course of a few days was summoned to the manager's office. Upon entering he was greeted with the following remark:

"What is the meaning of this requisition? The company has spent $15,000 to install this plant, which is thoroughly uptodate, and we do not propose to spend any additional money on a lot of frills. If you cannot get results with the plant as it is, we shall be compelled to find someone who can."

The question naturally arises—what can an engineer do under such circumstances? Obviously, the answer will depend largely upon the personality and the resourcefulness of the engineer.

Had a consulting engineer made this recommendation, the chances are ten to one that it would have been accepted without being questioned.

Why, then, was not the operating engineer equally successful in his dealings with the manager?

It is because the consulting engineers, as a class, have gained a certain prestige with their clients. A similar prestige belongs to the operating engineer. It is within his reach and he can gain it by taking advantage of his opportunities.

Again, there are many plants not supplied with measuring instruments, upon which the central station is looking with eager eyes. In most cases the central station is anxious to put its own instruments upon the boards of such plants, in order to be in a position to offer an attractive rate.

In such cases, the engineer, if he is making good, should have no hesitation in granting them permission to install the instruments; in fact, he should welcome it, as it affords him an opportunity to know what his plant is doing. Of course, he should take his own readings and be sure of the constants of the meter. With these data he can figure for himself the cost of producing electrical energy.

Novel Method of Supporting Stack

By Cadwalder Evans, Jr. *

When it was decided to increase the hight of the steel stack of the Stevenson building in Pittsburg, it was found that the corner column of the building would not support the additional weight; hence a steel tower was constructed and the new section of stack supported from it on a cantilever.

There has recently been completed for the central power plant of the Oliver estate at Pittsburg, a difficult engineering feat in an addition to the smokestack, as shown in the accompanying illustrations. This plant supplies all of the Oliver properties, including the Oliver building, a 25-story office structure, the McCreery & Co. store, a 12-story building, and a number of smaller buildings, with electric lights, steam heat, elevator service, refrigeration and compressed air, and is large enough to take care of any addition which may be made to the property, including the projected Hotel Oliver.

The plant is located in the basemenqt of the Stevenson building annex, and contains 3220 boiler horsepower. As originally constructed, the stack was a self-supporting steel structure 10 feet 6¾ inches outside diameter, rising through one corner of the building to a hight of over 221 feet above the boiler-room floor and 80 feet above the roof of the building, terminating approximately on a level with the fifteenth floor of the Oliver building, from which it is distant about 200 feet.

The gases from the stack caused considerable discomfort to the tenants above the eighteenth floor in the Oliver building; hence, it was decided to raise the stack. The first plan called for a symmetrical steel tower about the present stack but it was found that the corner column of the building was not heavy enough to carry the load, so the present overhung structure was decided upon. This consists of a steel tower 83 feet 9 inches high supported on four of the building columns and carrying the new stack on a cantilever. The tower is 25 feet 4 inches by 21 feet 5 inches in section and the center of the new stack overhangs the tower by over 6 feet. The new part of the stack is 124 feet high, making the total hight of 345 feet 8⅝ inches above the boiler-room floor and 323 feet 8⅝ inches above the ground.

*Superintendent of central power plant of Oliver estate.

FIG. 1. NEW STACK IN PLACE WITH 18-FOOT SECTION OF OLD STACK REMOVED

The new stack is entirely self-supporting, is lined with vitrabestos 2 inches thick and has an inside diameter of 7 feet 8 inches, which is 2 feet 6 inches smaller than the old part. The details of erection were very ingenious and comprised: First, the erection of the steel tower to its total hight, which brought it 6 feet above the top of the old stack; second, an 18-foot section of the old stack was removed and lowered to the ground, complete with its lining; third, a smoke-tight 12x12-foot wooden box with side walls 8 feet high and open at the top, was erected 14 feet above the reduced stack. This afforded a shield from the smoke in which the men were able to work while putting up the lower sections of the new stack. After this was completed, the temporary box was removed and most of the smoke was drawn through the 18-foot open gap. The top section of the old stack was then hoisted back into place in one piece and the extension joint between the old and the new sections was packed, thus completing the job.

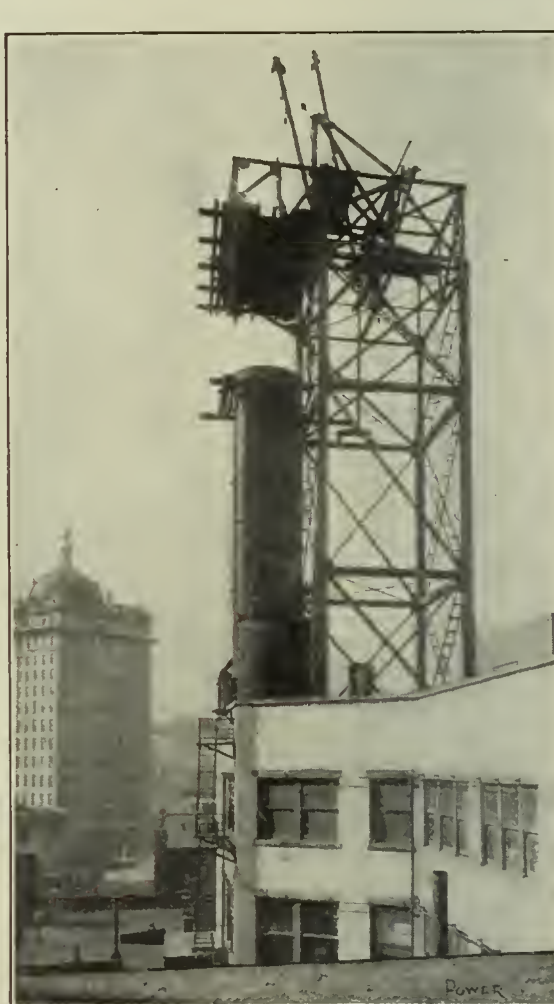


FIG. 2. TOWER IN PROCESS OF CONSTRUCTION

Real Cause of a Flywheel Explosion

By Hubert E. Collins

In 1907 the flywheel of a high-speed engine in the Hotel Knickerbocker, New York City, burst and caused considerable property damage. Facts were withheld at the time but information brought out in the preparation of a damage suit led to the conclusion that a dry link pin bound the governor and the engine ran away.

On March 1, 1907, at about 4 p.m., the flywheel burst on No. 3 engine in the Hotel Knickerbocker, New York City. The explosion of this wheel caused considerable property damage, and a barber was quite badly injured by a piece of the wheel coming through the floor of the barber shop where he was sitting in a chair. The fragment of the wheel passed so close to the barber that he lost his balance and fell through the opening in the floor into the engine room below.

Steam pipes were broken and the engine-room force performed acts of valor in stopping the havoc caused by the explosion.

An account of the accident, which was necessarily brief, as all information was refused, appeared in POWER at the time. The facts as here stated were brought out in the preparation of the damage suit of Dominicis versus Astor and Reegan. Dominicis is the name of the injured barber; Astor, the owner of the property, and Reegan, the lessee.

The same day the accident occurred, experts were called in to learn the cause of the accident, and found the governor wheel wrecked, which was the principal damage to the engine.

When the fragments were put together, it was found that one of them in the fracture had uncovered a flaw which appeared as in Fig. 1. This flaw extended around the rim for a distance of about two feet, gradually dwindling down to nothing from the proportionate size shown.

When the parts were reassembled, the wheel had the appearance indicated in Fig. 2. This sketch shows the location of all the fractures, and, of course, the moving parts of the governor and eccentric were stripped from the wheel. One of the stops for the weight arms was broken off.

Joint *B* was completely disrupted, one flange being broken into four pieces and the other one being cracked from the bolt holes out. On this joint one bolt was sheared on one end, one had both ends broken off, and one bolt was intact. There were three bolts to each joint, which were machined in the body 2½ inches to fit drilled holes in the flanges. The flaw began at the point indicated in Fig. 2 just below the flange of joint *B*.

It was contended by some that the flaw was the primary cause of the accident and this was given first consideration. The principal dimensions of the wheel were as follows: Outside diameter, 90 inches = 7.5 feet; mean diameter, 86.5 inches = 7.2 feet; revolutions per minute rating, 180; rim velocity in feet per minute, 4211; rim velocity in feet per second, 70.6; cross-sectional area of rim, 87 square inches; cross-sectional area of flaw, 3.8 square inches; cross-sectional area of rim through flaw, 83.2 square inches; weight of rim, 6130 pounds.

The strength of the rim through the flaw was first considered and, using the following formulas and process, the factors of safety were found:

$$\frac{r^2 \times D \times W}{5870} = \text{Total centrifugal force} = t$$

$$\frac{t}{6.28} = \text{Total force at two sections (tensile force)} = f$$

$$\frac{f}{a} = \text{Pounds pressure per sq. in. of cross-section}$$

In which

a = Area of cross-section;

r = Revolutions per minute;

D = Mean diameter;

W = Weight.

Now D = 7.2 feet, W = 6130, r = 180 and a = 87 − 3.8 (flaw) = 83.2 square inches. Substituting these values in the above formulas gives the following results:

$$\frac{180 \times 180 \times 7.2 \times 6130}{5870} = 243,614 \text{ lb.} = t$$

$$\frac{243,614}{6.28} = 38,792 \text{ lb.} = f$$

$$\frac{38,791}{83.2} = 466.2 \text{ lb. pressure per sq. in. of flaw}$$

Cast iron in flywheels can be safely allowed a tensile strength of 15,000 pounds and on this basis the factor of safety on centrifugal force is in this case

$$15,000 \div 466.2 = 32.1$$

As this increases or decreases in proportion to the square of the velocity, the factor of safety on the speed is

$$\sqrt{32.1} = 5.6$$

Or, in other words, the speed could reach

$$5.6 \times 180 = 1008$$

revolutions per minute to reach the limit of safety if the rim is considered alone, through the flaw section.

As a matter of fact, the joint of the wheel is much weaker than at the above section. In considering the strength of the joint, the cross-section of the rim without the flaw will also be considered. By referring to the data of this wheel, the pounds pressure per square inch of the rim may be computed and found to be

$$38,791 \div 87 = 445$$

As this design of wheel has only one-quarter the efficiency of a solid wheel, the allowable stress is

$$15,000 \div 4 = 3750 \text{ pounds}$$

The factor of safety on centrifugal force is

$$3750 \div 445 = 8.4$$

The factor of safety on speed is

$$\sqrt{8.4} = 2.9$$

It can be seen by this that the strength

FIG. 1. SECTION OF FLYWHEEL RIM

of the rim containing the flaw was much stronger than the bolts.

That the joint did not fail in any other way than would be expected from excessive speed is shown first by the appearance of the assembled fragments shown in Fig. 2. Referring to this figure it may be seen that joint *B* failed first, then the opposite section of rim from arm to arm containing the other joint left the wheel and the other parts followed these.

Prof. Charles H. Benjamin in his valuable papers in Volume 20, page 250, and Volume 23, page 168, of the Transactions of the American Society of Mechanical Engineers gives conclusive data on the manner in which wheels of this type fail. In every case the failure occurred in the same way as in the wheel in question.

Professor Benjamin tested wheels of 15 to 44 inches in diameter and made of

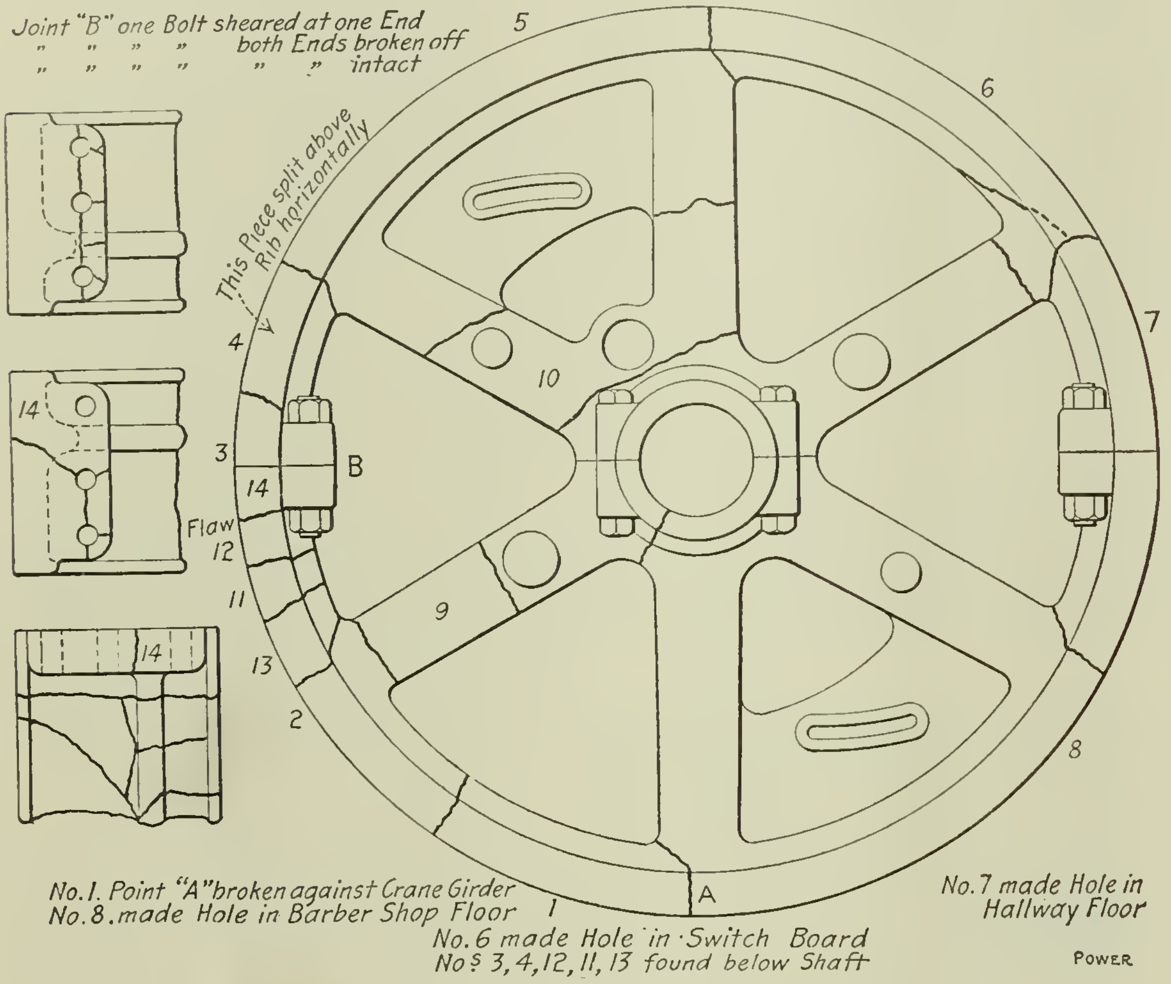


Fig. 2. The Broken Wheel Reassembled

closer iron than the average. He found the tensile strength of the iron to be 19,000 pounds, but on larger wheels it is safer to allow 15,000 pounds, as was done in considering this wheel. He also found the maximum and minimum rim velocities at the bursting point to be 196 and 184 feet per second, respectively, that is, the highest and lowest velocities at which any of the wheels in his tests let go. These tests verify the fact that the wheel in question was well within the limit of safety at its rated speed.

The acceptance test also brought out the fact that the engine was governing within its rated percentage as evidenced by speed tachometers, and the valves were covering the steam ports properly, as shown on the indicator diagrams. The diagrams show that with the throttle wide open and no load, the initial pressure in the cylinder was 29 to 30 pounds less than the steam pressure in the pipes and with full load the drop from steam pressure to initial was 2.5 pounds.

Real Cause of Accident

Having disposed of the flywheel probability, the real cause of the accident may be investigated. Fig. 3 shows the governor and wheel of this engine. The accident stripped the wheel completely from the shaft, and after the parts were assembled it was found that the link pin *A* was scored and cut and some of the brass from the link bushing had fused to the steel pin. This pin is shown in detail in Fig. 4. Where this brass fused to the steel it left little ridges of metal. By referring to Fig. 3, it may be seen that the two weight-arm links *B* and *C* are made fast to the eccentric by pin *A*. This pin passes through one end of each link. These links are brass bushed, and on the inside of the link next to the eccentric were found the plain marks of threads. Pin *A* made up tight in the boss of the eccentric against the shoulder *A*,

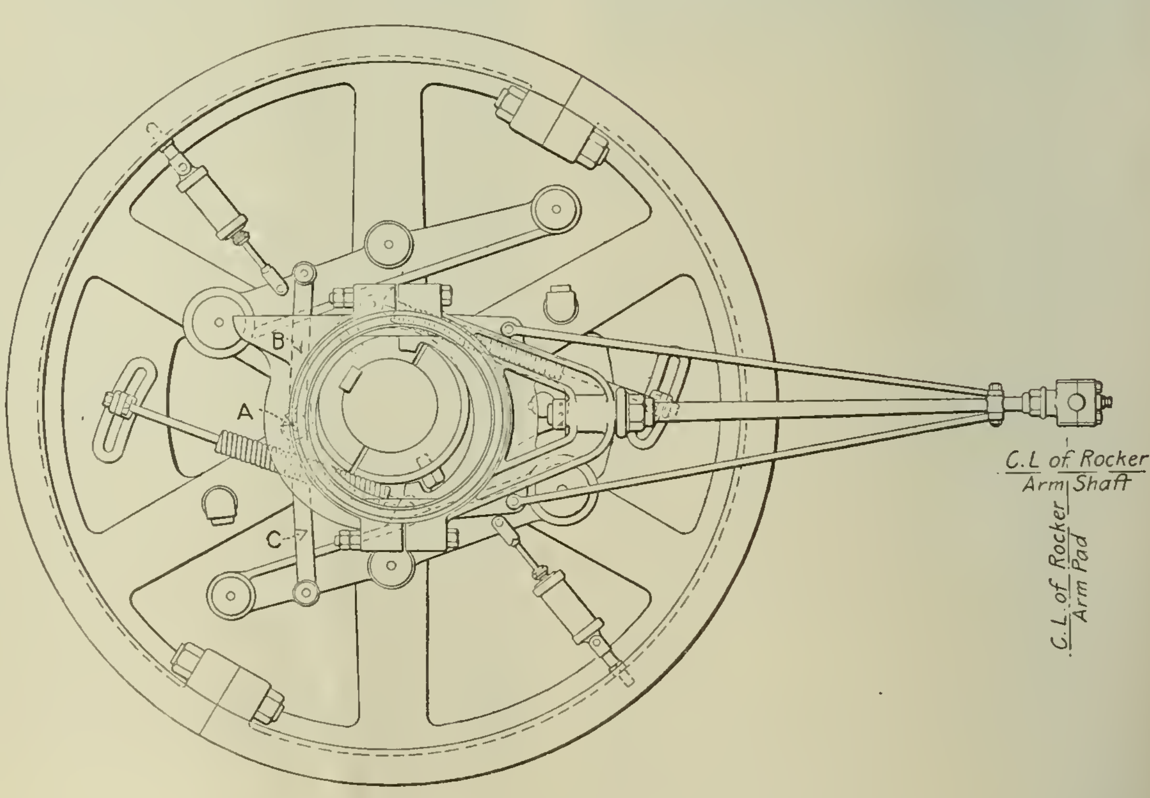


Fig. 3. The Governor and Wheel as They Appeared Before the Accident

Fig. 4. This made it self-locking. The two link ends fitted the large end of this pin.

This engine had been put in service at 2 a.m. on the day of the accident and was in service continuously up to the time of the accident, close to fourteen hours. No trouble was noticed until a few seconds before the accident, when a heavy pound started in the governor and then the engine suddenly speeded up, the generator making an ever increasing screeching noise. The engineer on watch started for the throttle and before he could reach it, the wheel exploded.

The evidence showed that the link pin was dry and had run hot. This had

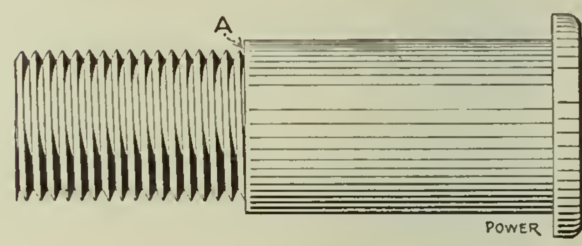


Fig. 4. Link Pin Which Caused the Accident

loosened the pin from the eccentric by pinching it, and the movement of the governor had gradually worked it loose until it was still holding by two or three threads; but there was still room enough for the inside link to pound on the threads between the shoulder *A*, Fig. 4, and the eccentric boss. That it did so pound is shown by the plain marks of threads on the inside of the bushing on the link. The pin was long enough in the thread to still hold and allow this.

This was when the pounding occurred a few seconds before the explosion. Then the most plausible theory is that the pin was pulled out of line enough to bind the governor and cause it to stick and let the engine run away.

Some criticism was made of the fact that this pin had no lock nut. On the contrary, there was no need of such, as it locked against the shoulder.

The final conclusion as to the primary cause of the accident was that "the pin was dry."

A Turbine Driven Roller Mill

A 750-horsepower Parsons turbine, designed to run at 2000 revolutions per minute, is geared to run the mill at 70 revolutions. A 100-ton flywheel takes up the shock of the mill.

The rolling-mill field, looked upon as one of the last and most secure strongholds of the reciprocating engine, has been invaded by the steam turbine. An installation at the Calderbank steel works of James Dunlop & Co. was the subject of a paper recently presented to the West of Scotland Iron and Steel Institute by A. Quintin Carnegie, of the Parsons Company.

About the time that the Parsons were experimenting with the "Vespasian," upon which it will be remembered the speed of the turbine was reduced to that of the propeller through gears, the question of the motive power for the new rolling mill was up, and it was proposed to use the exhaust steam from the existing mill engines for electrically driving the new mill through a low-pressure turbine. Calculations showed that a flywheel already on hand was large enough to permit the rolls to be operated with an almost constant load on the driving engine, and the idea of substituting gearing for an electrical reduction between the turbine and flywheel shaft presented itself. The electrical transmission would cost something like 15 per cent. in transformation losses, whereas the frictional loss, including that of the bearings of the gearing, would not be over 1½ per cent., while the gearing involved a much smaller investment.

The turbine, of which the accompanying section, Fig. 2, is reproduced from *The Engineer* and the halftone view, Fig. 1, from *Engineering*, is of the Parsons mixed-pressure type and runs at 2000 revolutions per minute, either with exhaust steam at a pressure of 10 pounds per square inch absolute, or with live steam direct from the boilers at a pressure of 60 pounds per square inch above the atmosphere. The two throttle valves are connected to the governing mechanism by means of steam relays and are arranged so that preference is given to the use of exhaust steam. When the supply of exhaust steam is insufficient, the balance required is automatically supplied by the high-pressure valve, the distribution of the load between high-pressure and exhaust steam being effected by the decrease in speed. In order to prevent air from being drawn in when there is a shortage of exhaust steam, a small device is provided, which causes the low-pressure throttle to close whenever the exhaust steam falls to nearly atmospheric pressure. The blade areas are so proportioned that the full load may be carried with atmospheric pressure at the first row of low-pressure blades, the high-pressure blades in this case running idly in steam of atmospheric

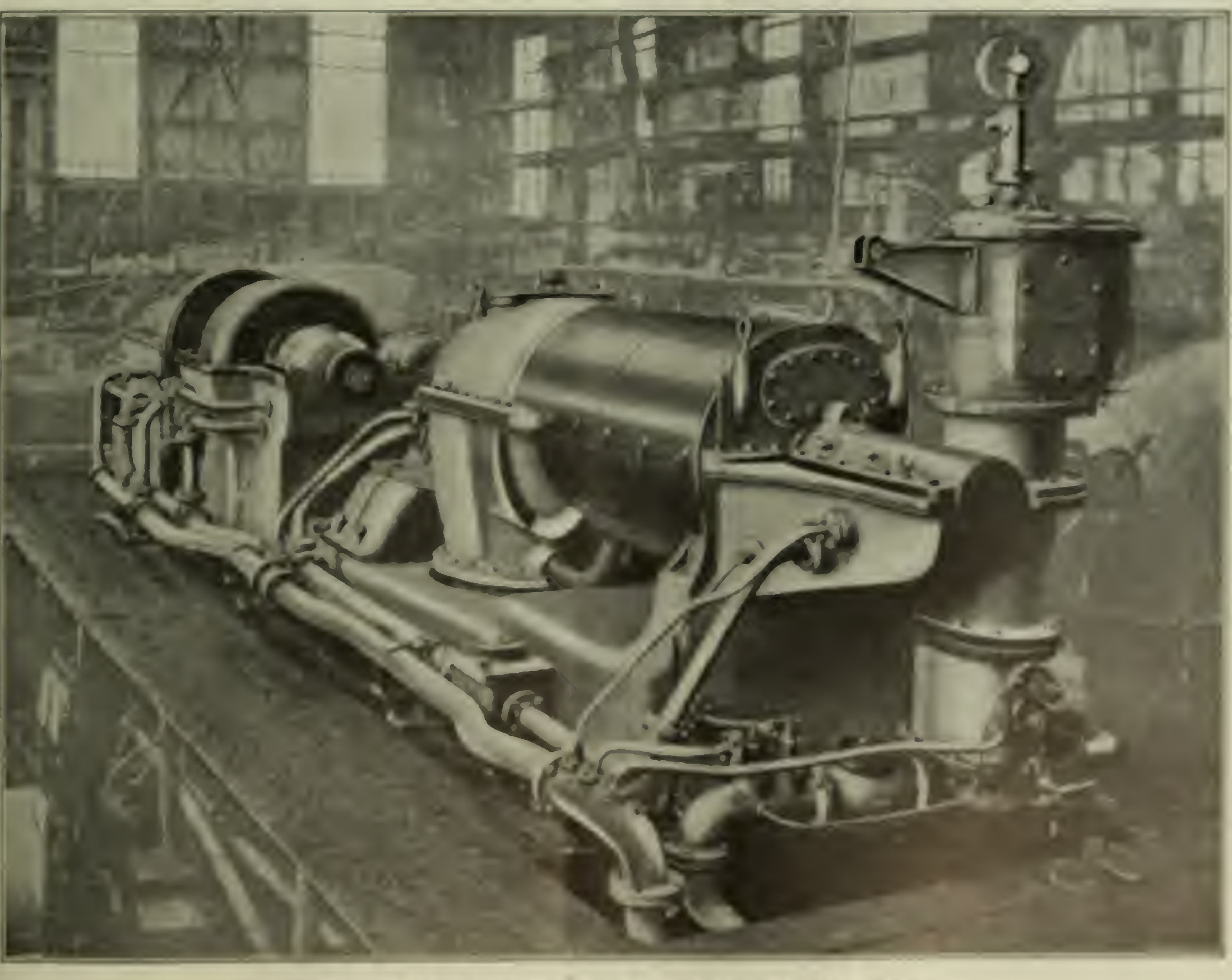


Fig. 1. Geared Turbine for Rolling Mill, Live Steam End

pressure. When the whole load is taken by high-pressure steam, the pressure in the first row of low-pressure blades falls to about eight pounds absolute, so that the smaller quantity of steam is still able to fill the blades and maintain an efficient velocity ratio. Full power from the turbine may be obtained from either source of steam supply or a mixture of the two.

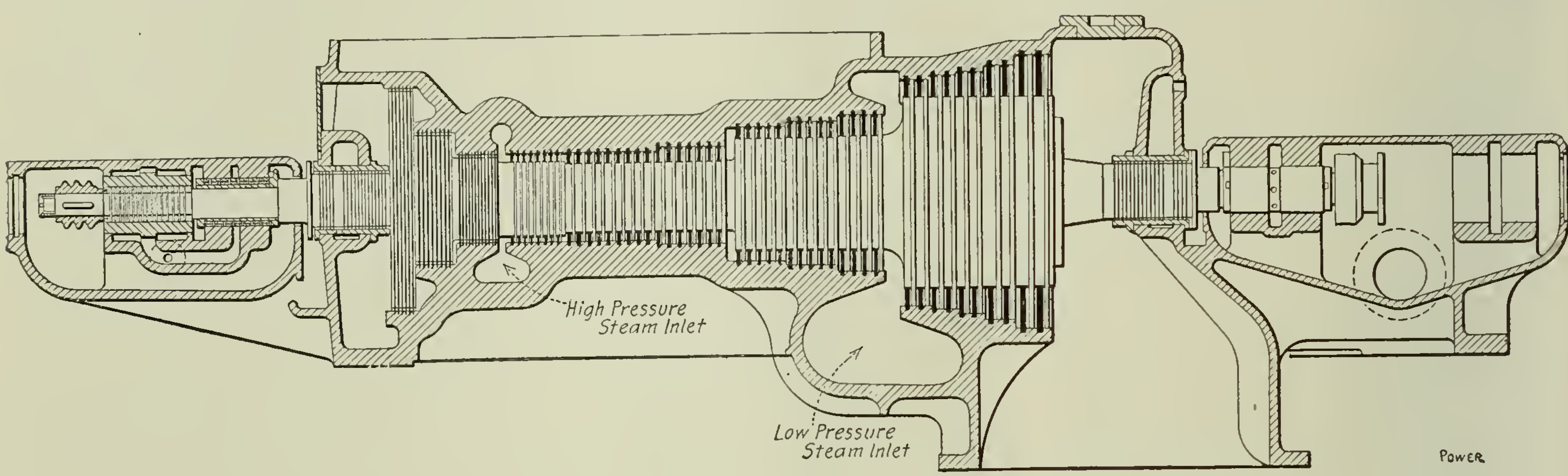


Fig. 2. Longitudinal Section of Turbine

The turbine was designed to develop 750 brake horsepower, and this has been found to be ample. The mill runs at 70 revolutions per minute, the turbine at 2000 revolutions and the intermediate shaft at 375 revolutions. The high-speed pinion is formed solid with its shaft and is made of chrome-nickel steel. The pitch-line diameter is 7.143 inches, and there are 25 teeth, 3½ inches diametrical pitch. The wheel into which it gears has 131 teeth and is 37.429 inches in diameter, with a total face width of 24 inches. The second reduction gear has a mild steel pinion, with 23 teeth, 2 inches circular pitch. The pitch circle diameter is 14.912 inches, and it gears into a wheel of 80.848 inches diameter, with 127 teeth. The total face width of the low-speed gear is 16 inches. The double helical teeth are at an angle of 23 degrees with the axis of the shaft. Both pairs of gears are placed in cast-iron gear cases with white-metal bearings for the shafts. Oil is pumped into the bearings under a pressure of from eight to ten pounds per square inch by a pump driven from an extension of the governor shaft, but the oil for the gearing is delivered by a separate pump driven from the intermediate shaft by means of a Reynolds silent chain. This pump draws oil from settling chambers in the bottoms of the gear cases and sprays it continuously onto the teeth. The level of the oil is kept sufficiently low to be quite clear of the bottoms of the wheels. The arrangement of the gear is shown in Fig. 3 herewith, also reproduced from *The Engineer*. Couplings of the flexible type are fitted between the turbine and the high-speed pinion shaft, and also between the first and second reduction gears. These allow for small errors in the alinement of the shafts, and also give the necessary end freedom for expansion of the turbine shaft.

Together with its shaft the flywheel weighs nearly 100 tons. It is carried on two adjustable gun-metal bearings, each 22 inches in diameter. One of these bearings forms part of the lower-speed gear box. The low-speed gear wheel is keyed directly on to the end of the flywheel shaft and is overhung from its bearing. The flywheel, which is of cast iron, is in two portions, connected with the usual shrunk links. The external diameter of the wheel is 23 feet. Since the stored energy in the flywheel is about 20 times that of the turbine and gears, it is evident that the latter are subjected to a small fraction of the shock due to the rolling mill. The flywheel shaft is connected to the main pinion of the mill by a pair of wobbling couplings. One of these is of cast steel, while the other is of cast iron, of such section as to allow its breaking in the event of any undue strain on the mill. Four of these couplings are said to have broken in one afternoon.

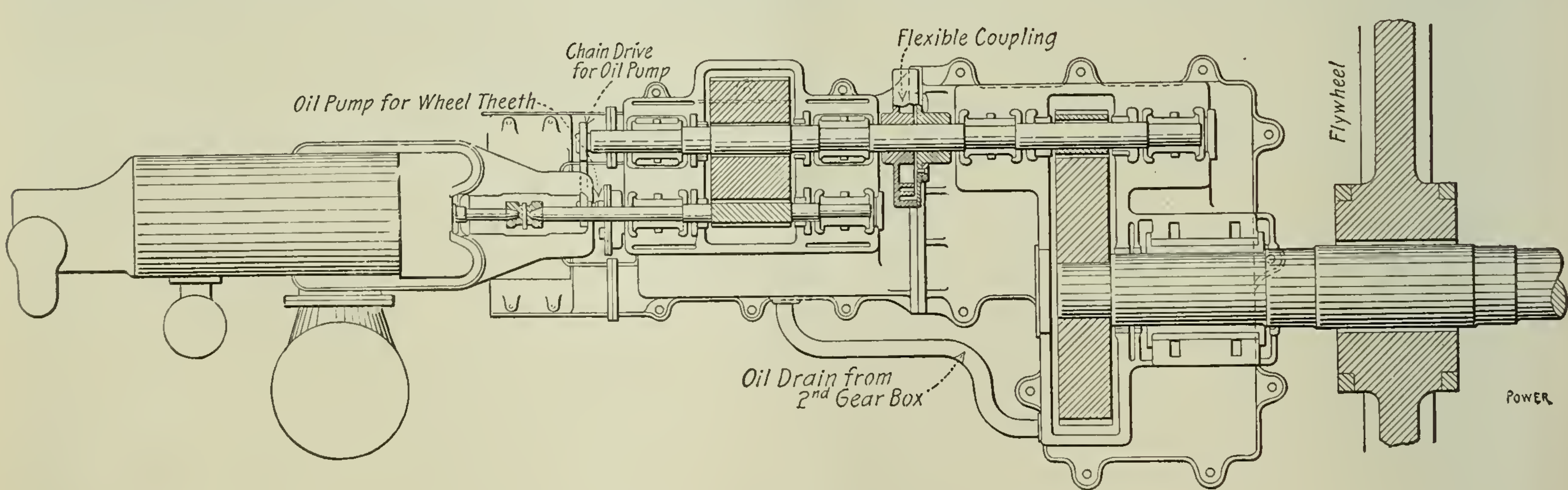


Fig. 3 General Arrangement of the Gears

The Summer School of Engineering under direction of the College of Engineering of the University of Wisconsin, opens June 26, continuing for six weeks. Regular and advanced courses are offered in direct and alternating currents, hydraulics, machine design, descriptive geometry, applied mechanics, shopwork, steam and gas engineering and surveying. Elementary courses adapted to the requirement of those not having preparation for the advanced work are offered in mechanical drawing, machine design and shopwork, in addition to which opportunity is offered for laboratory work in the electrical, steam and gas laboratories for those who have had power-plant experience or correspondence instruction. The teaching staff is taken from the regular instructional force, and all laboratory equipment of the engineering college is available for students.

Napier's Formula with Superheat

Some experimental observations upon the flow of superheated steam through an orifice. By applying these values to Napier's formula constants for superheated steam were obtained.

A short time ago, Mr. Harter presented a paper, at a meeting of the American Society of Mechanical Engineers, setting forth some incidental observations upon the value of Napier's coefficient with superheated steam. The values recorded were for superheats between 45 and 195 degrees Fahrenheit, but unfortunately the series was confined to a range of pressures between 138 and 148 pounds gage. Extreme care was taken in making all observations and the probable error was within 0.2 of one per cent.

The same orifice was used in all the tests and was formed in a ½-inch plate with edges rounded to a ¼-inch radius, the contracted diameter being 1.2 inches. In figuring the results no correction was made for expansion due to the temperature of the diaphragm, owing to the smallness of the error arising from this source.

The results are plotted in Fig. 1, in which curve No. 1 gives the Napier coefficient corresponding to each set of readings obtained in the tests. Calibration tests of the orifice for saturated steam showed a coefficient of about 72.3, the difference between this and the ordinarily accepted figure of 70 being, no doubt, due to the form of orifice. The formula for determining Napier's coefficient as plotted in curve No. 1 is

$$C = \frac{pa}{W}$$

where,

C = Napier's coefficient;

p = Test pressure, absolute;

W = Weight of steam flowing per second;

a = Area of the orifice in square inches.

Curve No. 2 shows the cubic feet of steam discharged per second for different amounts of superheat, the results being reduced to the basis of the average pressure existing during the tests in order to make the volume discharged depend upon temperature only.

Curve No. 3 shows the weight of steam discharged per second at the average pressure.

In commenting upon Mr. Harter's results, Professor Heck submitted some interesting comparisons of experimental re-

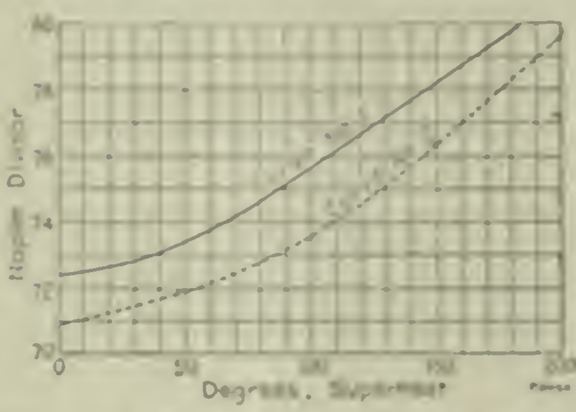


FIG. 2. THEORETICAL AND EXPERIMENTAL VALUES OF NAPIER'S CONSTANT

COMPUTATIONS FOR POINTS ALONG CURVE NO. 2, FIG. 2

Degrees of superheat	0	[illegible]	100	150	200
Initial temperature t_1, degrees	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Entropy	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Condition of steam at p_0, quality or temperature	0.9611	[illegible]	[illegible]	[illegible]	[illegible]
Total heat h_1 at p_1, B.t.u.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total heat h_0 at p_0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Energy of jet $(h_1 - h_0)$	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Velocity v_0 at p_0, feet per second	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Specific volume v_0 at p_0, cubic feet	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cross-sectional area a_0 of unexpanded jet at p_0, square inches	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Napier divisor, $N = a_0 p_1$	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

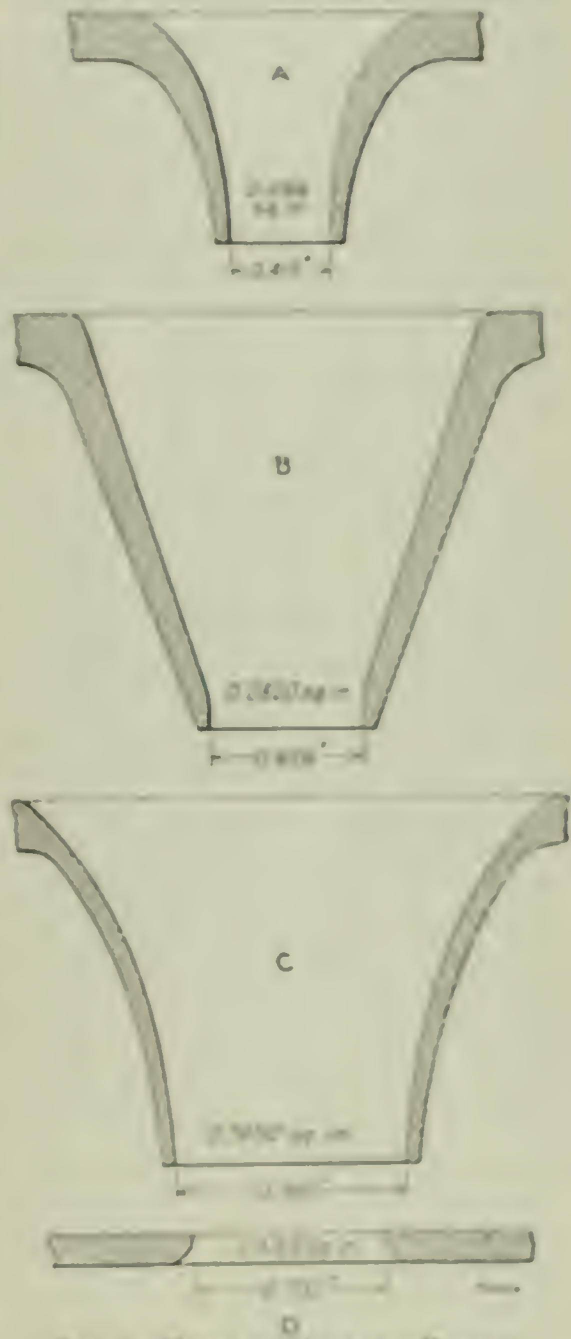


FIG. 3. NOZZLES USED BY RATEAU

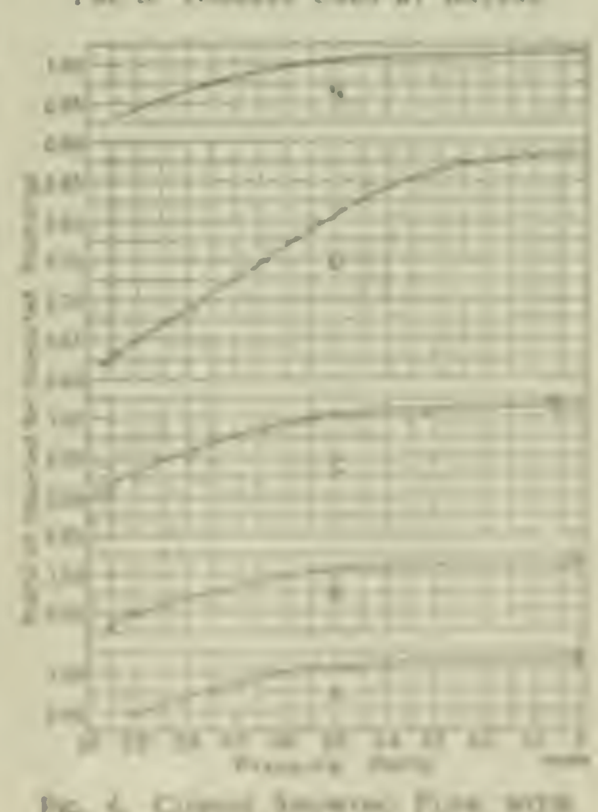


FIG. 4. CURVES SHOWING FLOW WITH NOZZLES SHOWN IN FIG. 3

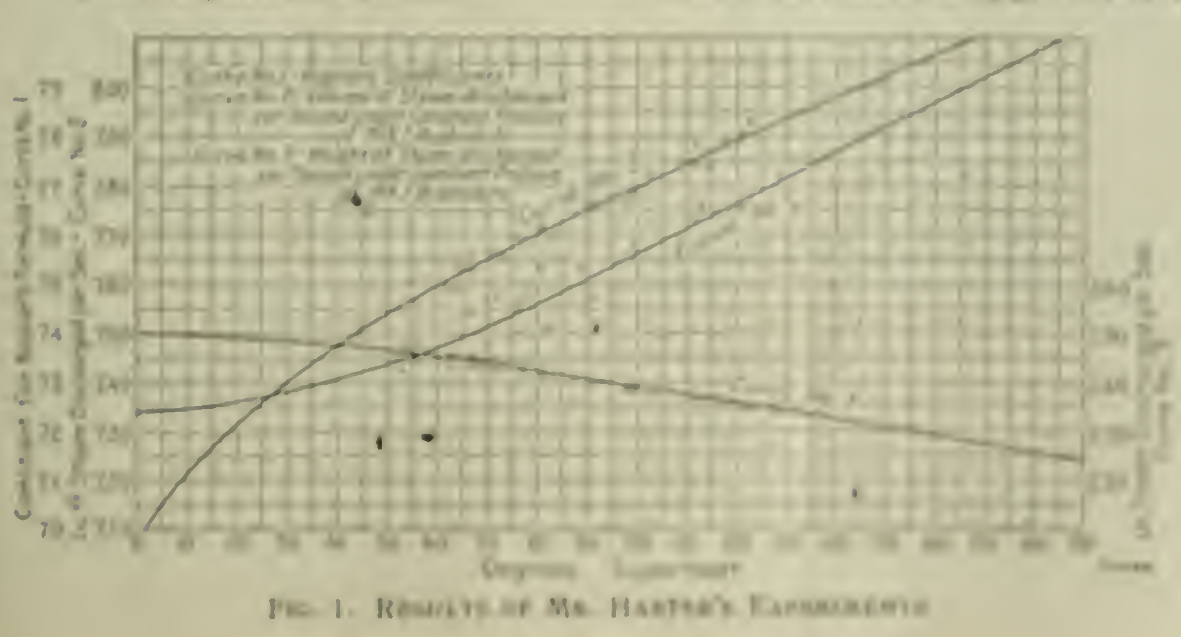


FIG. 1. RESULTS OF MR. HARTER'S EXPERIMENTS

sults with the theoretical values of Napier's divisor deduced from the truly adiabatic steam jet.

In Fig. 2, curve No. 1 represents Mr. Harter's curve No. 1, while curve No. 2 shows the ideal value of the Napier constant. The calculation for the five points along this curve is outlined in the accompanying table. The general data are: initial pressure p_1 equals 160 pounds absolute; pressure in throat of jet p_0 equals 92 pounds absolute, or 0.575 p_1, for which pressure the saturation temperature is 321.9 degrees Fahrenheit:

The steam quantities in this calculation were taken from an as yet unpublished table of the properties of steam, which differs from the Marks and Davis tables by amounts lying within the region of experimental indeterminateness.

The two curves in Fig. 2 show agreement in form, and indicate a coefficient of discharge of 0.97 to 0.98; this coefficient being the ratio of the ideal to the observed value of *N*.

In this connection it is shown how the coefficient of discharge works out for an important set of experiments made by Rateau, in 1900. Fig. 3 shows the nozzles and orifice used. In Fig. 4, curves *A, B* and *C* correspond with nozzles *A, B* and *C,* respectively. The curve *N* is the average of these three, while *D* applies to the sharp-edged orifice. The pressure ratio is the ratio of the final to the initial pressures, that is, $p_2 \div p_1$. The ideal flow is based on the assumption that when p_2 falls below 0.575 p_1, it ceases to exert any influence upon the rate of flow. These experiments show that it has a small influence; the discharge is equal to the ideal rate when p_2 is the same as the throat pressure p_0, but increases very slowly as p_2 falls. The coefficient of discharge thus becomes greater than unity, being about 1.02 when p_2 equals 0.1 p_1, which is about the governing condition in the tests reported by Mr. Harter. Curve *D* shows a marked contraction of the jet, which decreases, however, as p_2 becomes less.

Flow of Heat through Furnace Wall

As a result of recent investigations at the testing plant of the United States Geological Survey it has been found that a solid wall is a better heat insulator than a wall of the same total thickness containing an air space.

A set of exhaustive investigations have recently been completed at the fuel-testing plant of the United States Geological Survey at Pittsburg, Penn., by Messrs. Ray and Kreisinger upon the flow of heat through furnace walls. A specially constructed furnace was used, all temperature measurements were taken by means of thermocouples and every precaution was observed to insure accurate results.

The temperature difference was taken as a basis for measuring the relative heat transfer, the nearly true assumption being made that there is no cooling effect due to leakage currents of air through the brickwork or into, out of or along the air space. With this true, the quantity of heat passing through an inner part of the wall is exactly equal to the heat passing through another part farther out. For example, the quantity of heat which is conducted through the inner firebrick wall is exactly equal to the heat which passes across the air space, and is exactly equal to the heat which is conducted through the outer common brick wall, and also equal to the heat radiated from the outside surface. If this were not so, equilibrium would be impossible; that is, if more heat passed through the inner wall than through the outer wall and over the air space, then the heat would accumulate next to the air space and would be accompanied by a continually increasing temperature. Or, if more heat passed through the outer wall than through the inner one and through the air space, the heat in the outer wall would diminish and its temperature would drop—an event contrary to conditions of equilibrium.

The quantity of heat flowing by conduction from one plane to another through any portion of the furnace wall depends upon the difference of temperature between these two planes and upon the resistance to the heat flow. With the same temperature difference, if the resistance is high, a small quantity of heat flows through; if the resistance is low, a large quantity flows through. Or, if the quantity of heat is to remain constant, the temperature difference must be large if the resistance to the heat flow is high, and small if the resistance is low. For example, if the temperature difference between the faces of the firebrick wall is high, it may be said that the resistance to the heat flow through the firebrick wall is high; or, if the temperature difference between the two surfaces on each side of the air space is low, it may be inferred that the resistance to the heat passage across the air space is low. Thus it is possible to rely upon the temperature difference as being a true indicator of high or low resistance to heat flow between any two planes which are parallel to the surface of the wall.

The investigations particularly concerned the air-space type of wall construction as compared with the solid brick wall or walls in which the air space is filled with some solid material of low heat conductivity. The results showed conclusively the rather surprising fact that in furnace construction a solid wall is a better heat insulator than a wall of the same total thickness containing an air space. This is especially true if the air space is close to the furnace side of the wall. In view of this, where it is desirable to build the walls in two parts, so as to prevent cracks from being formed by the expansion of the brickwork, it is preferable to fill the space with some solid (not firm but loose) insulating material. Any such materials as ash, crushed brick or sand offer higher resistance to the flow of heat than an air space; furthermore, a loose material by its plasticity reduces the air leakage. It was found that one inch of asbestos was more effective as a heat insulator under the existing conditions than a 2-inch air space.

There is a general belief that since air is a poor conductor of heat, air spaces built into the walls of a furnace will prevent or reduce heat dissipation through the walls. Although there may be instances in which this is true, yet, as a rule, the effect of the air space is just the opposite. While the heat travels very slowly through the air by conduction, it passes over the air space very readily by radiation.

The quantity of heat passing through a portion of a solid wall by conduction depends upon the difference between the temperatures of the two planes limiting the portion of the wall, whereas the quantity of heat that passes across the air space in a wall depends upon the difference of the fourth powers of the absolute temperatures of the surfaces inclosing the air space. It follows that, in case the heat passes by conduction through the solid portion of the wall, the loss remains approximately the same so long as the temperature difference of the two limiting planes remains constant, no matter what may be the actual temperatures of the two planes. On the other hand, the heat passing across the air space by radiation increases rapidly with the temperatures of the inclosing surfaces, although the difference between these temperatures may remain constant. The important point is that the air space, which is advantageous in the walls of a refrigerator because the temperatures are low, is objectionable in a furnace wall because the temperatures are high.

A Perpetual Hydraulic Motor

By F. W. Salmon

How a young engineer was induced to spend his time working on a perpetual-motion machine which he knew was contrary to all natural laws and which he felt sure could not be made to work. The deception that he discovered and exposed and the lessons that he learned.

About the middle of a warm holiday afternoon in May, 18—, in the western corridor of an upper floor of a downtown office building in a city of the Middle West, an elderly man dressed in a gray suit was carefully searching for a certain door. This was made evident by the close examination he gave each door in turn. Although he was apparently fifty-five or sixty years old and had silver-gray hair, his walk was firm and decided; his face was clean shaven and he bore himself with a semi-military air.

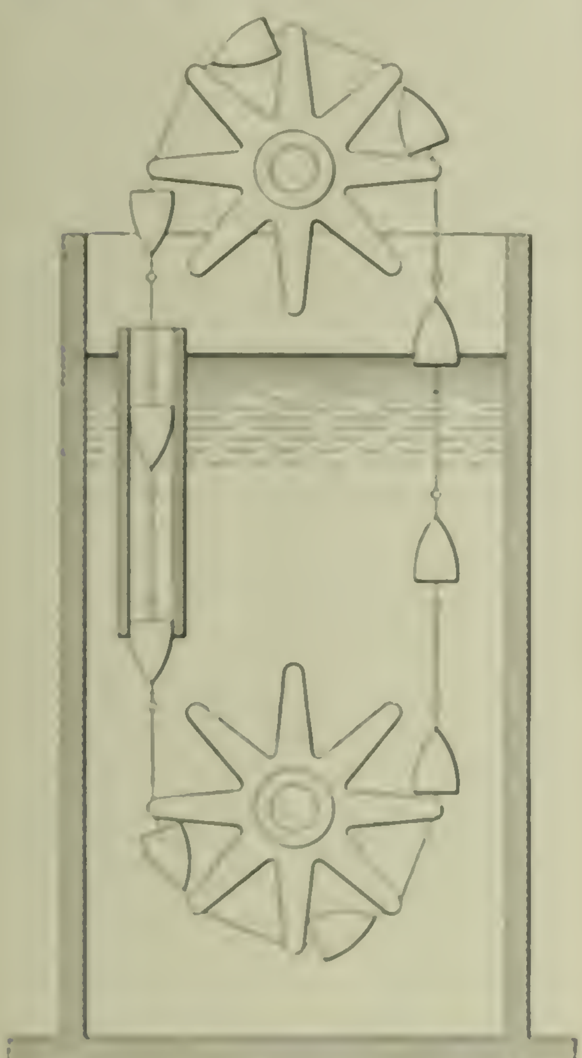


Fig. 1. Smith's Original Design

At room 418, after examining the sign on the glass, he tried the knob, but it would not turn. The door was opened by a man of perhaps twenty-five years. A few preliminaries and the men were acquainted; Charles F. Smith wished to consult Henry C. Bandcox about the former's invention—an invention that had been his dream day and night for perhaps thirty years. The dream was not a dream to him but, rather, a duty, his duty, to his race, his nation, yes, to the world.

Bandcox's erect carriage, his open and frank manner and the way in which he looked others straight in the eye, all carried confidence; surely he was honest and honorable, and surely he had a right to practise his profession as a consulting engineer, even though he was so young, for he had been trained in the best schools, the school of theory, the school of practice and the school of adversity.

Smith's most intimate friend, Hammond, had told him to find this man Bandcox and secure his service in perfecting the invention; Bandcox had but

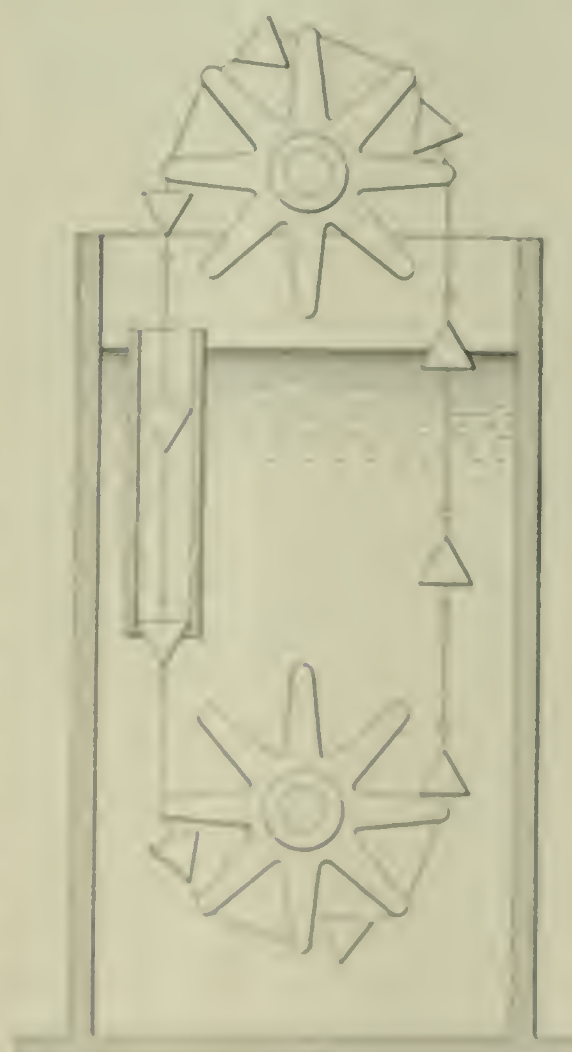


Fig. 2. Smith's First Improvement

a small practice and Hammond knew that he would give almost unlimited study and care to anything he undertook.

An hour later Smith folded up and put back in his pocket a sheet of paper on which there was a sketch, as shown in Fig. 1, while the words, "You are mistaken, Mr. Bandcox, I have seen it move, I know that there is power in it," were leaving his lips, and upon his face was a more set and determined look than before. Henry, in wishing him good-by at the door, courteously repeated his firm belief that no useful or profitable purpose could be attained by spending money on or time experimenting with such a device.

The old man had for half a lifetime treasured the idea that in the near future any man would be able to get power al-

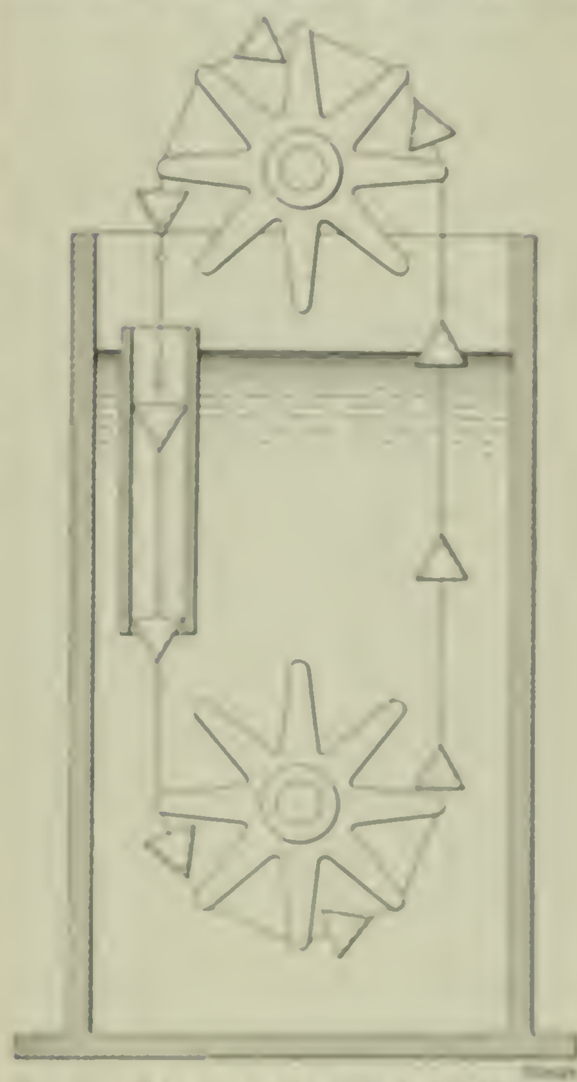


Fig. 3. Machine with Floats Open at the Bottom

most without cost with his device, as soon as some consulting engineer would show how to get the floats down again under the bottom wheel and mechanics would do "decent" work on his models, thus not allowing excessive friction to prevent the machine from making the initial move when tested.

The floats were made with the shape shown in Fig. 1, upon the theory that they would pass through the water with less resistance at the enormous speed that in the inventor's opinion they would attain in large machines when operated in deep water.

Perhaps a week later Smith again called on Bandcox, this time accompanied by his friend Hammond. Smith asserted that if a practical machine were designed and a satisfactory working model made to show to capitalists, unlimited capital would immediately be placed at their disposal. Hammond vouched for the excellent reputation of Smith and assured Bandcox that Smith would undoubtedly pay his bills for services promptly. Moreover, Hammond emphatically declared that he had seen a model run, though it was roughly made and very small. Bandcox, however, could not reconcile this with his theoretical knowledge.

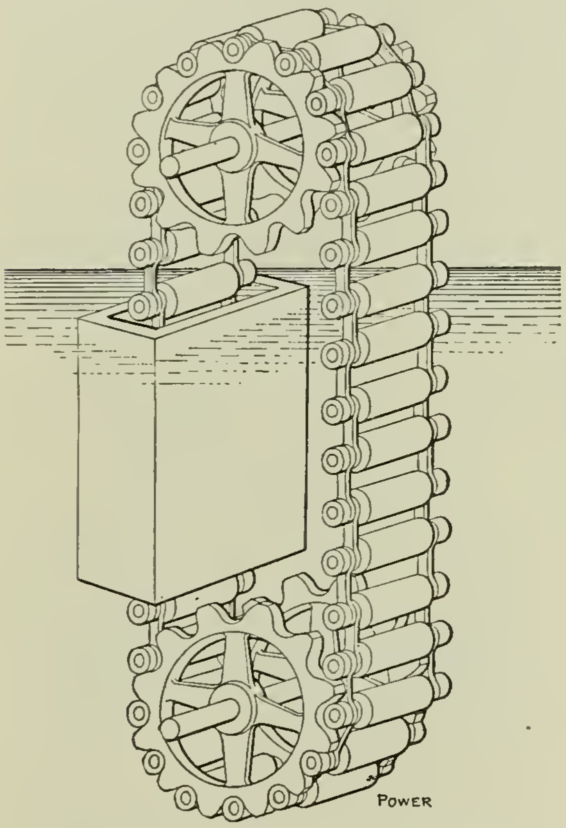


Fig. 4. Floats Built as Rollers to Eliminate Friction

During the discussion sketches as per Figs. 2 and 3 were made. In Fig. 2 the inventor arranged for a water-tight tube in which the floats were to pass downward. This was to nullify the objection raised by Bandcox that in the earlier design the efforts on the various parts of the chain were equally balanced.

In the design in Fig. 3 Smith thought he had solved every difficulty. The floats were open at the base of the cone so that they would fill with water in descending. Bandcox explained that there was nothing to cause them to rise on the ascending side.

Smith called later with pieces of the apparatus that it was claimed had "run"; still, Bandcox claimed that the machine was not feasible and advised against spending money in models or patents. But, Smith insisted that drawings be made upon which an application for a patent could be based. Finally, this was done; the drawings showed a design very similar to that in Fig. 4. Smith explained that in this design the last objection offered by Bandcox had been met, for should any of the floats in descending touch the side of the tube they would roll and thus not offer the resistance which was found so objectionable in the design in Fig. 2.

After this, Smith often called at Bandcox's little office, sometimes bringing interested friends with him, and many methods were talked over as to "the best way to overcome the cussedness of the thing," but Bandcox always protested against the machine as not being feasible. Still, Smith had several models made and these altered from time to time but to no purpose. So, gradually, his visits to Bandcox became less frequent and finally ceased entirely.

On one cold day of the following spring, Bandcox sat in a little workshop at a board on trestles in one of the back rooms of the factory of—well, let's say the Olivett Manufacturing Company, in the small town of, say, Olivett. He was a good engineer and a good student, but he was neither a good "business getter" nor a good "cash collector" so he had given up his office with the last of his little capital and "taken a job" on a small salary with an expert "business getter" who reaped large profits from Bandcox's labor and skill.

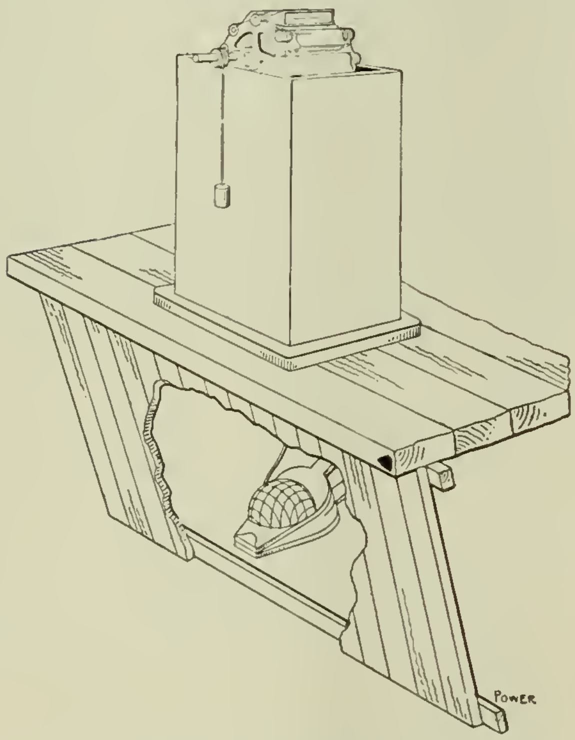


Fig. 5. How the Machine Was Made to Work

A letter in an envelop bearing several "Forwards" was thrown in to him; he shoved it in his pocket but later his curiosity awakened, apparently, and he opened and read it.

What, was it possible! Smith's machine a success—runs nicely and gives greater power than even the inventor claimed. A model had been made by Thompson, the modelmaker on Water street, and it was now in his shop where it runs daily and is seen by hundreds. The letter ran on, Smith wanted Bandcox to come at once and make the drawings and specifications, both for the patent and for a larger machine. The evident rectitude and honor of Bandcox had so impressed Smith and Hammond that they searched for him at this important time.

A few letters were exchanged and Bandcox paid out his hard earned wages for a ticket to go back to his home town. When he arrived he went directly to the model shop and found Smith waiting for him, more erect than ever, cordial and kind. Now what did Bandcox have to say? There was the machine, just like one of the sketches made in Bandcox's office which he had always thrown down as "not practical, no good, out of the question." This model ran and it gave power, yes, *power*. See it raise this large weight when the clutch is thrown in. Yes, Bandcox gives in, acknowledges that it works, that it gives power but he still insists that in some way or in some detail not readily discernible it differs from the sketches that were shown to him some months before.

Smith and Thompson talked and acted as though they thought Bandcox more or less insane. "Would he not believe what he saw with his own eyes?" Just pour in a few drops of fresh water and the machine would start, run and give power; anyone could pour in the water that Thompson would courteously hand him when desired.

The young engineer was quite busy for the next two weeks, examining the machine and its surroundings, measuring the volume of water it took, the weight it would raise and doing many other things. At last, he had his report ready to show Smith, Hammond and Thompson what he had found. How simple! For months a man in Thompson's employ had been drawing good wages for himself and for Thompson working on the model. The model worked because a small pipe conveyed air into the water tank just under the ascending buckets, as shown

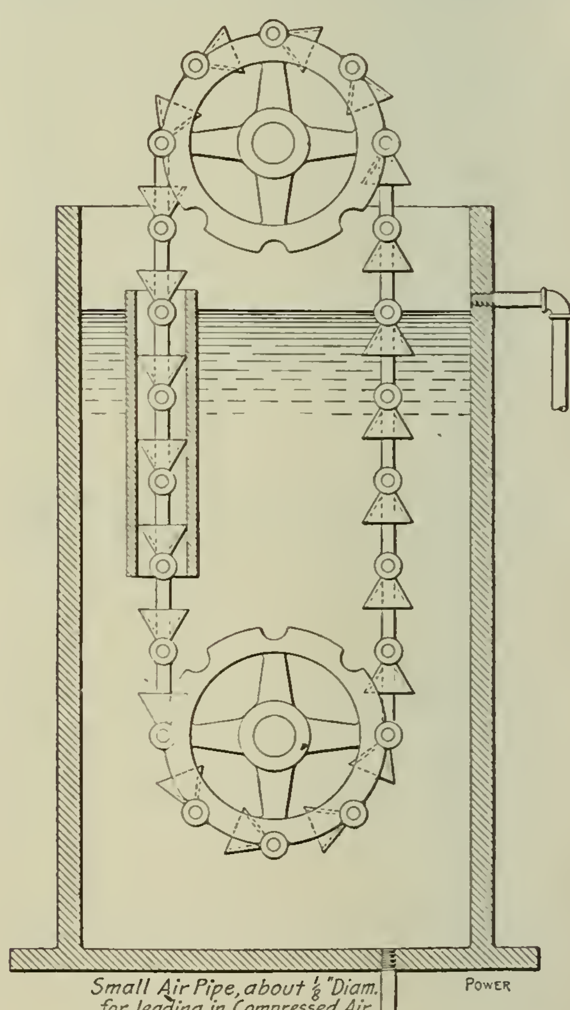


Fig. 6. Section of Machine, Showing Air Supply

in Fig. 5. The duty of the man whom Thompson employed was to work the foot bellows and keep out of sight. The air entering the bottom of the tank came in contact with the floats on the up side, as shown in Fig. 6, and caused the machine to work.

The exposure of Thompson's deceit caused Smith such great disappointment that he gave up in despair his cherished dream of securing power without cost.

Bandcox went back to his position in Olivett, poorer in pocket but richer in experience and wisdom.

It was but a short time ago that I sat on one side of the fireplace in Henry Bandcox's home on a cold night and Henry sat on the other. We were finishing our cigars after his family had retired and we talked of the incidents recounted above. He went on to say that it was a bitter experience and had cost him a high price one way and another but he learned many things by it. For instance, a young engineer, wishing to run a consulting office, must be a "business getter" as well as an engineer. He should not pay out much of his own cash for his clients but, on the contrary, should have them put up the cash for expenses as needed and balance often. Again, if a client comes along with something that is worthless, have nothing to do with it—just have nothing to do with it, drop it and keep away from it as though it were dynamite, for the only bills that are paid cheerfully (if any are) are those that represent a part of some profitable venture or transaction. Although some men seem willing to profit by the losses of their clients, honorable men would not wish to.

Economical Generation of Steam

By William Kavanagh

> *Attention is called to the losses occurring through poor firing and lack of attention to the boiler-room equipment. Suggestions for minimizing these losses.*

Economy in a steam-power plant primarily begins in the boiler room, and depends largely upon two factors: good firing and proper care of the equipment. It will not suffice to spasmodically clean boilers, repair furnaces and occasionally put the grate bars in good order.

How then are the highest economical results to be obtained in the boiler room? This question is partly answered by having the boiler equipment in duplicate or, at least, in having a sufficient number of clean boilers to replace an equal number that have been running for some time. The period during which a boiler can be operated economically depends in a great measure upon the quality of the feed water and also upon the attention the boiler receives while under steam. If boilers are handled in the following manner, they may be operated economically or, at least, with as good economy as conditions will permit:

First, the feed water should be filtered and softened (if hard) and its temperature raised as high as possible before it enters the boilers. Second, the bottom blowoff should be opened at a time when the least ebullition is going on in the water. This will occur at about the time steam is to be raised in the morning, assuming the boilers are shut down for the night with banked fires. Just before spreading the fires the bottom blowoff should be opened and some water allowed to escape to the sewer or tank provided for that purpose. If the boilers have been properly set and fitted with an independent feed pipe, the greatest amount of deposit will be found at or near the blowoff; therefore, it is poor policy to feed and blow through the same pipe, especially if the boilers cannot be shut down regularly for cleaning. The blowoff should be located at a point in the boiler where the least amount of agitation is present in the water and it should be independent of the feed pipe. Furthermore, the feed and the blowoff should not be located at the same end of the boiler.

Another factor which has an important bearing upon economy is clean boiler tubes; these should be blown free of dust at regular intervals, as dust is a good nonconductor of heat and its presence on the surfaces of the tubes always denotes a loss of fuel. If the boilers be of the horizontal tubular type the tubes should be scraped as well as blown and, if they be of the water-tube type, the tubes should be blown both horizontally and vertically; the mere thrusting of a steam pipe between such tubes and allowing the steam to blow for a few moments is little better than nothing at all. In general, it will be found that the water-tube boiler is difficult to keep clean, and the blower used for blowing the dust from the tube surface should be bent to nearly a right angle so as to enable a jet of steam to be directed against the sides of the tubes as well as along their upper and lower surfaces.

The feed water can be raised to a sufficiently high temperature by employing what is known as the "series system." With this system the water approaches the boilers by stages, passing from one heater to another, the coldest water entering the coldest heater and the hottest water the hottest heater, being subjected there to the temperature of the hottest exhaust steam. The first heater is called the "primary" heater and if three heaters are used the middle one is called the "secondary" heater and the third the "main" heater.

This system is practicable only where the steam is taken from such sources as the receivers of a triple-expansion engine. Where an economizer is used the water issuing from the main heater passes through the economizer and thence to boilers.

Another fault often met with in practice is that of leaving the feed line exposed. This is also true with respect to steam lines, engine and pump cylinders and steam chests. All surfaces containing steam should be covered when possible to prevent radiation. Furnace linings should be tight, and hollow walls should not be allowed in the boiler setting, and all cracks and leaks in the walls of the setting should be stopped.

The firing should be regular and in no case should the whole of the incandescent fuel bed be covered with fresh coal. Usually, the best method of firing is to cover one side of the fuel bed first and when this has reached its maximum incandescence the other side is covered, thus establishing an alternate method of firing. There is a wide difference of opinion as to how coal should be burned. Some firemen prefer the "sprinkling" method, that is, spreading the coal over the fire in a thin layer, repeating this regularly and often. The objection to this method is that the amount of cold air admitted to the furnace is largely increased. The opposite to this method is to fire heavy each time, thus excluding the cold air. This practice is also objectionable because a distillation of the volatile gases of the coal will occur and find their way to the uptake without being burned.

However, the most effective method of firing often depends upon local conditions and for that reason only experienced firemen should be employed. There is no doubt that a large percentage of the losses occurring in a steam-power plant originates in the boiler room, and is incurred by poor firing, dirty boilers, poor boiler settings, dilapidated furnace lining and grate bars, loss of coal by allowing it to mix with ashes and also by having a bed of good coal lying on the boiler-room floor to be ground into dust by continual walking upon it. Again, it is not uncommon to find a badly packed boiler-feed pump that must be run at high speed in order to maintain the water level in the boilers. Leaky pipes and joints, valves, etc., all have a tendency to increase the total loss.

Locomotive Tubes, Their Treatment*

By F. N. Speller †

In which the author touches on the main points requiring attention, such as corrosion, leaking, strength of material, weldability and uniformity of material.

The tube industry owes much to the railroads for its development; in fact, the invention of lap welding may be traced to the necessity which arose on the building of George Stevenson's first locomotive for a tube which would be safer and stronger than the butt-welded tube, the only one made at that time. Since Stevenson's day the manufacture of locomotive tubes has increased in quantity and quality as the demands of railroad service became more exacting and the whole tubular industry was no doubt favorably affected thereby. Seamless steel tubes were introduced about 1886 and established a new standard of strength and ductility and endurance under many conditions of service. Later on, a satisfactory grade of soft steel was produced which could be lap welded like charcoal iron and this also has been much improved, so that there are now practically three classes of tubes for locomotive service: charcoal iron (lap welded), steel (lap welded) and seamless steel. Charcoal iron formerly was made from a special grade of pig iron made in a small blast furnace using charcoal fuel. The product of this furnace was charged into the refinery, where about one-half of the impurities were oxidized and fluxed away, the metal being subsequently treated in lots of 300 pounds or so in a slightly modified type of the old catalan forge with charcoal as fuel. The use of so much charcoal has necessarily been stopped and in many other respects the manufacture of charcoal iron for tubes has of late years been considerably modified. Of those changes we are not in a position to speak, for, as it was evidently impossible for obvious reasons to continue the manufacture of charcoal iron strictly along the old lines, we abandoned the making of charcoal-iron tubes about two years ago in favor of lap-welded and seamless steel, which had by that time been proved a fit substitute and in some respects decidedly superior to the older material.

When steel is spoken of in this paper the method of manufacture is referred to more than the finished product, as the steel used in the manufacture of tubes, as a matter of fact, is a purer form of iron than that made by the charcoal process, and like the older metal cannot be tempered.

A special grade of bessemer steel was at first used in the manufacture of lap-welded tubes, on account of its superior welding quality, but later on had to be abandoned as under some conditions it was found to develop brittleness in the beads after the tubes had been in service some time. The substitution of basic open-hearth steel low in carbon and with less than 0.05 per cent. phosphorus and sulphur has been found after more than two years' trial to entirely do away with any tendency of this kind, and as now made there is little difficulty in securing a strong weld with this steel. Seamless and lap-welded steel tubes are now made from practically the same grade of soft basic open-hearth steel.

It is a good thing for manufacturers and consumers to get together and learn each others' troubles. Perhaps out of the discussion to which we are leading up, something of value to both sides will result. Let us then take up what seem to be the main points requiring attention in the locomotive tube in order that it may give the best service under modern conditions.

Resistance to Corrosion

The manufacturer should furnish a tube in the best possible condition to withstand corrosion and pitting; that is, the metal should be as uniform in composition and density as it is possible to make it. Much can be done to lessen the tendency to pitting by proper attention to the making of steel and the way it is worked. We have been experimenting on this problem now for several years and have gone to considerable trouble in the matter of testing and inspection of material and in the process used for manipulating the steel so as to produce a tube which will resist corrosion as well as iron can be made to do so, and, judging from the reports of comparative service tests which have been received, steel so made is, in this respect, at least the equal of the best charcoal iron.

After all, however, the solution of this problem is largely in the hands of the user. Iron or steel will corrode in spite of anything that can be done if certain material is in solution in the water, particularly dissolved oxygen or carbonic acid. By the removal of these harmful agencies corrosion may be reduced to practically nothing. It is generally understood nowadays that water conditions have everything to do with corrosion, and the simplest solution of the problem is to treat the water with the object of making it as harmless as possible. The development of the modern tube to withstand corrosion and the treatment of water have together practically eliminated this trouble, so that it is rarely the case that tubes fail nowadays through pitting.

Leaking in the Flue Sheet

The construction and handling of the engine has so much to do with the trouble experienced from leaky flues that it is difficult to determine how much, if any, of the responsibility for this should be placed on the tube material. If railroad engineers will tell us what qualities are required in the tube to make it hold tight in the flue sheet, we will be glad to follow their suggestions as closely as possible. At the present time the steel tube is made as stiff as possible consistent with the best welding quality and ability to stand up successfully under expansion and beading in the tube sheet.

Strength and Ductility of Material

The tube should be of such quality as to stand repeated tightening in the flue sheet without cracking or showing undue evidence of fatigue, nor should these weaknesses develop during the life of the flue in service. The material found best adapted to give these properties is a special grade of soft open-hearth steel carrying not over 0.05 per cent. phosphorus or sulphur.

Weldability

The quality of the metal and method of handling are equally important in safe ending. Soft steel has been found somewhat harder to weld than charcoal iron, but it has been greatly improved in this respect. The necessity for a good welding quality steel is of first consideration in making locomotive tubes so that they may be easily safe ended, and this point has received a great deal of study, especially in the manufacture of lap-welded tubes where it is, of course, one of the first essentials to manufacture. Charcoal iron carries considerably more impurities than soft open-hearth steel, and these impurities form a self-fluxing mixture which facilitates welding. Railroad specifications have been so tightly drawn on composition in some cases as to work against the production of a good quality of steel for locomotive-boiler tubes by calling for unnecessarily low phosphorus and sulphur. There is now very good reason to think that a mistake has been made in this direction and that the general welding quality of the steel would be much improved, and the steel at the same time would lose nothing in other respects, if the maximum

*A paper read before the Pittsburg Railway Club, April 28, 1911.

†Metallurgical engineer for National Tube Company.

phosphorus and sulphur limits were both raised to 0.05 per cent. With producer gas, now generally used of necessity, it is a very difficult matter to keep the average sulphur in the heat below 0.035 per cent. and in order to remove this sulphur in the open-hearth furnace the steel has to be held and worked in such a way as to frequently leave it dry and difficult to weld.

Before the steel can be welded in practice a fluid cinder must be formed on the surfaces which are to be united. If the metal is heated too far above the point at which this cinder should flow, it will be burned and destroyed. We endeavor to have the range of temperature between the cinder-forming and burning points in the steel as wide as possible, so as to assist in lap welding and give the largest margin of safety in safe ending. Considering the variety of the requirements it seems that the composition of the metal should be left largely to the discretion of the manufacturer so far as is consistent with a certain specified standard of physical quality in the finished tube. We frequently go to the trouble of rephosphorizing for the purpose of improving the fluxing and welding quality of the steel.

The method of safe ending has as much to do with obtaining satisfactory results as the material, but no attempt will be made to lay down specific rules as to construction of the furnace and heating, for many of the practical shop men present who are welding flues every day are much more able to discuss this side of the problem. However, there are a few broad principles on the heat treatment of tube steel which should be taken into consideration. The preliminary heating of the body tube preparatory to flaring out the end should be carried to a bright orange color, judging by good shop light, 1750 degrees Fahrenheit. In the case of steel on steel, if the body tube is allowed to cool black after heating to this temperature and inserting the safe end the grain structure will be refined and the metal put in much better condition for the welding operation which follows. Moreover, if the preheated body tube is returned to the furnace without cooling, the metal may be crystallized or burned before the safe end has been heated hot enough to weld. Should there be any considerable difference in thickness between the safe end and body tube, it is evident that there is again a risk of overheating the one before the other is sufficiently heated to weld. If the body tube is returned to the furnace while red hot and the safe end is at the same time a gage or two heavier, there is, of course, all the more chance of crystallizing or burning the body tube at or near the weld. Taking unnecessary risks of this kind often explains subsequent failures which should not be charged up to the flue maker.

Tube Subjected to Crushing-down and Flattening Tests

It is not unusual for a flue welder who has never handled steel to have trouble for a few days. Remembering the above points and using his experience to the best advantage as to the condition of the furnace, the character of the flame, temperature, etc., the average man will soon be able to do equally reliable work with steel as with charcoal iron, as the experience of welders all over the country will show.

Uniformity of Material

This is a quality which the tubes should have in a high degree, both as to physical and chemical properties. There is no difficulty as to the average steel tube nowadays standing the master mechanics' tests made on one sample out of each hundred tubes. We have, however, recently designed a machine to make the flange, crushing down and flattening test on each end of every tube. This gives assurance both as to the character of the metal in each individual tube and also, in the case of lap-welded tubes, as to the welding quality being satisfactory. Steel tubes are now made in one grade of material suitable for either body tube or safe ending.

There is no difficulty in making steel tubes to stand the Master Mechanics' test on one sample out of each hundred tubes, the company has, however, recently designed a machine to make the flange, crushing down and flattening tests on each end of every tube, as shown in the illustration. This gives assurance both as to the character of the metal in each individual tube, and also in the case of lap-welded tubes, as to the welding quality of the material. Steel tubes are now made in one grade of material, suitable for either body tube or safe ending. Analyses of ends of tubes which have been used on railroads in the Pittsburg district showed that while the sulphur of the body tube is about 0.03 per cent. when new, the tube after being in service a year or so shows 0.06 per cent. of sulphur, and sometimes more, indicating that the steel gradually absorbs sulphur from the gases, which suggests that perhaps we are a little too particular as to the initial percentage of sulphur. The Master Mechanics' requirements are sulphur and phosphorus 0.05 per cent. In the analyses made during production the sulphur will average 0.03 to 0.035 per cent., and the maximum will exceed this. It is difficult to get the percentage of sulphur down to less than this without drying out the steel so as to impair its welding qualities.

Discussion

Mr. Redding said that in their practice they brought the tubes up to a welding heat in one operation, stuck the safe end in and continued the heating without any cooling of the body tube, as Mr. Speller recommended. They had, however, very few failures under this process with the cold-drawn seamless tubes. He thought that the absorption of sulphur from the fire was an additional reason why the initial sulphur should be kept down. With a high initial percentage of sulphur, the undesirable limit will be sooner reached.

Mr. Speller claimed that men who have had a great deal of experience in tube welding will not get into trouble from the overheating of the body tube, even if it is not allowed to cool before the safe end is heated with it. He said that the analyses indicate that the sulphur on the surface of tube heads reaches a maximum independent of the original sulphur contents. The cases of burning that he had seen were where the tube is burned back on the body tube, rather than right at the weld, in consequence of the body tube being hotter to start with, reaching too high a temperature before the safe end attained the welding heat.

Angus Sinclair said that he remembered locomotives with 6-foot tubes, and had seen them grow to 22 feet, and could not remember any time when there was not trouble from leaky tubes. He thought that the greater part of the trouble came from gross negligence in handling the engines, although there is no doubt that inferior material has been used for tube purposes to some extent. In Scotland they had nothing but brass tubes, but they had the same trouble. The man on the dumping pit is the fellow who causes most of the leaky tubes. He told how he got along very nicely with an engine which had a bad reputation, by being careful with the feeding and firing, always bringing the engine in with plenty of water, closing the dampers as soon as the fire was out and keeping the cold air from running through. When a blower is put on after the fire is out, it is "beyond nature" that the engine should keep from leaking.

Mr. Redding said that in the later-day service the fireboxes are so big, and the demands for steam so great, that they had to fire with the fireboxes wide open. The ash pans do not have dampers any more, and after the engine starts for the roundhouse there is no reason why the cold air cannot get to the tubes. Tubes are necessarily cooled down very quickly after the fires are out.

A gentleman present stated that cases are frequently cited where steel has been subjected to a few hours' test with acid and reduced perhaps 40 or 50 per cent., wrought iron a little less, and the so-called ingot iron showed no depreciation whatever. If this were a fair test, it would indicate that we should return to the old wrought iron, but the speaker doubted the fairness of the test. He said that they were building quite a number of power houses, and for the smokestacks had used different kinds of metal with a view of ascertaining which would best resist corrosion. They had something like sixty power houses and were now using open-hearth steel, his people considering it the most economical, for the reason that when they specified wrought iron, they paid for wrought iron and got steel anyway. They did, however, use charcoal iron for safe ends for tubes, because they felt that they got a little better weld between the charcoal wrought iron and the steel tubes than they did with steel safe ends.

Mr. Speller replied that a committee of the American Society for Testing Materials had gone into this subject very thoroughly, and their verdict, in which they say that the acid test is unreliable and misleading, will be found in the *Proceedings* of that society for 1908 or 1909. The reason is that there is no comparison between the action of acid solutions and natural corrosion. The very pure iron that the speaker referred to as having stood the acid test is open-hearth steel refined to the very last point, so that it may contain as high as 99½ per cent. iron. So far the indications are that ordinary soft steel, if properly made, will stand up just as well, but it will be some time before we have enough tests to actually prove that point. They felt that steel especially made for welding is as good as anything procurable at present. They had watched this point for several years. The usual method of testing was to compare a set of tubes of one material with another in the same engine. They would then duplicate them and reverse the position in the engine. Sometimes railroad men preferred to take several engines and put several sets of tubes in. They had made tests on at least twenty railroads, with the result that they had found very little difference between modern steel and charcoal iron.

Mr. Lovekin said that about ten years ago he had fitted six steamers that were built for the American-Hawaiian Steamship Company, with the Shelby cold-rolled steel tubes, and they have been running with both coal and oil fuel ever since, with no tube troubles. Since that time they have built about twenty steamships, all of them fitted with the Shelby tubes. The small amount of trouble experienced in marine practice as compared with locomotive practice might be due to the fact that the marine men do not cool and heat up their boilers as the railroad people do. In a ship a fire is kept up continuously, sometimes for sixty days. With an oil-fired furnace no cold air enters; the temperature is much more uniform and the conditions more favorable. On the other hand, they had had trouble in their power houses and blamed it on the steel tubes (feed pipes?) which had rusted out in six years. They now have wrought-iron tubes and do not know whether they will last six years or not. He thought that the trouble was from air in the feed line. He asked Mr. Speller to explain what was meant by a Spellerized tube.

Mr. Speller replied that five or six years ago they started to study the question of corrosion in all its phases, and found that the amount of forging and working which steel received was a factor that had much to do with the durability of the material, so they got up a process, which has become known by the name referred to. It has a decidedly beneficial effect, but it is not the only thing by any means. Care must be taken in the making of the steel itself. They found that the lap-welded steel tubes so made will stand up at least as well as the best charcoal iron.

Doctor Unger said that the two points which had impressed him in listening to the paper and the discussion were—how easy it is for the user to destroy material that was initially good, and how easy it is for the purchaser to insist on specifications that do not have any value. Anybody who is interested in the question of corrosion can find a full discussion of experiments in the *Proceedings* of the Iron and Steel Institute for 1908. This fact, not previously known to metallurgists, was found: If iron or steel is heated to about what we call a blue heat, or approximately a temperature at which lead would melt, it would be corroded much more quickly than if quenched from a higher to a lower temperature. It is easy to see how one in welding tubes may get a condition such as that described.

We know that our water supply is becoming much more impure. On account of the coal developments the water has become much polluted, and it frequently happens that we have in the Monongahela river as much as seventy parts of sulphuric acid to a million of water. This means that the plant to treat this water requires a great deal of salts, and by an analysis of the water used in the boiler we frequently find that we are trying to make steam from what one might call a solution of brine.

The air in Pittsburg one hundred years ago was much more pure than at the present time. Vegetation is disappearing. We are filling the air with poisonous gases, with the consequence that roofs made of iron and steel will not last as long as formerly. You all know that the tinplate made years ago was very much better than today. The same is said of galvanized materials. He also understood that steamfitters must not use anything but wrought-iron pipes, especially if they go through ash piles, because they will be corroded very much quicker. "There is nothing lasts like old-fashioned wrought iron." They had taken locomotives and put some steel tubes and wrought-iron tubes in them, and after about three years the wrought-iron tubes were removed and found to be badly corroded and pitted and would not hold steam any longer, while the steel tubes put in in the same way and at the same time were in good condition. In order to satisfy himself on this question he had been carrying on experiments for three or four years by immersing wrought-iron and steel tubes for a period of a year, and then removing and cleaning them to learn the results. They afterward placed both wrought-iron and steel tubes in an ash pile for fifteen months, and had them removed and cleaned. They now have tubes buried in loam, and expect to allow them to remain there for two years to see what the effect will be. They had a number of sheets of various material, bessemer steel, two grades, open-hearth steel and three grades of wrought iron. They cut small pieces of these sheets and gave them what is known as the acid test. In one case a good grade of wrought iron dissolved 30 per cent. slower in acid than did the steel, but he found that the iron that had dissolved so slowly in acid did not resist atmospheric influences by one-half as well as the steel sheet. The only real test of corrosion today is an exposure test under service conditions.

Mr. Conrad said that corrosion is due, not only to impurities in the water, but to expansion and poor circulation and low temperature in the boiler. It has been his experience on modern locomotives, with tubes 20 feet and over in length, that the tube corroded mostly from the front tube sheet back about 4 feet. His conclusion was that this was due to the fact that the circulation was poorer at the front end of the boiler than further back, and the temperature lower. Dissolved oxygen and gases will attack iron at a low much more quickly than at a higher temperature. On one case, where an engine had run 101,000 miles with both iron and steel tubes, there were forty-six iron against fourteen steel tubes that were pitted badly enough to be consigned to the scrap pile. On three other engines, which had made a mileage of 62,000 miles, when laid up for general repairs the iron and steel tubes with which they were fitted had stood up equally well. Some years ago they had had trouble with corrosion in condensers and had tried a number of different kinds of tubes. They finally settled upon a brass tube, which resisted corrosion very well, but the bottom of the condenser would have holes eaten into it. They came to the conclusion that it was due to poor circulation, and overcame it by entering the steam at the bottom. He found that in certain cases tubes had been spaced too closely, impairing the circulation and producing trouble. This is especially true of an alkali water, which has a tendency to pull away from the hot sheets. He had seen this demonstrated by a model boiler with 1/4-inch tubes, filled with an alkali water, and heated by alcohol. When the water began to circulate and the fire became intense, the water frequently left the sheet, but only momentarily. This, of course, had a tendency to loosen the tube in the sheet.

A speaker said that they had been using steel tubes for about twelve years in districts that had very bad water. They used steel safe ends, with the seamless tubes. In heating for welding in the safe ends they do not depend upon swedging the tube, but ream it, thus giving a bright surface. They also cut off the safe ends with dies, which gives two bright surfaces of new metal to come together for welding. Their tubes are tested by hydraulic pressure up to about 300 pounds, and seldom develop a leak. It does not matter what kind of a tube you buy, if it is not given proper care. In applying their tubes at first they used a roller, but are using it very little now. At the roundhouse the rolls have been thrown away entirely.

It was stated that the superintendent of motive power on one of the railroad systems had reduced their boiler troubles to a minimum by carrying 10 per cent. below the pressure of steam allowed; that is, on boilers which were allowed 200 pounds, they carried only 180, and the question was raised as to why it would not be well to extend this practice to the railroads which were having boiler difficulties.

Mr. Redding replied that they need every ounce of power that they can get. He had tried both iron and steel tubes and found that the steel safe ends and the steel tubes would stand more punishment. On engines which do not receive very severe treatment they frequently have tubes that last too long, for some of the State laws require that they be removed every three years.

Mr. Lovekin asked what was the use of the copper ferrule between the tube and tube sheet. He said that he had visited the works of the Babcock & Wilcox Company abroad, and their manager said that they had very little trouble with tubes, as they reamed all of the holes and ground every tube, allowing no more than 0.005 clearance between the tubes and the aperture.

Mr. Conrad explained that the reason for the use of the copper ferrule is that that material is much softer and has a greater coefficient of expansion than iron. It helps to make a joint and cushions the tube, maintaining the tube tighter. He has known of a case where orders have been given on a railroad to extend the copper the same length that they would the tube, with the consequence that the tube was entirely away from the sheet, but the expansion of the copper under the bead was disastrous.

That the purchase of coal on specifications needs to be followed up with analyses of the deliveries has been amusingly demonstrated by the recent experience of a Massachusetts city. The school board of this city has for some time been buying coal for the school houses on specification, but only recently did it take any steps to see whether it was actually getting the quality it was paying for. Lately it has made the first analysis of the coal delivered to it, and discovered that the coal was below the stipulated quality. As a result of this analysis, costing $10, the coal dealer has paid to the city a rebate of $873.01.

Sampling Coal

Following are the specifications for sampling coal as prepared by Arthur D. Little, Incorporated, chemists and engineers, of Boston. By this process the final sample is fairly representative of the entire shipment:

The original sample should preferably be collected in a large receptacle with the cover attached, by taking small shovelfuls from many parts of the car, barge or vessel as it is being unloaded, or from as nearly all parts of a pile as possible, care being taken in all cases to secure practically the same amounts from the top, middle and bottom of the coal. The original sample thus taken should amount to 500 pounds or more, preferably 1000 to 2000 pounds. A separate sample should be taken from each thousand tons or less delivered.

The gross sample thus collected should contain the same proportion of lump and fine coal as exists in the whole shipment. It should be protected from the weather in order to avoid gain or loss in moisture and should be immediately quartered down to a smaller sample, according to the following method:

The large lumps of coal and impurities should be broken down on a clean, hard, dry floor with a suitable maul or sledge, and after being thoroughly mixed, should be formed in a conical pile. The pile is then quartered, the two opposite quarters are rejected and the remaining two broken down to a smaller size, mixed and reformed in a conical pile and quartered as before. This process should be continued until the lumps are 1/4 inch in size or smaller and a one- or two-quart final sample remains. All of this final sample should be placed immediately in one or more glass or metal jars and sealed air tight. The following table gives the largest sizes allowable in the samples of various weights and the coal should preferably be broken into still smaller sizes before quartering:

Weight of Sample	Largest Piece Allowable
[illegible] pounds or over	[illegible]
[illegible] pounds	[illegible]
[illegible] pounds	[illegible]
[illegible] pounds	[illegible]
[illegible] pounds	[illegible]
[illegible] pounds	[illegible]

The sample should be worked down as rapidly as possible to avoid loss of moisture through exposure to the air. The outside of the jar should be plainly marked and a corresponding designation placed inside. The following data should accompany the sample:

Coal purchased by [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

Electrical Department

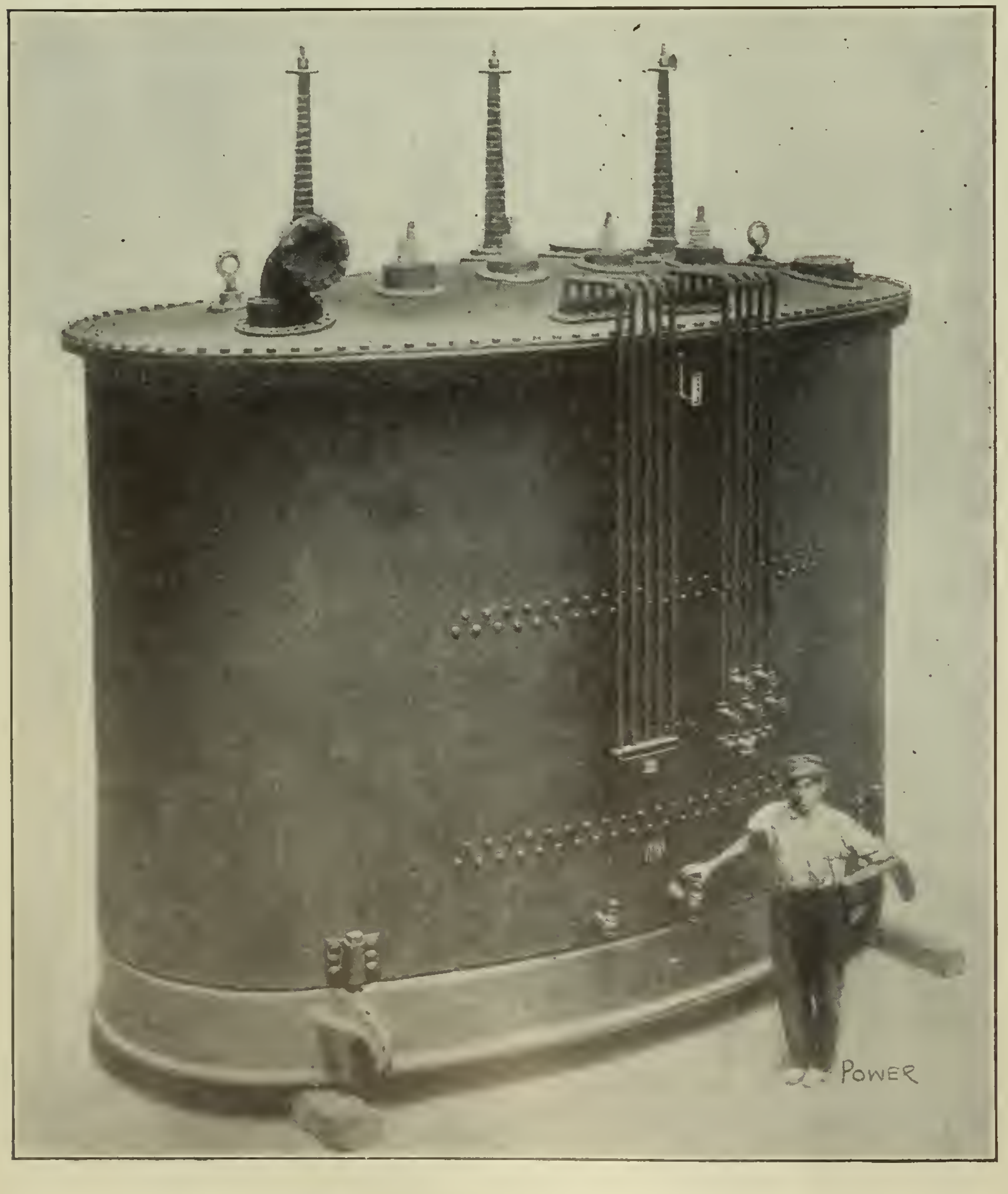
Especially conducted to be of interest and service to the men in charge of the electrical equipment

A Large Transformer

The Pennsylvania Water and Power Company generates power from the Susquehanna river at McCall's Ferry, where it will have an ultimate capacity estimated at 100,000 kilowatts. At present the power generated is transmitted 40 miles to Baltimore, and lines to other large cities, of which there are several within economical transmission distance, are contemplated.

The Baltimore substation at present contains four Westinghouse three-phase transformers which are interesting because they are the largest ever built. They are of the water-cooled shell type and are used to step down the 25-cycle line currents from 70,000 to 13,200 volts for primary distribution. Each transformer is rated at 10,000 kilovolt-amperes. The appearance of one of these transformers is shown in the accompanying picture, but this does not give an adequate impression of their size. The tank is elliptical, having an overall length of 15 feet 11 inches and an overall width of 8 feet 8 inches. The hight to the tops of the terminals is over 16 feet and the joint between the tank and the cover is 11½ feet from the floor. The weight of each transformer, complete with oil, is about 145,000 pounds—nearly 75 tons.

It is difficult to get a mental grasp of the magnitude of such a piece of apparatus. If the output of one of these transformers were delivered to 16-candlepower tungsten lamps, it would supply 500,000 of them; these lamps laid end to end would form a "string" 31½ miles long. If suspended at intervals of 10½ feet, they would illuminate a pathway a thousand miles long. Using arc lamps instead of incandescents, one transformer would supply 25,000 lamps and these would illuminate a boulevard 100 feet wide, reaching from New York City to Toledo, O., or from Chicago to Memphis, Tenn.



A 10,000 Kilovolt-ampere Transformer

Grooving Commutators

By C. L. Greer

It has for some time been a practice in street-railway shops to groove or undercut the commutators of car motors but the practice does not seem to have spread extensively to power-station apparatus. From my own experience I believe that this practice would be helpful in many cases of commutator trouble with generators and rotary converters. Where there is a tendency to high mica, the undercutting of the commutator (cutting the mica below the surface of the copper bars) will greatly reduce and sometimes completely eliminate sparking at the brushes. I know of a 300-kilowatt motor-generator set which gave continuous trouble from sparking, making frequent turning of the commutator necessary. After grooving the commutator the machine ran sparklessly and the commutator took on the chocolate-colored polish which follows perfect commutation.

I once had the care of a 250-kilowatt three-phase rotary converter which gave continuous trouble from sparking at the brushes. The commutator developed burned blackened spots at irregular intervals around its circumference. In some places six or eight bars were affected and in others only two or three were burned. The accompanying sketch illustrates the results of the trouble. The bar burned away from the mica, with bad sparking at the brush as the bar passed from under it. This kept the commutator very rough, making frequent use of the sand-paper block necessary. Finally it was decided to groove the mica out at the bad places, after which there was a decided improvement.

Where no special means is provided for grooving, the work may be done with a hack-saw blade. A new blade should be broken, which leaves a sharp tooth on the broken end of one piece; with this the mica may be cut down easily. A straight-

Effects of High Mica

edge may be laid along the mica and the blade drawn along between the bars. One or two strokes will produce a groove which the blade will follow easily. Only a slight depression is necessary; I have found a sixty-fourth of an inch to be sufficient. If, as in the case of my rotary converter, the trouble occurs in spots, the bad bars may be marked on the end before turning the commutator and only the mica at the bad spots cut down. Though my experience with this remedy has been limited, I believe that it is worth trying where sparking and burning of the bars occur.

Alternators for Waterwheel Drive

Alternators direct-coupled to waterwheels operating under such heads as are common in modern hydroelectric power plants run at relatively high speeds and operate under conditions which make rugged construction necessary. Hence one finds machines built especially for this class of service. In general features the waterwheel-driven alternator does not differ from its prototype driven by a large reciprocating steam engine; the chief differences are in mechanical construction.

Fig. 1 illustrates a polyphase alternator built by the General Electric Company for use in hydraulic stations. The picture shows clearly that the shaft and bearings are exceptionally massive; that the shaft and base are made extra long, to permit sliding the stationary armature along the base far enough to uncover

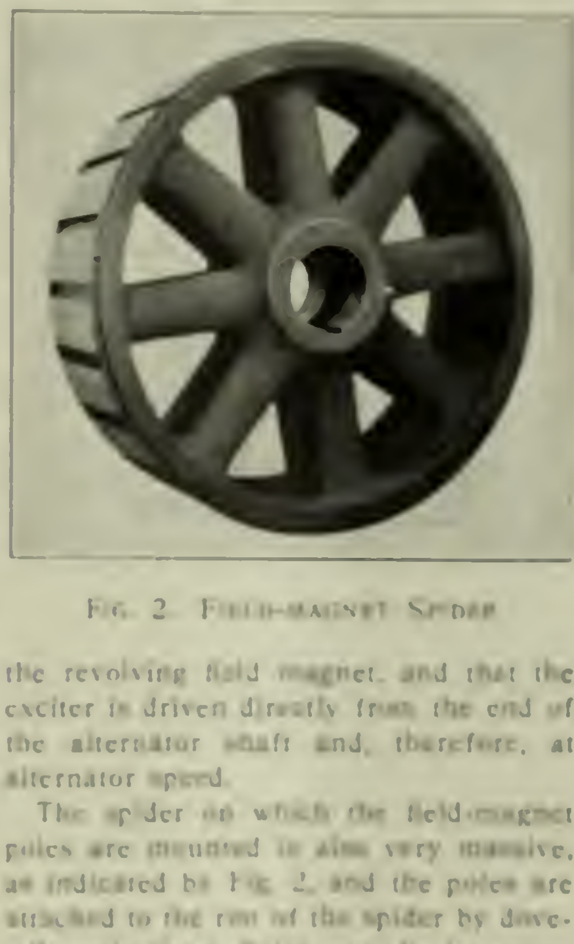


Fig. 2. Field-magnet Spider

the revolving field magnet, and that the exciter is driven directly from the end of the alternator shaft and, therefore, at alternator speed.

The spider on which the field-magnet poles are mounted is also very massive, as indicated by Fig. 2, and the poles are attached to the rim of the spider by dovetail projections fitting snugly in corresponding slots across the face of the spider. The poles are prevented from shifting in their slots by end rings bolted to the edges of the spider; these are shown in position in Fig. 2. The poles are laminated and the laminations are bolted together between heavy cheeks, as shown in Fig. 3. The free ends of the poles are stamped with extensions, or poletips, as usual, and the cheeks cover the polar extensions and are provided with flanges which support the ends of the coils.

The armature core is built up of circular segments with the joints staggered in successive layers, as usual in large

Fig. 3. Field-magnet Pole

sizes, and these are dovetailed in ribs across the inner face of the housing in exactly the same way that the magnet poles are dovetailed to the spider rim. Fig. 4 shows this construction and also shows a simple bolted-on type of magnet pole that is used in alternators which run at sufficiently low speeds not to require the dovetail fastening. The armature housing is ventilated by openings through the main ring and by spaces behind and at the sides of the armature core, as illustrated in Fig. 3. The core

Fig. 4. Section of Armature

and joints are ventilated by the usual spaces or radial ducts at intervals in the core body; two of these spaces are provided in the core here illustrated.

When the armature winding is a basket coil, the protecting coils are secured to

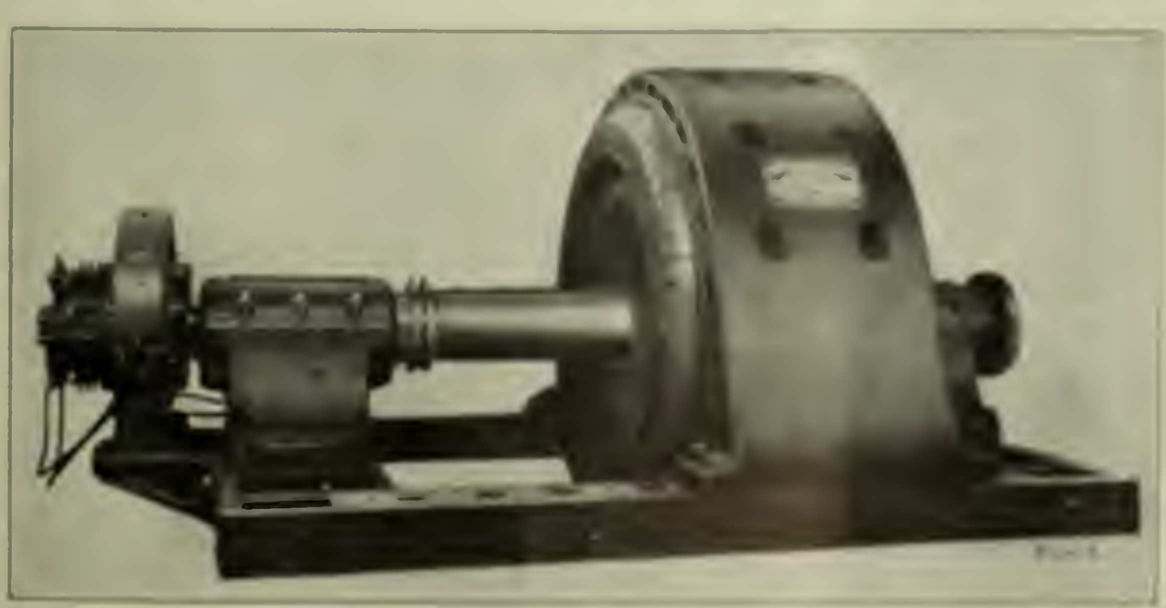


Fig. 1. Alternator for Direct Drive by Waterwheel

insulated metal rings in order to prevent accidental displacement or distortion due to magnetic disturbances produced by violent load fluctuations. Both the field-magnet and armature coils are form-wound and heavily insulated, of course, before being put in place.

The bearings are self-oiling and in the larger sizes provision is made for water-

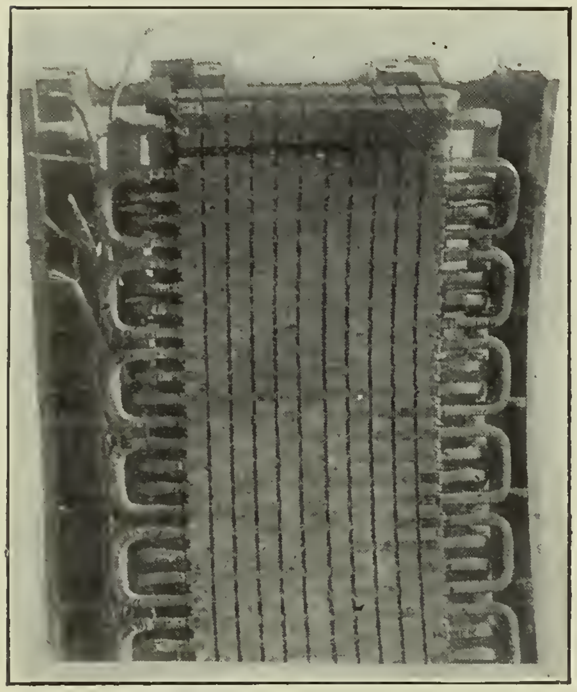


Fig. 5. Part of Armature Face

cooling by means of tubes extending horizontally through the oil wells; the cooling water is circulated through these tubes and takes out the heat from the oil.

CORRESPONDENCE

Trouble with Series Incandescent Lamps

We had a little experience with a lamp on a series circuit which, although not exactly in the usual operating engineer's line, may prove of interest to plant operators in smaller places who have more or less to do with the outside distributing system.

Our street circuit contains 67 series incandescent lamps of 32 candlepower each, supplied with a constant current of 6.6 amperes controlled by a reactive regulator. We added one new lamp to the circuit and on the first night it burned out. It was replaced the next day and the burned-out lamp was found to have a hole burned in the glass, but not much importance was ascribed to this fact. The next night the operation was repeated and the damaged lamp was found in the same condition as the first one. This appeared strange, as in a series system all the lamps get the same current and it was not reasonable to suppose that a lamp at any particular point could receive any more current than the others.

Our next move was to take one of the old lamps from another point in the system, and try it at this point; it worked perfectly. We next put in a new lamp and it burned out in less than five minutes; it looked like a defective lamp, but we decided to investigate elsewhere before trying any more lamps. An examination at the station showed that the circuit was getting a little more than 7 amperes. The regulator was adjusted to pass exactly 6.6 amperes and another new lamp was put in; after that no more trouble was experienced. That was more than six months ago and we have added a number of new lamps since but have had no more trouble with burnouts.

By way of explanation, there had been no new lamps added to the system for some time previous to the trouble and it was known that the regulator could not have been out of adjustment for any great length of time.

Can anyone explain why the new lamps would not stand the excessive current and the old ones would?

G. S. Sprague.

Geneva, Neb.

Mr. Wilbraham's Interpole Motor Trouble

I found Mr. Wilbraham's article of March 28 concerning brush setting on interpole motors very interesting, but cannot in all respects agree with his conclusions. He states that he had compound-wound interpole machines arranged for variable speed by means of a combined armature and field controller and that after cutting out all armature resistance the speed was 800 revolutions per minute, which by field weakening could be increased to 2800 revolutions per minute, but some of the motors at about 2600 revolutions per minute would stop and reverse.

While the armature reaction and flux distortion are more or less as he outlines them, the fact that the motor stops and reverses is not due to a shifting of the neutral point and with it the zone of commutation but to the fact that the compound winding is differential rather than cumulative. As the magnetism due to the current in the series winding is maximum and that due to the shunt field current constantly decreases as the field is weakened, the final result is reversal of the polarity of the field-magnet poles and consequent reversal of the direction of rotation. Now if the series field winding were so connected that it assisted the shunt field winding instead of opposing it, the action described could not take place. Changing the direction of the current in the series winding is, therefore, to my mind the correct remedy rather than shifting the brushes.

It is primarily an error to buy a compound-wound interpole motor, for several reasons. Trouble may be caused by it, as already shown, and the compounding adds uselessly to the cost. The series winding on the interpoles of a shunt-wound motor will serve the same purpose as a main series winding; therefore, a main series winding in addition to this represents a duplication of equipment subserving no desirable end.

H. T. Dean.

Cambridge, Mass.

Mr. Dean's idea as to the prevention of the reversal of the motors by changing the series field windings from differential to cumulative is correct; that was tried at the time but the commutation was so much worse that it was abandoned. Moreover, preventing the motors from reversing was not the only thing to be considered; the guarantees as to speeds at different points had to be met and with the series field winding connected cumulatively the magnetic densities were so high that a greater range of shunt field adjustment was necessary to effect the range of actual field strength that was necessary. For this reason, as well as because of the impaired commutation, the remedy used was the only one that was practical under the operating conditions.

Mr. Dean's supposition that the interpole winding serves the same purpose as the series winding of a compound-wound machine is entirely wrong. The interpole winding adds no torque or counter electromotive force whatever to the armature; a shunt-wound interpole motor will have the same sort of speed characteristic as the ordinary shunt-wound motor, except that the speed regulation will not be so good because of the additional resistance of the interpole winding in series with the armature. It is to correct this poor regulation that a differential field winding is used. The only use of the interpoles is to give good commutation under conditions which would cause sparking in an ordinary motor and this is done by inducing in the coils that are short-circuited by the brushes an e.m.f. which reverses the current in those coils and thereby prepares them for insertion in series with the coils beyond them. The interpoles exert no influence upon the coils that are not short-circuited and these are the coils that do the work.

R. W. Wilbraham.

Philadelphia, Penn.

[The delay in printing the foregoing letters was due to our inability to reach Mr. Wilbraham, who was absent from his office.—Editor.]

Bill Grimes tried t' get funny tother day an' put wun over on yer Uncle Si; he didn't get anythin' on me so ez it cud be notised very much. He called me up an' sed he'd lost th' vacuum on his condenser, an' ast me ef I'd loan 'im wun. I told 'im ter use th' wun he carried in his hed.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

A Reversing Marine Diesel Engine*

By Th. Saubeblich

The prejudice against Diesel motors which still exists in shipbuilding circles has to a great extent broken down, and recently it has become clear that various shipyards are in position to build Diesel engines free from faults and reliable in working, even with their present equipment.

Hitherto the Diesel engine has been made almost exclusively single-acting. As a rule, the four-stroke cycle has been used, but recently the two-stroke cycle has come into prominence. The efforts to utilize the Diesel engine for large stations and finally for the propulsion of large vessels have given an impetus to the employment of double-acting engines both on the four-stroke and two-stroke cycles. In fact, leading ship owners, having recognized the great value of internal-combustion engines, are already approaching shipbuilders with orders involving their use.

The constructor is now confronted with the task of giving to the Diesel engine the reliability in working and capacity for maneuvering which distinguish the marine steam engine, and further, in consequence of the absence of steam supply, to find gear simple enough in handling and maintenance to suit the rough requirements of a ship's auxiliaries.

The advantages of the Diesel engine for marine purposes as compared with the steam engine differ according to the type of ship and the size of the equipment, but in general the following are among the most notable: The gain in useful space by the reduction [elimination?] of boiler equipment and small size of the fuel holders; increased capacity due to the small weight of the engines and the fuel; utmost utilization of the otherwise limited useful space taken for fuel bunkers; gain in time, and economy of wages due to quicker and easier bunkering, and also to decrease in coal trimming; quicker starting of the engine; reduced and easier management; wages and space economy by reduction of the number of the stokers; reduced cost of fuel; better engine rooms, resulting in the increased mechanical capacity of the personnel, especially in hot climates; the possibility of carrying more fuel, and therefore enlarged field of action.

But the introduction of Diesel marine engines also involves the solution of recent economic and constructional problems, of which the chief are the lack of suitable fuel in many harbors and the lack of steam for actuating the auxiliary engines on deck and in the engine room, as well as for heating.

The engine here described is the first marine Diesel engine built according to special design and put into service by a shipyard on the North Sea—J. Frerichs & Co., in Osterholz-Scharmbeck and Einswarden. It is a reversing four-cylinder engine of 200 horsepower, installed in the service boat "Frerichs," which is a single-screw vessel. She has been in commission about a year, being used principally, but also serving occasionally for transportation between Einswarden shipyard and the opposite bank of the Weser. The fuel employed is the so-called gas-oil, 1000 kilograms (2200 pounds) of which are stored in two tanks under the cabin. Double this quantity can, however, be carried. This quantity of fuel is sufficient for a voyage of 240 sea miles at 9½ knots.

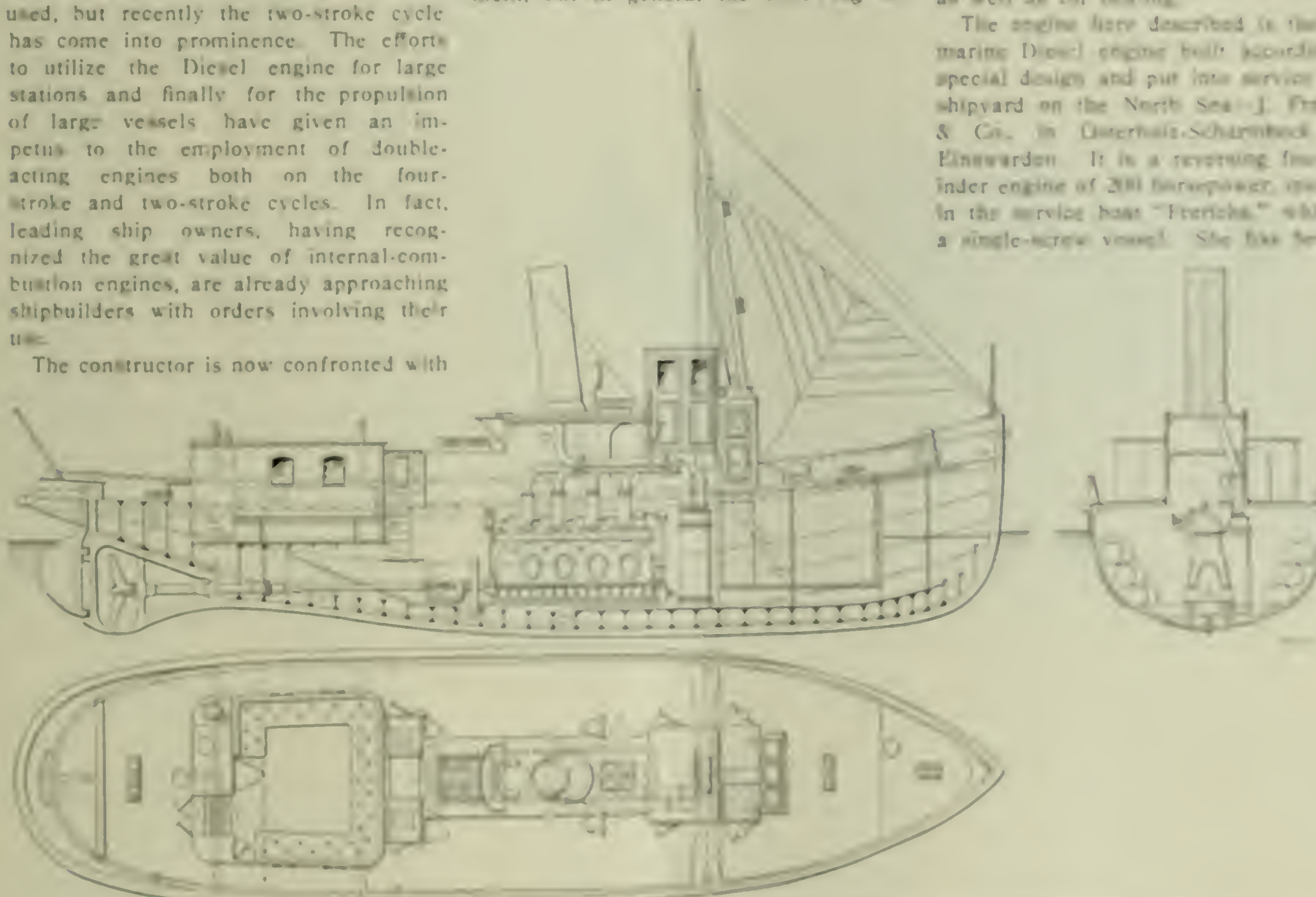


Fig. 1. Showing Arrangement of Diesel Engine Equipment of the "Frerichs"

*Abstract of a paper recently read before the Schiffbautechnische Gesellschaft (Technical Shipbuilders' Association), Germany.

The external appearance of the vessel is similar to that of a steam tug, because of the funnel provided for carrying away the exhaust gases.

Fig. 1 shows the arrangement of the power plant in the vessel and Fig. 2 gives an excellent idea of the appearance of the engine. It operates on the four-stroke cycle and the maximum speed is 360 revolutions per minute; at this speed it develops 200 brake horsepower—50 horsepower per cylinder—and drives the vessel at a speed of about 10 knots.

The cylinder head is the largest and heaviest casting in the engine, and on it are collected all the principal valves—the suction valve, the exhaust valve, the starting valve and the fuel valve. All these parts have to be got into a restricted area little bigger than the piston diameter, and yet to avoid unequal thicknesses of metal reasonable spaces must be left between the separate parts. This arrangement is also necessary to insure equal cooling and to avoid stresses being set up by unequal heating. Furthermore, an exceedingly sound casting is absolutely essential, particularly at the joints and valve faces and at those surfaces subjected to the high internal pressure in the cylinder or connected with the high-pressure air supply.

Fig. 3 indicates how all these requirements were met. As may be seen from the engraving, the suction and exhaust bends are separated from the two tubes or passages which take the starting and fuel valves. The exhaust bend is entirely surrounded by water and is of such a shape as to give an easy flow to the gases. The exhaust and admission valves seat direct on the cover, for in no other way was it possible to bring them so close together.

It may be objected to this arrangement that dismantling is more difficult than when separate valve cages are employed, as it involves the removal of the whole cylinder head, but in engines of this size no trouble in this direction has been experienced. The only real objection is that that part of the valve spindle exposed to the hot gases may wear more rapidly than the remainder, which is water cooled, but to reduce this objection the lower part of the spindle is protected by a cone from the direct impact of the hot gases. In the case of larger valves the employment of a liner is, of course, recommended. In order to make the cooling as effective as possible, the walls are made only ½ inch thick.

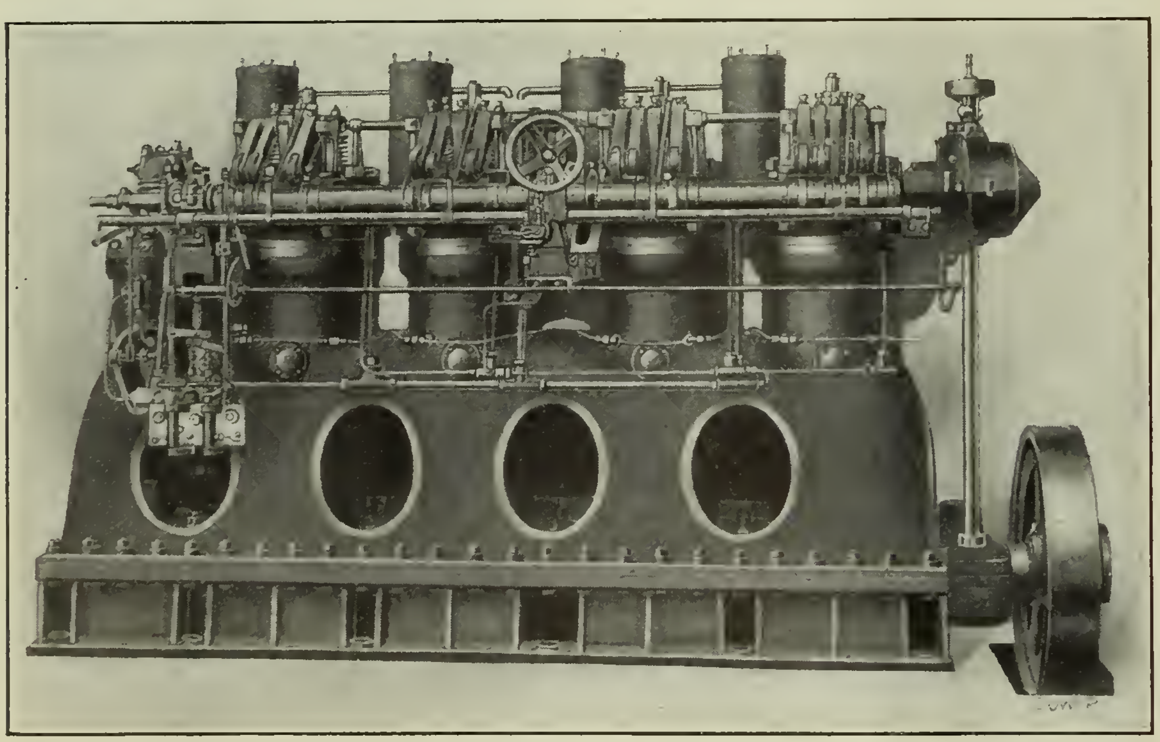


Fig. 2. A 200-horsepower Reversing Marine Diesel Engine

The reversing gear of the engine is based on the principle of shifting the cam shaft, on which two separate sets of cams are fashioned, endwise, the valve levers being raised just before this movement takes place and lowered again when it is complete. These movements are effected in the following way by the use of a single handwheel: The shaft *a*, Fig. 4, passes over all the cylinder heads, being carried by the columns *b*, of which there are two mounted on each head. To this shaft are keyed the fingers *c*, one over each exhaust and inlet valve, and the lever *d*, linked by *e* to the curved lever *f*, which, in turn, is linked to the piston rod of the reversing cylinder; the latter has pipe connections *g* and *h* extending to the valve box beneath the handwheel. Here either valve can be released by movement of the ⊥ lever *l*, which is effected by one end or the other of the notched quadrant *n* coming into contact with it; this quadrant is keyed to the handwheel shaft. The valve being opened, further movement of the plate releases the lever and the valve again closes. Owing to the form of the quadrant *n* and the notches in the quadrant *p*, this movement can only be effected in the central position *II*.

In Fig. 5 is shown a sector *T* which is provided with the cam face which moves the lever *B*, and thus moves the reversing cam shaft *N* endwise. The sector is coupled, by the link shown, to the shaft *w*.

The action of the reversing gear will now be easily understood. The hand wheel is moved to the middle position and is then revolved till the stop *r* on the notched quadrant comes against the quadrant *p* and stops further movement. During this action the valve *i* would be opened for a short time, allowing compressed air to get under the piston *k*, forcing it up. This causes movement of the linkage and presses the valves down into the cylinder. When they have reached their lowest position the action of the cam *T* moves the cam shaft endwise. By that time the piston *k* has returned to its starting position, lowering the valve rockers on to the second set of cams. The glycerin dashpot acts as a brake to prevent reversal taking place too violently.

Provision for lifting the rocker arms of the starting and fuel valves off their cams is effected, as indicated in Fig. 6, by mounting the respective rockers on eccentrics keyed to the shaft *w*. By turning the sleeve, the fuel-valve lever moves away from its cam while the starting-valve lever approaches its own cam; in this position both levers are clear of their cams and the shaft can be moved end-

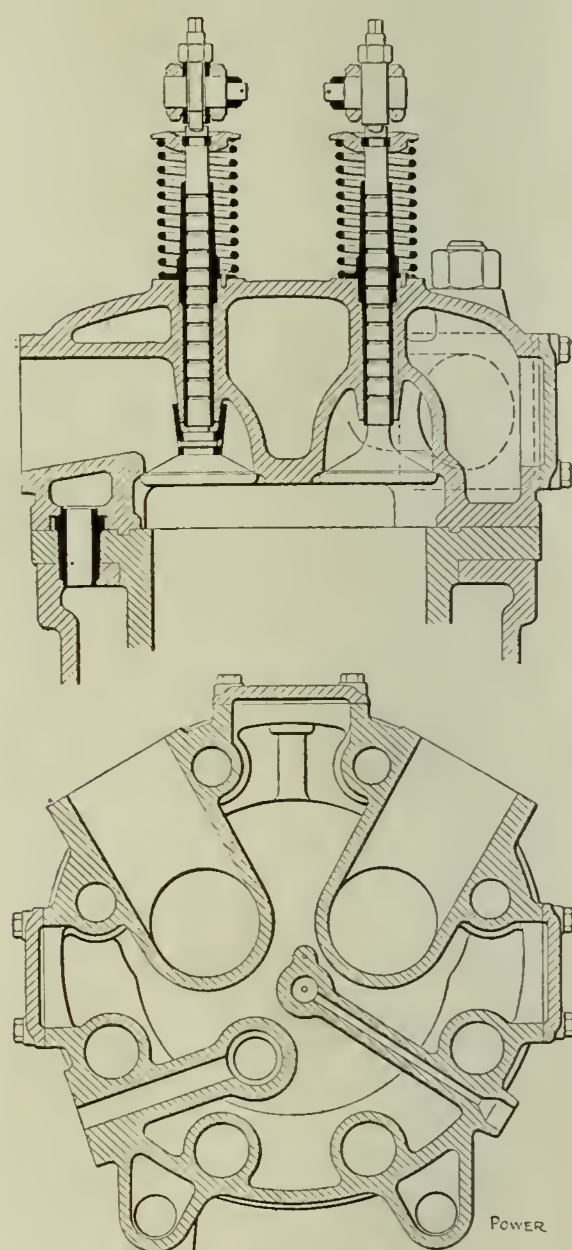
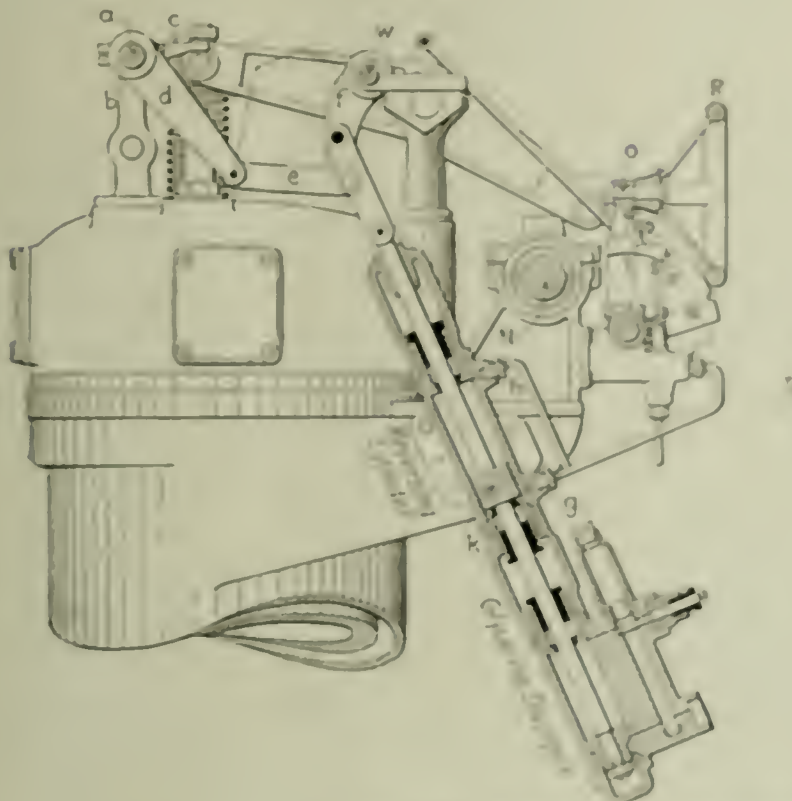


Fig. 3. Cylinder-head Sections

wise. By further movement to the starting position, the fuel-valve lever leaves its cam while the starting-valve lever comes into actual contact with its own.



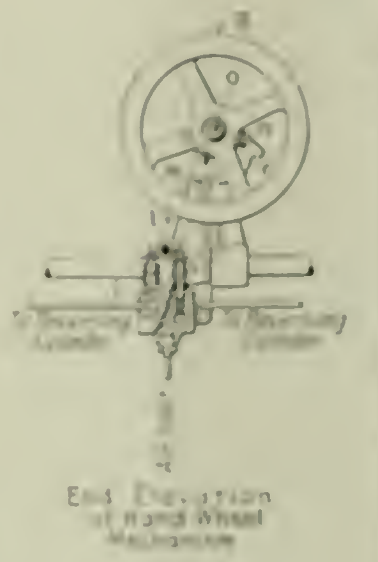


Fig. 4. Reversing Mechanism

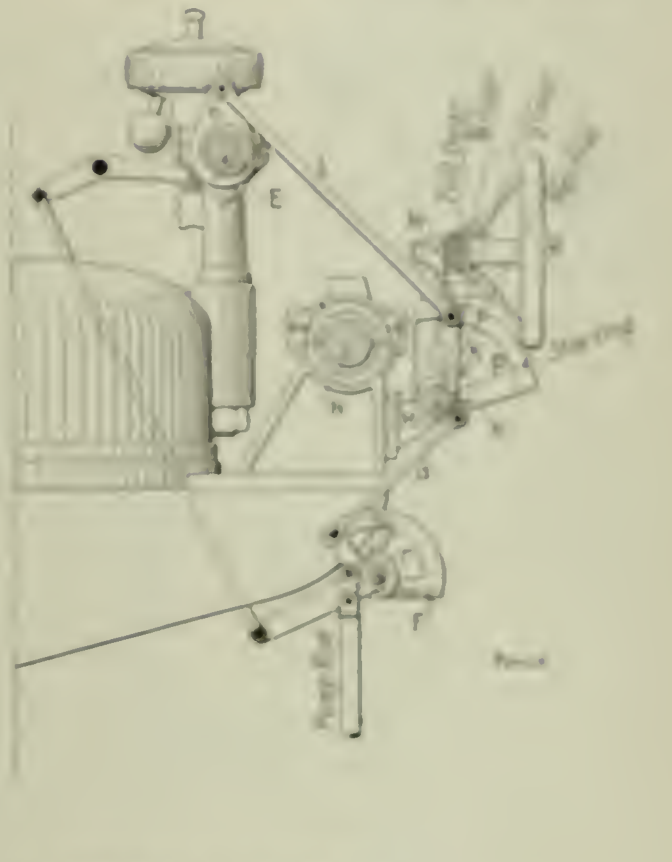


Fig. 7. Reverse-gear Details

Rotation is given to the eccentric sleeve by means of the mechanism shown in Fig. 7, from which it will be seen that it is coupled by the rod *L* to the shaft *M*, to which is also keyed the hand-wheel bracket *H*. This bracket, with the hand wheel, can be moved to three principal positions on the notched quadrant *p*: the first for running, the second neutral and the third or lowest for starting. Further notches for half and slow speeds are also provided. This control is effected through the link *d*, which acts upon the fuel-pump regulator rod. As the centrifugal governor also acts upon this rod, an elastic coupling in the form

Fig. 5. Cam-shaft Shifting Mechanism

of a flat spring *F* is provided. The governor was originally provided for the test stand, but in view of the fact that the engine might run light it has been retained.

The engine is started by means of compressed air and the compressor is a two-stage machine driven from the main shaft by a crank which is so set that when the engine cranks are on the dead center the compressor crank is not. Consequently, the compressor can be used as an air motor to start the engine even though the latter may stop on the center, which, however, is unlikely. Fig. 8 is a sectional elevation of the compressor. The low-pressure stage is double-acting and with-

Fig. 6. Air- and Oil-valve Mechanism

out suction valves, air being admitted by the piston overrunning a central port. On this low-pressure cylinder are placed the starting valves *A* and *B*, operated by the cams and links shown. This stage being double-acting, it is easy to arrange that it shall start in any position from which it is not possible for the power cylinders to start.

The lubrication of the gudgeon pins, which is always troublesome, is effected in this engine by the device shown by Fig. 9. The tube *A* on the piston at each outward stroke is driven into oil contained in the cup shown, some oil enters the tube and, being retained by the little ball valve, is driven up by the next stroke of the tube.

It is not generally possible to obtain such good diagrams from high-speed as from low-speed engines, owing to the very short space of time in which combustion has to take place, but almost ideal diagrams, as shown in Fig. 10, are obtained from this one. The average pressure shown by this diagram is about eight atmospheres. The fuel consumption measured on the test bench is between 215 and 220 grams (7½ ounces) per brake horsepower-hour.

The boat which is driven by the engine just described fully meets all the expecta-

Fig. 8. Air Compressor

tions formed of her as to maneuvering. The insurance companies have made exhaustive tests in this respect with a view to fixing the premiums payable and have satisfied themselves that the maneuvering capacity is equivalent to that of a steamship; they have therefore made the premium the same as that customary for steamships. The maximum speed of the

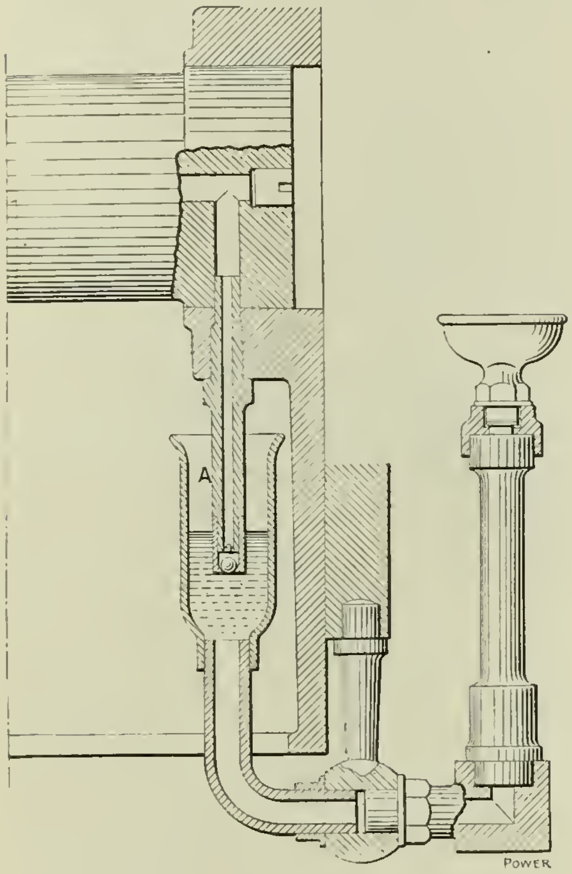


FIG. 9. GUDGEON-PIN OILER

FIG. 10. AN AVERAGE DIAGRAM

boat can be reduced, by regulating the engine, from about 10 miles to about 3.8 miles per hour, the revolutions of the engine being lowered from 360 per minute to about 150 per minute.

Reversing is carried out with surprising celerity and smoothness. Tests carried out in comparison with similar ships with steam engines have given the results stated in the accompanying table.

RESULTS OF MANŒUVERING TESTS

	A Steam tug. L. 20.95 m., br. 4.86 m., d. 2.18 m I.H.P. about 180; revs. about 185; reversing hand wheel.	B Motor tug "Frerichs." L. 18 m., br. 4.9 m., d. 2.00 m. I.H.P. about 185, revs. about 300; reversing hand wheel.
	Seconds	Seconds
1. Engine starts from rest, ahead, about.	4–5	2–5
Engine starts from rest, astern, about	4–5	2–5
Engine reverses, from beginning of motion, full forward to full astern.....	15	8
2. Beginning of boat's motion forward from rest........	6	11
Beginning of boat's motion astern....	10	12
I. Boat comes to rest from full forward to full backward..	30	27
II. From rest to full speed astern.....	20	10

Comparison of Actual Gas Power and Central Station Figures

BY SAMUEL W. RUSHMORE

The central-station people have been urging us to use their service for our plant* having motors of a total rated capacity of 350 horsepower, at the following wholesale rates:

CENTRAL STATION RATE FOR 20,000 KILOWATT HOURS PER MONTH

Primary charge per month..........	$225.00
First 3,000 kw.-hours @ 3c..........	90.00
7,000 kw.-hours @ 2c..............	140.00
10,000 kw.-hours (or over) @ 1c. kw.-hr	100.00
Total per month at present load....	$555.00

As we are using producer gas for our japanning ovens, soldering-iron and annealing furnaces and blacksmith forge, if we adopted the central-station service we would be obliged to purchase about $125 worth of city gas per month, making the total cost of station service for our present load of 20,000 kilowatt-hours per month 3.9 cents per kilowatt-hour.

We therefore made a test run of one week, keeping the fuel bed in the producer at constant level and carefully weighing all coal used day and night. The switchboard watt-hour meter had been calibrated and found to be accurate a short time before; also, the water meter in the connection to the vaporizer. The producer is of our own construction, of the common suction type with a shaking grate; the fuel bed is 5 feet in diameter and carried 5 feet deep above the grate. The test was made with two single-cylinder horizontal Körting engines: one of 21¼-inch bore by 34½-inch stroke, rated 140 horsepower at 160 revolutions per minute, and the other of 19¼-inch bore by 31½-inch stroke, rated at 100 horsepower at 155 revolutions per minute. Business being rather slack, the total load was only about 180 horsepower but of a very steady character.

In addition to the engines there is a Sturtevant gas exhauster drawing the gas from the producer for the furnaces; this quantity is estimated at about 125,000 cubic feet during the week. The plant was operated nine hours a day for the first five days and four hours on Saturday. The total energy delivered from the switchboard was 5094 kilowatt-hours, with following operating costs:

Total pea coal consumed during the test, including all standby losses, 15,218 lb. @ $3.15 per ton..................	$21.51
7½ gallons cylinder oil @ 40c..........	3.00
5 gallons engine oil @ 25c............	1.25
2 gallons kerosene @ 10c.............	0.20
8 lb. waste @ 10c..................	0.80
Wages, engineer and producer man....	33.00
Total............................	$59.76

*Manufacturing acetylene-gas search lamps.

According to these figures the average cost of labor and supplies was 1.17 cents per kilowatt-hour. If, however, we credit the plant with $30, which would otherwise be paid for city gas, the cost comes down to about 0.6 cent per kilowatt-hour. Of course, these figures do not include any fixed charges or repairs, but with liberal allowance for these items the cost directly chargeable to power would not be much over 1¼ cents per kilowatt-hour. Should we adopt the central-station power, we would not throw out the engine plant, so the comparison was made on actual operating cost.

In this particular plant the cost of repairs is practically negligible. The 100-horsepower engine has been in operation for about four years, often day and night, with no actual repairs. The large engine has been running for over a year with only the usual adjustments, costing about $10 per engine (average for two years) every sixty days. In two years the producer has required no repairs. We dump the fire only twice a year and point up the brickwork with carborundum cement. The producer had been in continuous service without dumping for three months prior to the test.

During the test the water meter showed that the vaporizer had taken 91 cubic feet of water, or about 0.38 pound of water per pound of coal. The water was all evaporated and passed through the fire. The gas was of good quality throughout and there was no trouble from clinkers. Noting the low water consumption and having been told that the proper ratio was 0.7, we tried to increase the water feed, but this seemed to impair the quality of the gas and the best results were obtained with the proportion stated.

In our plant the exhaust gas is passed through a special boiler from which we obtain about 150 pounds of steam per hour. Although this was not considered in the test it forms a valuable addition to our steam-heating plant and during the summer months when the heating boiler is shut down we use a large part of this steam for distilled water in our chemical work and for drinking in shop. The jacket water from the engine is passed through pipes buried in the cement floor of one of the buildings, making a further saving in coal for heating; all things considered, therefore, we believe we are producing our power at a cost, including all charges, of not much over 1 cent per kilowatt-hour.

To the quoted cost of central-station power must be added interest and depreciation on a $3000 investment for a motor-generator—about $25 per month—and at least $15 per month for attendance.

We have two producers, each rated at 200 horsepower, but up to 225-horsepower output we secure very satisfactory results with but one in service.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Some Test

Herewith are the results of a recent boiler test with which I do not agree.

In the first place, the test was started with what he designated as a "flying start," which consists of running the boiler to its utmost capacity for an hour, getting the walls white hot, then winging the fire back and forth on the grate several times and immediately starting to weigh water.

The first thing he did after starting was to rake all the coke and unburned coal from the ashpit that had been dropping through the grate bars during the preliminary run and put it on the fire, although it was not weighed and no record taken or allowance made. This performance was repeated three times during the nine hours' run.

The log of the test shows 121 weighings of water, 37 readings of feed-water temperature, 109 readings of steam-gage pressures and 17 readings of stack temperatures and drafts.

The accompanying table gives, first, the results of the test as a whole, and, second, the results for the first and the last half of the test as shown by the detailed log and by memoranda not forming a part of the official record.

The first reading of the steam pressure at the start was 132 pounds. The pressure kept going up until a maximum of 148 pounds was reached within the first 20 minutes and continued high for some time. The highest pressure recorded for the last hour of the run was 124 pounds, from which it gradually decreased until the finish of the test, when it was 93 pounds.

At the start there was a good, clear 8-inch fire and at the finish there was not enough fire to barely cover the grate; as was evidenced by the fact that it was dead out and the walls black in ten minutes after the draft was shut off and the test stopped. No new coal was used in the last thirty minutes, although the steam pressure was steadily falling; in fact, 32 pounds of coal was weighed back as not used.

I have been present at or have conducted many boiler tests, but I never yet have been able, by fair means, to increase the evaporation in the last half of a test and make it 9 per cent. better than in the first half when the fire was new and clean and the walls red hot from the preliminary run.

FRANK C. KNIGHT.

Bridgewater, Penn.

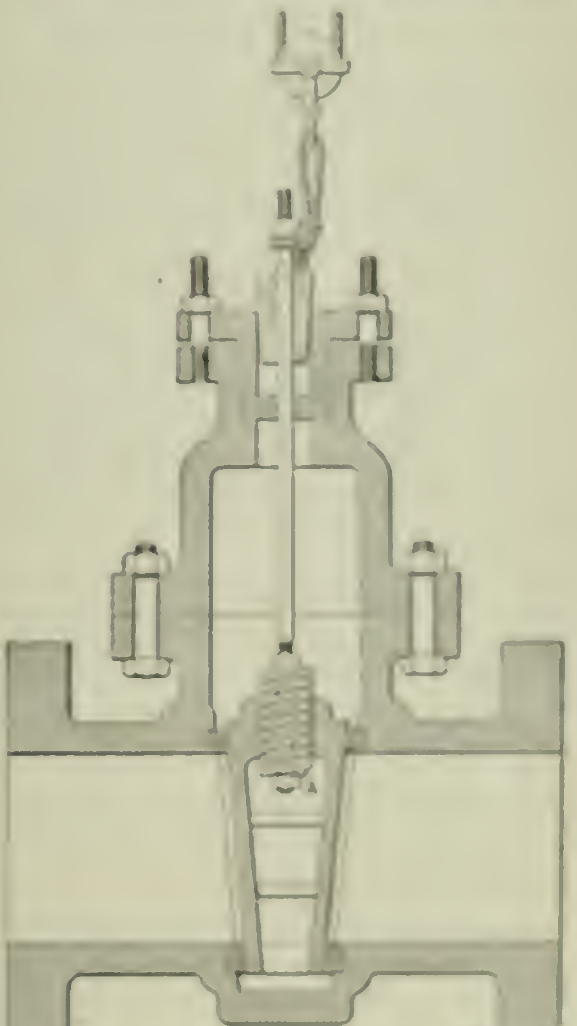
RECORD OF TEST MADE ON ONE HORIZONTAL RETURN TUBULAR BOILER 66 INCHES BY 20 FEET

	Whole Test	First Half	Last Half
Duration of run, hours	9	[illegible]	[illegible]
Steam pressure ([illegible]-minute readings), pounds gage	[illegible]	[illegible]	[illegible]
Feed-water temperature ([illegible]-minute readings), degrees Fahrenheit	118	[illegible]	[illegible]
Temperature stack gases ([illegible]-minute readings), degrees Fahrenheit	[illegible]	[illegible]	[illegible]
Draft in uptake ([illegible]-minute readings), inches of water	[illegible]	[illegible]	[illegible]
Draft over grate ([illegible]-minute readings), inches of water	[illegible]	[illegible]	[illegible]
Coal consumed ([illegible] weighings), weight as fired, pounds	[illegible]	[illegible]	[illegible]
Coal consumed per hour, pounds	[illegible]	[illegible]	[illegible]
Water evaporated (121 weighings), pounds	[illegible]	[illegible]	[illegible]
Factor of evaporation	[illegible]	[illegible]	[illegible]
Water evaporation per pound of coal as fired, pounds	[illegible]	[illegible]	[illegible]
Equivalent evaporation from and at 212 degrees, pounds	[illegible]	[illegible]	[illegible]
Commercial horsepower developed, horsepower	[illegible]	[illegible]	[illegible]
Coal burned per horsepower per hour, pounds	[illegible]	[illegible]	[illegible]

Operating a Broken Valve

A pumping engine was shut down in order to renew some rubber valves and make other minor repairs. When the work on this unit was completed the discharge valve was opened and the pump was slowly started while the suction valve was being opened. The valve at first turned hard and then, all at once, turned easier than usual. It was thought at the time that the threads on the stem had worn down. So the gear wheels, packing box, gland and valve stem were removed and just below the collar it was found that the stem had twisted off, the result of an old fracture.

To get a new valve stem and cut threads on it would take some time. It was necessary, however, that the pump should be started as soon as possible for the water supply in reserve was decreasing while this unit was down. It was decided to open the valve with a tackle, a part



SHOWING HOW THE VALVE WAS REPAIRED AND OPERATED

of the threaded stem was cut off and a hole drilled through from end to end for a threaded rod so that a nut could be screwed on each side of the stem to hold it tight in the valve disk, as shown in sketch at A.

Threads were put on the other end of the rod for a nut. Then the end with the threaded stem was screwed into the valve disk and the packing box put into place. A wooden plug with a hole in the center through which the rod could pass was made to fit the packing box.

The plug was hammered in place and a nut was screwed on the end of the rod and a rope fastened to it. From a beam above, a tackle was fastened and connected to the rope on the rod. The engine was then started as usual and the valve was gradually opened by means of the tackle.

Some air leaked in around the rod where it passed through the plug. As this type of pump is given air on its suction, to make it run smoothly it is not necessary to stop the leakage. When convenient the pump was shut down and a new stem was put in place.

K. LAWRENCE.

Kansas City, Mo.

Tank Gage

Water is pumped from a well into a tank several hundred yards distant from the engine room. This tank is fitted with a float indicator, but owing to the fact that it was not in view of the engine room an inconvenience was experienced.

To remedy this fault a pipe line was run from the tank to the boiler room, on the end of which was connected a low-reading pressure gage. The gage was placed on the wall of the engine room beside the steam gage. Aside from having a very neat appearance, it is accurate and saves the attendant many useless steps.

H. ENT.

Conejos, Colo.

Boilers Foam

In my plant there are five 78-inch by 18-foot return-tubular boilers. These boilers are supplied with water from three sources: First, from what is known as table water from the mine; second, drain tile water from the farm, and third, deep-well water. The deep-well water is practically the same as the table water from the mine.

Trouble is encountered with the engines taking over water from the middle to the latter part of the week on account of the boilers foaming.

Nos. 1, 2 and 3 are domeless boilers and each has a 6-inch pipe connection about the center of the boiler on top for supplying steam to the main header. The water line is carried about 18 inches from the top of the shell.

No. 4 boiler has a 30-inch dome. Inside the dome, in the upper sheet, there are four 4-inch openings which allow steam to pass into the dome and through a 6-inch pipe to the main header.

No. 5 boiler has a 36-inch dome also and an opening of 8x14 inches in the upper shell inside the dome to allow the steam to pass into the dome and from there through a 6-inch pipe into the main header.

The foaming trouble only occurs when the hoist engines are in operation and, sometimes, after they have been in motion a few minutes. Most of the trouble apparently comes from the domeless boilers.

These boilers are washed out once a week and the water is carried as low as safety will allow.

Can any engineer suggest a remedy for this foaming and state whether the domeless boilers are responsible for the trouble?

JAMES M. STEWART.

Elgin, Ill.

Did Not Hook On

The diagram herewith is from the low-pressure cylinder of a Corliss cross-compound engine, one end of which did not hook on.

Why does the diagram from that end include any area? Why does not the expansion line follow back upon the same line as the compression?

Furthermore, the expansion line for the last half of its length runs practically parallel with the atmospheric. What holds it up?

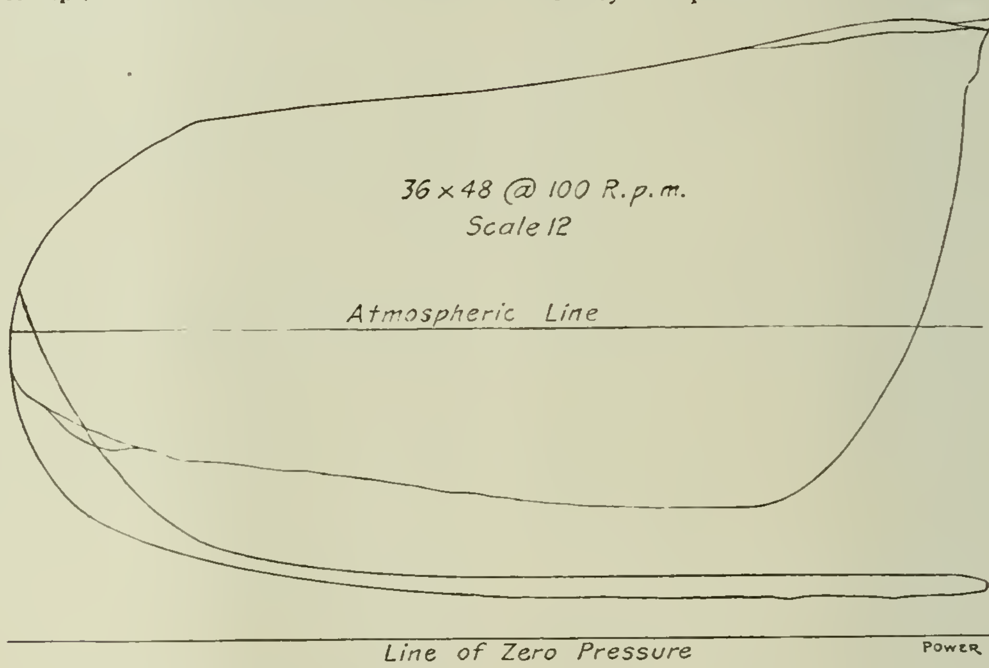


DIAGRAM FROM LOW-PRESSURE CYLINDER OF CORLISS ENGINE

The diagram was taken with a 12 spring.

Shall be interested to see the comments of POWER readers upon it.

S. E. MEAD.

New York City.

Co-operation

The personal factors in a power plant are, the proprietor or the board of directors, the chief engineer, the assistant engineers and the rank and file. Each of these has his own business to attend to and any encroachment causes friction and ultimate trouble.

The owner, or the board of directors in the person of the managing director, is the "boss." He superintends the marketing of the power and has plenty to do in interviewing and arranging terms with customers and keeping an eye on the net financial efficiency of the concern.

It is to the advantage of the chief engineer to get up schemes for increasing the efficiency and cutting the costs of the plant operation. To him should be left the purchase of fuel, lubricants and other supplies and stores, the examination of subordinates and the ordering of the internal management and working of the engine-room and boiler-house staff.

The assistant engineers should look upon their chief as a friend who is there to be consulted and not, as is too often the case, as a man who is holding down a better job and is, therefore, to be envied and, if possible, ousted. All repairs and adjustments should be made by, or under the immediate supervision of the assistant engineers and their reports should be passed on to the chief.

The rank and file, or the oilers, water tenders and firemen, should be under the immediate control of the shift engineer with whom they are working, but complaints of all kinds, whether from the ranks or from the assistants, should have the personal attention of the chief.

Everyone in the plant should have free access to the "boss" at all reasonable times. One of the surest ways to insure friendly coöperation and smooth working is by the "boss" considering the personal comforts of the staff by the provision of good accommodations in the way of coat cupboards, lavatories and the like.

JOHN S. LEESE.

Manchester, Eng.

Blowoff Valve Left Open

The boiler equipment of a plant where an accident recently happened, consisted of two return-tubular boilers set in one battery with the blowoff pipes connected to a single pipe at the rear.

One boiler had been cut out for cleaning, and, after it was washed out, the engineer went inside to examine the internal conditions. His assistant was left in charge of the plant. When the usual time arrived for blowing down the boiler under steam, he opened the blowoff cock.

The cock on the dead boiler was still open and as the steam filled the idle boiler the engineer inside was scalded to death instantly. This was the result of carelessness on the part of two men and both should have known better than to have gone about their work with the blowoff valve open.

EDWARD T. BINNS.

Philadelphia, Penn.

Solvents in Boiler Water

In most methods of feeding solvents into steam boilers the amount of the solvent fed bears no fixed relation to the amount of the feed water used and, although the solvent may be fed in direct proportion to the feed water, the amount of the scale-forming matter in the water often varies. Therefore, some means of determining the strength of the solvent in the water in the boiler is desirable.

Too much solvent in the water is a waste and may also cause foaming; too little solvent leaves scale-forming matter that is not acted upon.

A simple test for compounds containing soda, soda-ash, or tri-sodium phosphate is phenolpthalein. If the phenolpthalein, which can be purchased at most any drug store, is dissolved in alcohol and five or six drops of the solution added to one-half pint of the water to be tested the water will assume a red or pink color, the shade depending on the amount of soda in the water. A large amount of the soda will produce a deep red color; a small amount will produce a lighter pink color.

If the sample of the water to be tested is drawn from the water column, care should be taken to blow out all condensation before taking the sample. The water should be allowed to cool before testing and the same proportions of solution and water should be adhered to for uniform results.

If the engineer will apply this test to the water in his boiler each day just before introducing the compound used and vary the amount of the compound according to the strength of that already in the boiler he will effect a saving in compound and secure better results.

G. E. MILES

Salida, Colo.

Skimmer Caused Boiler to Scale

There are two boilers in the plant where I am employed, one of 40 horsepower and one of 100 horsepower capacity.

Before a producer-gas plant was installed, the large boiler was used to run the works and the small boiler was used for heating purposes. Both boilers were fired extremely hard. The 100-horsepower boiler had a boiler cleaner attached to the back of the boiler on the inside for the purpose of removing all the scum from the water. The small boiler had no cleaner.

We cleaned the boilers once a month and used the same water in both and under the same treatment. To the surprise of all, the large boiler was always badly scaled and nothing that was done would prevent it. The small boiler never had as much as a double handful of scale, and that was in the form of a soft, white sludge that was easily washed out. The same boiler compound was used in both boilers.

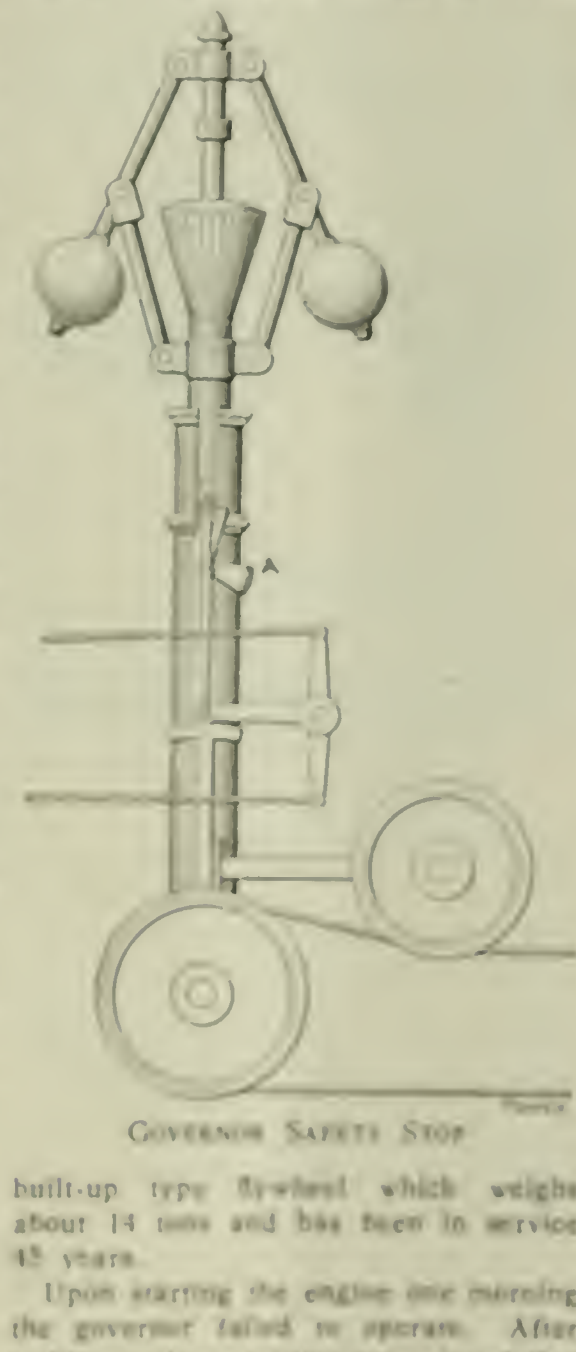
After weeks of hard work, I decided to take off the cleaner, and while some may think it a queer thing to do, it turned the trick. There has been no more trouble with scale and the tubes are as clean as the day they were put in. It appears that there was something in the water that the cleaner took out that prevented the boiler scaling when it got a chance to work.

H. WESTWOOD.

Waterloo, Can.

Governor Safety Stop

The accompanying sketch shows a safety device for a governor which I have had on a 16x42-inch Corliss engine that has been in constant service for 31 years. This engine carries a 16-foot built-up type flywheel which weighs about 14 tons and has been in service 15 years.



GOVERNOR SAFETY STOP

Upon starting the engine one morning the governor failed to operate. After making a close examination I found that the key holding the pinion on the upright shaft had worked out. Had this key come out while the engine was running, the engine would have been wrecked. The governor is of the old style, with a safety device which acts only when the governor belt breaks, as shown in the sketch.

I afterward discarded the belt arrangement and fixed a safety latch on the governor column, as shown at *A*. This latch rests under the guide boss, which is connected to the bell crank, when the engine is not in motion. Upon starting the engine this latch drops out of the path of the guide movement as soon as the governor rises from it. This allows the governor full control, if either the belt should break or anything else should affect the gearing. The latch is held in place by the hand while the engine is being stopped.

R. L. BLACEY

Glasgow, Mo.

Burning Fuel Oil

The plant I am in charge of is burning crude oil as a fuel. The plant consists of a 55-horsepower automatic engine and a 16-foot by 54-inch tubular boiler. Before I started to burn oil I ran the plant on two tons of slack coal per day at $1.85 per ton.

Six barrels, 42 gallons each, of crude oil is now burned per day. The burners are of the jet type and air is drawn into the burner by the suction of the jet where it mixes with the oil in the burner.

The oil tank is located about 100 feet from the building and has a fall of 3½ feet to the burners. I would like the advice of other engineers as to whether I could run on less oil, and whether it would pay to install a pump and a gravity burner; would a heater be necessary, also?

W. A. HARLOW

Paola, Kan.

Automatic Lubricators

After an experience with automatic lubricators, since their introduction, I am convinced that their proper location is upon the cylinder or steam chest of the engine, for when so placed the temperature of the oil remains practically constant.

If the lubricator is located upon the engine frame, the temperature of the oil changes with that of the air in the room, and the amount of oil fed also varies. The ball valves used in the pump cannot seat quickly, because the low temperature of the oil causes it to become thick and the ball has a tendency to float in the oil; therefore, part of the oil drawn in at each stroke of the pump is forced back into the reservoir before the valves close. This causes the engineer as much trouble in obtaining a proper feed as the older style of lubricator.

The best results are obtainable when the plunger feeds two or three drops at each stroke and the speed of the pump is regulated to give the desired number of drops per minute.

BEN W. LYMAN

Ware, Mass.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Engine Running Under

In the March 7 issue in reply to an inquiry it was stated that the frictional load on an engine is reduced by running an engine under instead of over. This decrease, it is claimed, is made by the diagonal thrust of the connecting rod pushing the crosshead against the upper guide with a pressure which is reduced by the weight of the crosshead.

I cannot see how the frictional load is reduced, as the connecting rod in order to lift the crosshead must put a pressure equal to the weight of the crosshead on the wristpin and crankpin, thereby reducing the friction in the guides but increasing it on the wristpin and crankpin.

RUSSELL B. BUCHANAN.

Leadville, Colo.

The Stuffing Box

The interesting "talks" on the stuffing box which appear serially in the advertising space of the current issues of POWER are worthy of consideration. The statements seem revolutionary, but I am heartily in accord with them.

One of these statements, that the square-bottomed stuffing box and gland are more efficient than the beveled sort, I have always believed. Any engineer may test this by fitting babbitt rings to the bevels. Then notice the difference in gland tension required to cause ordinary

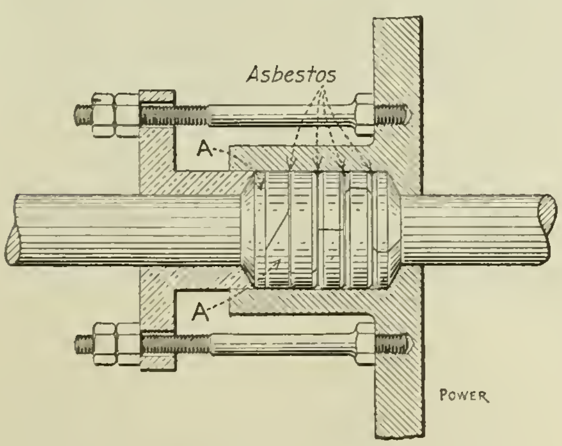


FIG. 1. A CASE OF PACKING RINGS

packing to become steam tight, as compared with that necessary to make the same packing steam tight, when the babbitt rings are omitted. As every turn of the gland nuts means increased friction on the rod, the experimenter will at once question the advantages of a beveled-bottom box. The life of the packing is considerably prolonged, as less of its elasticity is wasted when it is first applied.

Another valuable truth expressed by the writer of the "talks" is that, the temperature of the stuffing box being lowest nearest the gland, the inner rings of packing deteriorate faster than the outer rings. The inner rings, I believe, soon become nothing more than space fillers in the box, so that something more wearable and ultimately less expensive

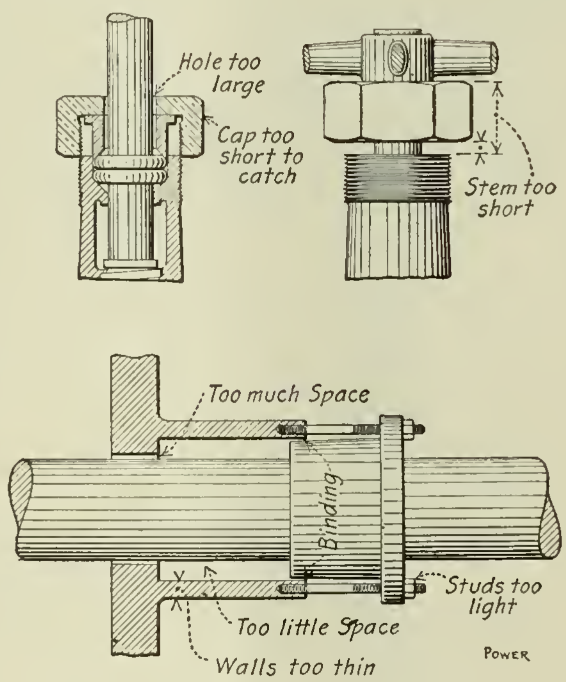


FIG. 2. COMMON FAULTS IN DESIGN

could be advantageously substituted. To test this, I once placed four well fitted babbitt rings of good grade in a certain stuffing box, which required six rings of ordinary packing to fill. Between each, a layer of asbestos was interposed, as shown in the sectional sketch in Fig. 1. Now this box when packed entirely with soft packing required renewal of its contents every six months, resulting in the use of twelve rings yearly. After the change was made the two soft rings *A* were found to give satisfactory service for four months, which now results in the use of only six rings yearly. Thus, at the expense of a little more labor, a material saving of packing was effected. And I believe there exists less total friction on the rod; though, probably, as all the friction is constrained within a narrower limit, there may be present a tendency to wear shoulders more quickly. As yet, however, the rod looks good, and shows no deleterious effect from the change, though the precaution of allowing more lubricating oil and distributing it better was taken.

I heartily wish that the writer of the

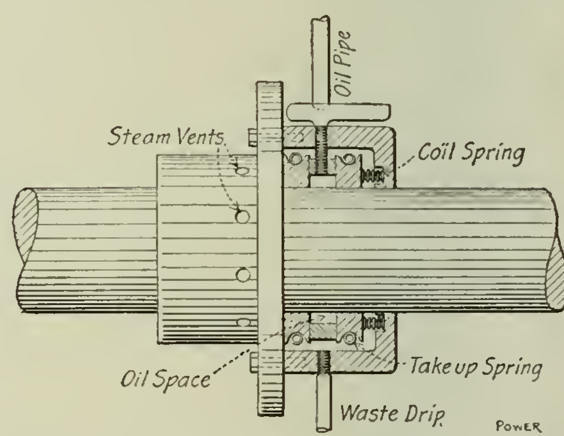


FIG. 3. PREVENTING SHOULDERS ON ROD

advertisement would discuss some of the evils of construction which at times sorely beset the engineer. In Fig. 2, I have endeavored to illustrate graphically the most common faults, with the expectation that they will be noticed by some designers. The stuffing box should not be cast integrally with the cylinder, but rather it should be bolted on in such a manner as to allow slight up and down adjustment, which would permit the packing to enter freely and fit snugly around a rod that is a trifle low of center. Even where adjustments can be made in the bull ring of the piston and the shoes of the crosshead, it is not always convenient to take off the cylinder head. If the rod is out of center with the stuffing box, how beneficial to the packing it would be, not only to be able to level the rod, but also to drop down the stuffing box to accommodate the new center, while waiting for an opportunity to center the piston.

I once ran across this improvement. An engineer had had his rod trued up and was fearful lest the packing would again form shoulders upon it. To prevent this, he bolted to the gland a small extension casing which inclosed two spring-tied metal rings; see Fig. 3. Between these he fitted a space ring which he ground oil tight with the two split rings, and into this space he led the oil pipe, which supplied a thin mixture of flour of graphite and cylinder oil. If he made a good job at surfacing the rings, it will be perceived that the rod is evenly lubricated.

M. CASSIDY.

South Framingham, Mass.

Dangerous Boilers

When reading Mr. Utz's letter in the March 28 issue, entitled "Operating a Dangerous Boiler," I was reminded of an old boiler at this place, operated by a railroad company. The boiler and engine are an old "traction" engine with the wheels removed. The back end of the boiler rests on two tee-irons and the front end is supported by railroad ties. A hole dug in the ground under the back end serves as an ashpit. The sheet around the rivets is wasted away to a dangerous extent and the plates are rusted and pitted badly. The boiler leaks badly around the mud ring and around the bolts that hold the bearing lug to the boiler. This lug supports the flywheel end of the crank shaft. The boiler is fitted with an old lever safety valve which is not in operating condition.

This outfit is used to drive a centrifugal pump which pumps water from a creek into a large reservoir. It is only run when the supply of water in the reservoir gets low. Anyone that can shovel coal is allowed to run it. One evening a few months ago, I happened along by the boiler house and saw the engineer (?) standing on the creek bridge about four rods from the boiler. I asked him what he was doing out there. He said that he was waiting for the steam to go down. When asked how much steam he had, he said that about two minutes ago when he left "her" there was 140 pounds.

Walter B. Brown.

Deshler, Ohio.

Water Hammer

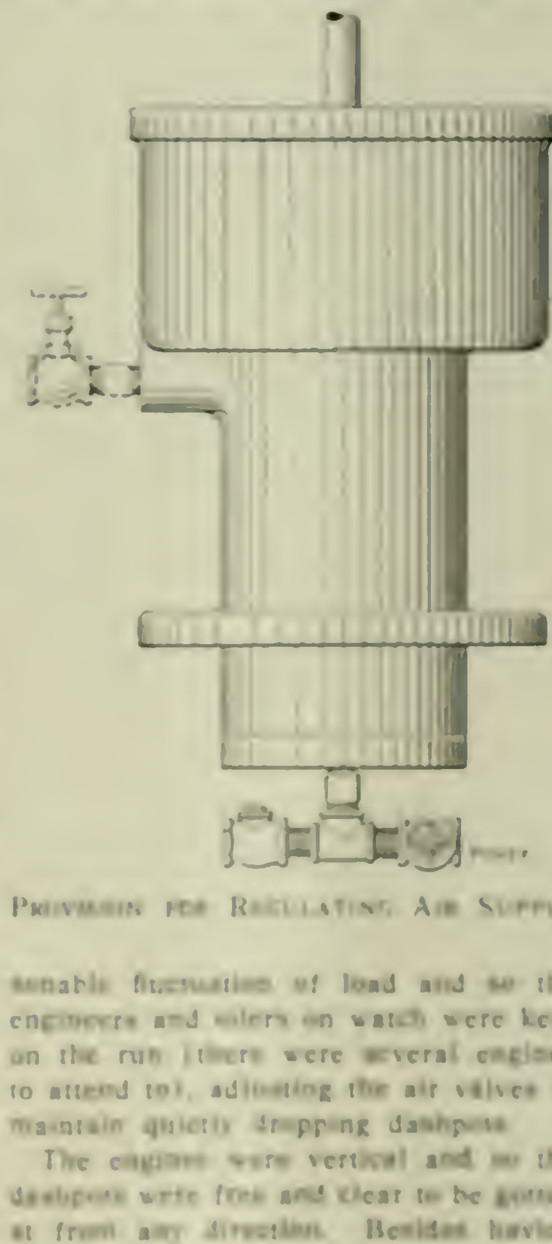
In reply to Mr. Payler's letter of March 7, in which he asks, "Is water hammer due to the presence of water lying along the bottom of the lowest part of a line of piping, or is it due to a conflict between the cold air and the inrushing hot steam which causes the violent hammering?" I think that water hammer is due to the above two causes; directly to the first cause, while the second cause helps it along, or indirectly due to it. When steam is admitted into a pipe containing air at a lower temperature than the steam, part of the steam is condensed. Water hammer can result if the amount of steam condensed is large enough to form a slug and if this slug travels at a rapid rate through the pipe. When steam is admitted into a line of piping containing cold air and water lying along the bottom of its lowest part, some of the potential energy of the steam is immediately changed into kinetic energy. This inrushing steam sets in motion the water that was there before and the condensed steam. It is the sudden stopping of this water by an elbow, a closed valve, etc., that causes the violent hammering. Again, the kinetic energy that the water had is now changed to potential energy, and if the pipe is not strong enough a rupture will occur.

Thomas H. Brickman.

New Orleans, La.

Dashpot Troubles

Dashpot troubles described by R. A. Cultra, in the April 18 issue, bring to mind something in that line which happened in a power station in which I was engaged some time ago. The low-pressure cylinders were equipped with the Corliss valve gear, with dashpots for the steam-admission valves. The pots had the regulation air-cushion valves attached, but in spite of these the pots would slam under heavy-load conditions. If attempts were made to adjust the air valves to stop the slamming, the pots would not act quickly enough with light or even normal loads. The adjustment could not be made so as to cover a reasonable fluctuation of load and so the engineers and oilers on watch were kept on the run (there were several engines to attend to), adjusting the air valves to maintain quickly dropping dashpots.



Provision for Regulating Air Supply

The engines were vertical and so the dashpots were free and clear to be gotten at from any direction. Besides having the regular air valve referred to, the center of the bottom was drilled and tapped for an ordinary brass pet cock, to drain the pot in case of leakage of oil past the leather packing and also to admit air to the chamber when drawing out the pot for overhauling. These pet cocks were of little or no use as means of regulating the drop of the pots. It was a case of the pots either dropping too hard and slamming or not dropping fast or far enough.

Someone in the station suggested that the pet cock at the bottom be taken out and a check valve, opening outward, be put in. This was tried on one of the pots with partial success. With the check valve, the slamming was not quite as bad as before, but with very heavy loads the slam was enough to be troublesome. The next move was to have a globe regulating valve connected up with the check valve, as shown in the accompanying sketch. The quantity of air admitted could be controlled to a nicety and the best thing about it was, that it could be regulated to suit quite a range in load changes. On the upstroke of the dashpot a certain amount of air was admitted through the globe valve into the vacuum chamber; when the releasing gear permitted the pot to drop, the contained air was forced out of both the check valve and globe valve, bringing the pot to its seat quietly. This depended on the hight the pot had been raised and the amount of air admitted through the globe valve.

It did not require very much skill to regulate the globe-valve opening and, when regulated, it very seldom required any more than ordinary attention. All the engines were equipped in a similar way and the men were not bothered in that way again. It is the best plan that I have ever seen for the purpose.

Charles J. Mason.

Scranton, Penn.

High Pressure Drips

I noted R. E. Knigge's comment in the April 11 issue, on my criticism of Mr. Meinzer's arrangement for returning condensation from high-pressure traps to the heating main. I must say that I am still skeptical. Theoretically, there may be an apparent gain, but practically, local conditions and the arrangement of the drip-return pipe have a great deal to do with the advisability of so utilizing the drip returns.

I have a number of high-pressure traps in the place where I am employed and I find that the drip-return pipes are quite cold a short distance from the trap. This would indicate that the heat liberated through a drop in the pressure will recondense very quickly if led away in the same pipe with the condensation. As a matter of fact, I am inclined to believe that evaporation and recondensation take place almost simultaneously.

I have had experience, as marine engineer, with compound or quadruple-expansion engines, but I have never run across such an arrangement as Mr. Knigge describes, although I readily see the advantage that may be gained by something like it but not exactly the way Mr. Knigge describes the arrangement, that is, to drain the high-pressure condensation into the low-pressure receiver. If the outlet of the high-pressure traps are connected to the low-pressure receiver by a vapor pipe which carries the vapor only to the receiver, instead of the whole condensation, the results undoubtedly would be beneficial, but if the whole condensation is led into the receiver, I am very skeptical of results.

The same thing in my opinion is true when returning high-pressure drips to the heating system. If the traps should be lined up along the heating main and piped at the outlet with a vapor pipe to the heating main and a condensed-water pipe to the heating return, I have not the slightest doubt of the benefit to be derived.

Condensed water when released from under, say, 100 pounds to atmospheric pressure or slightly above, as used for heating, will liberate enough heat to evaporate approximately one-tenth of the water. If this liberated steam is collected from all over a large plant in a common return with the condensation and carried any distance, I am of the opinion that it will recondense before getting into the heating main.

At any rate, I would not recommend to anyone to invest good money in an improvement, which seems to me very doubtful of beneficial results.

VICTOR BONN.

New York City.

Water Coils Burn Out

Many good men have encountered the difficulties described by R. A. Booth, in the April 4 number. Coils placed in a furnace require a continuous stream of water circulating through them to prevent pipes from bending or burning out. The scheme of running feed water through pipes placed in the combustion chamber has been attempted with unsatisfactory results.

An exhaust-steam feed-water heater is probably the most economical method of heating feed water; otherwise the exhaust is wasted. Exhaust from all steam pumps and other engines should be utilized for this service with proper heaters. Live-steam feed-water heaters always proved to be a success where they were properly installed and equipped. Peculiar as it appears, it has been proved that a decided economical advantage is gained with live-steam feed-water heating over hot-water heaters separately fired. Where I am employed, there were three boilers directly fired for heating-water purposes only; they were cut out and a large live-steam feed-water heater was installed. The heater received its steam supply from a battery of steam boilers already in use.

I hesitate to state the amount of fuel saved for fear my veracity may be questioned. I will state, however, that the saving in labor and fuel was considerable and that the water supply was even more satisfactory than in former times.

The pipe described by Mr. Booth burned out or bent because the water heated up to such a degree that an overpressure was raised, forcing the water out of the pipes into the boiler and leaving the pipes empty for a short period. While empty the pipes were overheated and ultimately burned out. If they lasted four months with Mr. Booth they did exceptionally well.

In several cases serious accidents have happened to boiler brickwork, due to ruptures of the feed pipes in the furnace space.

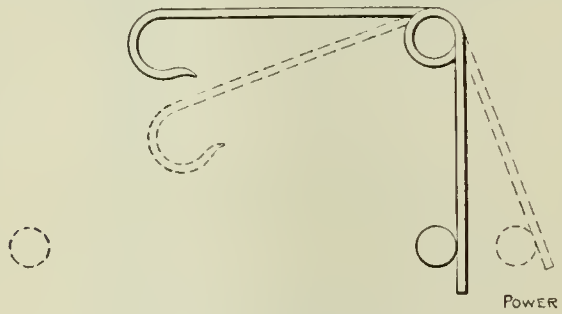
J. E. NOBLE.

Toronto, Can.

Indicator Cord Hooks

I noticed in the March 28 issue of POWER an article on indicator-cord hooks by Julian C. Smallwood. I am using a hook which is similar to the one Mr. Smallwood describes, only I believe my hook has his beaten for high speeds. After numerous attempts with several different kinds of hooks, I gave up the task of trying to indicate a high-speed engine, which was part of the power equipment of my plant.

While searching the advertising sections of POWER for a way out, I ran across a small cut of a Trill indicator with a cord hook attached. I sent for



INDICATOR-CORD HOOK

the hook at once and tried it out. I was both pleased and surprised at the results. The engine ran 220 revolutions per minute, and I indicated it without an error on the part of hooking on and unhooking. The illustration shows the hook and the method of attaching.

To hook on, hold the eye of the hook lightly between the thumb and forefinger and above the rod onto which you wish to hook. Advance the hand forward so that the hook will overlap the travel of the rod about 1½ inches. When ready to hook, drop the hand suddenly so that the rod may strike the lower part of the hook.

To unhook, close the hand around the cord and advance toward the hook until at its extreme travel it nearly touches the hand. When ready to unhook, suddenly advance the hand forward about 1½ inches, allowing the forefinger to strike the lower part of the hook.

JOHN C. PITTS.

Cherokee, Okla.

Cleanliness in the Power Plant

The editorial in a recent issue on the above subject was interesting and correct. There is perhaps no one who does not admire beautifully polished and well groomed machinery and clean, orderly power plants. It pays to keep them in that condition.

A corner filled with filth and trash invariably invites and receives more of the same. Rusty and oil-stained brightwork means more and continued rust and stain, and a greasy and ill kept floor will get into such a chronic state of deterioration that everyone who comes along will take pleasure in adding to the general mess.

Such conditions mean a slovenly crew who are too lacking in pride and ambition to keep up and properly care for the requirement in their charge, too indolent to be concerned or interested in anything but the clock.

Where the spirit of cleanliness and order is lacking in the chief, it is apt to be absent among the crew and the tendency is toward the plant "running down." In time this means a general overhauling more costly by far than if the care had been given in the regular daily order of things.

It is very easy to keep a plant to the top notch of cleanliness when once started in that direction. The spirit of neatness is infused into all hands and becomes a habit. An employee, though not directly interested, would look twice before dropping a piece of waste or trash upon a freshly scrubbed floor, and he would be a great deal less apt to roughly handle or mar the clean and shining valve gear than the rusty and oil-stained one.

Cleanliness about the power plant fosters thoroughness and carefulness in the employee, and often leads to the detection of flaws in machinery that might go unnoticed were polishing and wiping not attended to. It raises his self-respect and develops his esthetic qualities.

Cleanliness always pays from the standpoint of the engineer. Traveling salesmen spread the fame of a power plant, mill or factory of exceptional cleanliness, and the name of the engineer responsible for it becomes favorably known over a wide territory. Better positions have frequently been obtained in this way.

A young man holding his first position as chief in a small power plant was approached one night by a visitor who had been admiring the spick and span condition of the little station and was asked if he could keep a certain factory as clean as he did that station. He gave an affirmative answer and forgot the incident, but two years later he was sent for by his erstwhile visitor and made superintendent of the factory mentioned.

His cleanliness and good order were his silent though eloquent recommendations.

In another case a firm had been much embarrassed by the insurance inspector's reduction of ten pounds of steam from the boiler pressure. A new engineer cleaned the room and settings thoroughly, scraped the boilers inside and out and the insurance company voluntarily raised the pressure to its former limit.

For a similar reason a fire-insurance inspector will frequently recommend a reduction of rates on an otherwise bad risk because of the good order and cleanliness or "on account of management."

Yazoo City, Miss. F. C. HOLLY.

Piston Rings

I noticed in the April 11 issue of POWER, George H. Handley's favorable comment on a letter, contributed by me in the March 7 issue, on the lap-joint and diagonally cut piston rings. It seems that his plan for leakage prevention in rings of the lap-joint order is not exactly faultless, though an improvement when used in conjunction with this ring.

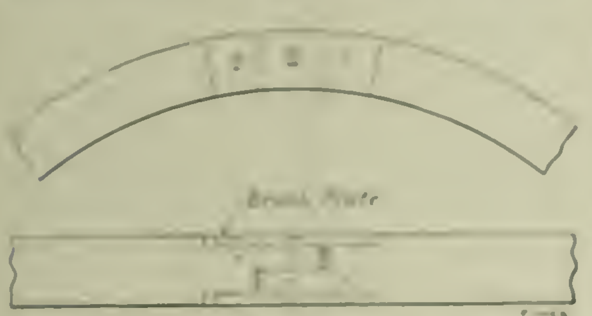


FIG. 1. MR. HANDLEY'S METHOD

There are two objections to the use of such a ring as Mr. Handley proposes: First, he says that care must be taken to use tap screws of proper proportion, with thin rings—an acknowledgment that the ring is unduly weakened at an already delicate point. This has been proved by numerous reports of instances where "tips" of rings of this order have broken and caused a badly cut cylinder, if not a general smash up, even though they were made as strong as possible.

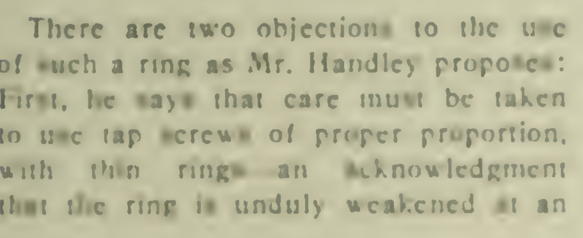


FIG. 2. BACKING UP PISTON RING

In the second place, this does not render the ring absolutely "leak proof," since leakage will occur past the brass plate when the ring becomes worn. This leakage, however, cannot be so great as in the ring without the plate, because the opening exposed is not so great and, too, the steam has a more constricted and "round about" passage to cross over, before reaching the other side.

I believe the method I proposed is less objectionable, because the ring cannot leak, if the cover plate is properly made. The ring would not be weakened much, even if a small hole were drilled and a curved-spring cover fastened underneath, as indicated in the cut. Whereas, in Mr. Handley's plan, the ring is much weakened by drilling across the ring and more still by the cut on each side.

LLOYD V. BEETS.

Nashville, Tenn.

Central Station vs. Isolated Plant

This is in confirmation of W. J. Creelman's article under the above heading in the April 18 issue. It should be remembered, however, that the conditions at each place must be fully considered before judgment can be passed. After an ordinance had been passed, forbidding the installation or retention of boiler rooms under sidewalks, the question among business men arose as to whether the purchase of light and power, as formerly done, would be cheaper than the running of a private plant. The city and central plant referred to are among the largest in the country.

To purchase the power would cost about $67,000 annually, which was quite an item. The engineer convinced the owners that it would be cheaper to install their own plant, and here are a few of the obstacles they overcame in doing so:

It was a case of swapping places with the kitchen as a starter. Then this change of location necessitated a new chimney, and to accomplish this meant the sacrifice of a living room on each floor, clear to the top of the hotel. The complete change cost $[illegible].

When they came to excavating about the boiler room, it was noticed that a great amount of seepage was present, and kept increasing as excavations progressed. Many of the older buildings in our city are on what are called "floating foundations," and at places where our building had settled, the plumbing drains beneath the cellar floor had broken at various places, causing the seepage. This required the complete overhauling of all the plumbing drains, which amounted to an additional $50,000. Since completing the plant they have been enabled to save from $[illegible] to $[illegible] annually over what it would have cost them had power been purchased at the above price.

C. S. COLLINS.

Notre Dame, Ind.

I have read so many arguments for and against the isolated plant that I would like to put in one word myself. I positively know that the isolated plant will pay if properly installed and given a fair chance. Too many plants are thrown together with cheap apparatus and little discrimination.

One of the first things which should be looked after is to see that good apparatus is provided and carefully installed. If the engineer on the job cannot do it, put the work in the hands of some good conscientious consulting engineer. Then by all means have a system of operation. Keep track of every detail. Run it as any successful business is run—as the central station is run. When asked for reports have them on tap. Then you need not fear the outside interests. Reports are as important as the operation of the plant. We have been running here for seven years and have not had a shutdown for any cause, except when cutting in new lines to add apparatus—this is done after midnight. We run day and night the year around and have produced electrical energy for 1.[illegible] cents per kilowatt-hour. While the central station is all right in its place and is needed, it cannot touch the isolated plant if handled right. The report shows what we are able to do. The output was considerably increased without adding to the running expenses.

COMPARATIVE COAL AND LOAD DATA

Date	Coal	Load Kw.-hours	[illegible]	
1907				
Oct.	[illegible]	[illegible]	[illegible]	[illegible]
Nov.	[illegible]	[illegible]	[illegible]	[illegible]
Dec.	[illegible]	[illegible]	[illegible]	[illegible]
Totals	[illegible]	[illegible]	[illegible]	[illegible]
1908				
Oct.	[illegible]	[illegible]	[illegible]	[illegible]
Nov.	[illegible]	[illegible]	[illegible]	[illegible]
Dec.	[illegible]	[illegible]	[illegible]	[illegible]
Totals	[illegible]	[illegible]	[illegible]	[illegible]
1909				
Oct.	[illegible]	[illegible]	[illegible]	[illegible]
Nov.	[illegible]	[illegible]	[illegible]	[illegible]
Dec.	[illegible]	[illegible]	[illegible]	[illegible]
Totals	[illegible]	[illegible]	[illegible]	[illegible]

ASA P. [illegible].

Binghamton, N. Y.

Dennis Flanagan, th' ingineer at th' light plant, [illegible]

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Causes of Pitting of Boiler Tubes

The tubes in my boiler are pitting badly. The feed water comes from a coal mine most of the time, but I use rain water when I can get it. What causes the pitting?

M. F. H.

The pitting is caused by sulphuric acid in the water which comes from the mine. The acid may be neutralized by an alkali. Equal parts of unslaked lime and crude soda ash dissolved and fed to the boiler with the feed water will stop the pitting. But just how much to use can only be determined by experiment. Blue litmus paper will turn red in the water if acid is present and the red paper will turn blue if there is an excess of alkali. No change of color will take place if the water is right. If the water is passed through an open heater, most of the solids will be deposited there.

The soda will serve to prevent some of the scale-forming material from depositing as a scale and will keep it in a condition in which it may be blown out. An analysis of the water will determine whether soda or something else is better for this part of the process. Heating the water to 200 degrees or over will cause most of the scale-making impurities to precipitate.

Advantages of Butt-Strap Boiler Joints

Why is a butt- and double-strap boiler seam a better form of construction than a lap seam?

L. J. F.

The butt joint allows the shell to be built truly cylindrical while the lap joint prevents it. The pressure inside the shell tends to make it round and this tendency bends the lap-jointed sheet near the outer row of rivets at every change of pressure, however slight. As the pressure changes at every stroke of the engine, there are thousands of bending effects each hour. With the butt joint if the shell is round at the start changes of pressure do not bend the sheet.

Capacity of Expansion Tank

What capacity of expansion tank will be required for a hot-water system of 30,000 square feet of radiating surface, allowing 1.75 pints of water per square foot, assuming that the water expands 0.00043 of its volume for each degree of rise in temperature?

J. J. B.

It will require $1.75 \times 30{,}000 = 52{,}500$ pints of water. Assuming a temperature rise in the water from 60 degrees to 200 degrees, the increase in volume of the water will be $0.00043 \times 140 \times 52{,}500 = 3160$ pints, or 395 gallons, and the expansion tank should have this capacity. This is a little over 5 per cent. of the capacity of the system. Heating engineers usually allow 10 per cent. of the volume of the system for expansion with a temperature rise of 120 degrees.

Safety Valve Blow Back Adjustment

If a safety valve is set to blow at 100 pounds and stops at 90 pounds, how can it be adjusted to stop at 98 pounds?

C. D. N.

In most pop safety valves there is a supplementary ring surrounding the valve disk which forms a huddling chamber, increasing the effective area of the disk. This ring is threaded and may be turned, through the holes provided in the case, increasing or diminishing the huddling area. Increasing this causes more blow back, and diminishing it causes less.

Flat Bearing Surface

Can a perfectly flat surface, suitable for a bearing, be made on a planer? If not, how can it be made?

P F. S.

A perfectly flat surface cannot be made by planing. Such surfaces are obtained only by scraping. For some kinds of bearings planed surfaces are suitable but not if extreme accuracy is necessary.

Producer Output

How much horsepower should a No. 7 Wood producer deliver, using Texas lignite?

How many cubic feet of gas should be delivered per pound of lignite gasified?

With gas of 135 B.t.u. per cubic foot, how many horsepower should a 600-horsepower gas engine deliver at the belt?

H. W. N.

A producer does not deliver horsepower, but the horsepower that can be developed from producer gas depends on the quantity and quality of the gas and the efficiency of the engine. With lignite of 8000 B.t.u. per pound a No. 7 producer will deliver about 25,000 cubic feet of gas an hour containing about 125 B.t.u. per cubic foot; a good engine will develop about 300 brake horsepower on that quantity and quality of gas.

From 35 to 55, according to the character of the lignite and the way the producer is handled.

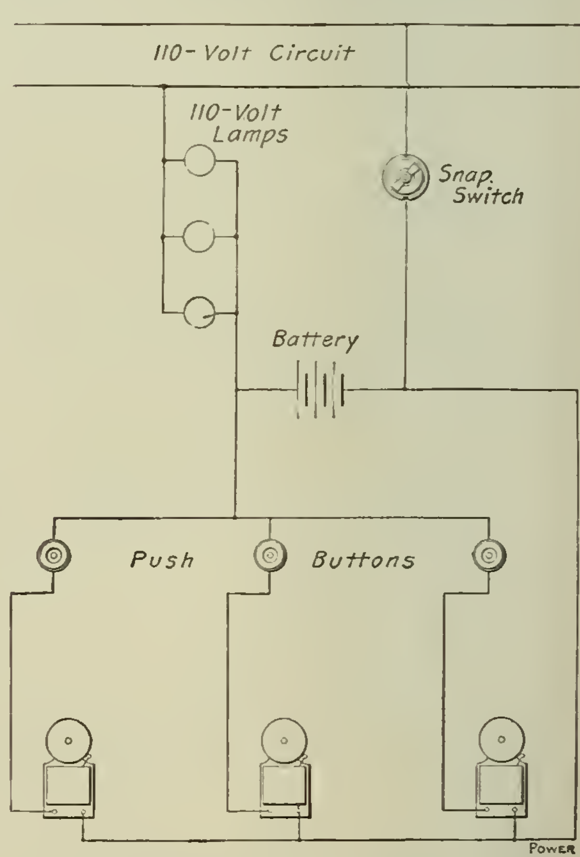
Its full rating: 600 horsepower.

Reducing Direct Current Voltage for Bells

How can I make a transformer to reduce the voltage of a 110-volt direct-current circuit to about 5 volts for ringing bells?

E. G. H.

You cannot. A transformer will not work on direct current. If you have a large number of bells, the best arrangement is a dynamotor to take motor current at 110 volts at one commutator and



Bell Supplied from 110-volt Circuit

deliver bell current at 5½ volts at the other. If you have only one or two bells, connect three or four 110-volt incandescent lamps in parallel with each other and in series with three storage-battery cells; then supply the bell circuit from the terminals of the battery, as indicated in the diagram.

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POWER

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A Square Deal and Efficiency

The manager was recounting the advantages that had accrued on the installation of a series of devices that enabled him to keep accurate record of operating conditions. The changes had brought the plant from chaos, on the one hand, to system, order and economy on the other; from guesswork and hit-and-miss methods, worry, loss and inefficiency to smooth running and profit making.

But after all this, he wound up with the information that, "For a short time we gave the firemen a small bonus for good performance, to find out what they could do. After they had demonstrated what they could do if they tried, we set their best mark as a standard and made them live up to it!" That is one way of doing business.

Every manager must determine at the beginning whether he will or will not give his men a square deal. On this depends in a great measure the permanent success of the undertaking. Dissatisfaction among the men may easily result in as much loss as a lack of proper cost keeping. Bonus systems, in one form or another, have been introduced in many places, with good results, but if a firm does not intend to keep up the bonus system when once installed, it had better not establish one at all, for the reaction when it is discontinued is bound to result in dissatisfaction.

It would be interesting and rather instructive, we imagine, to look over the payroll of this company about the time the bonus was discontinued, and note the new names coming up on the list.

Habitually getting new names on the boiler-room payroll is not a policy which can be followed to the best advantage. The new man, however willing, will require time to attain the efficiency demanded and this will mean loss of money to the company. One firm estimates that it costs one hundred and fifty dollars, in inefficiently burned coal, to break in a new fireman. At this rate it will not require many changes in a year to mount up to a respectable figure. One day and one night fireman changing every two months would mean, on this basis, a loss of eighteen hundred dollars a year.

The better way is to keep the men who have been trained to the standard of efficiency prevailing in the plant, giving them substantial evidence of appreciation, and this, in connection with an accurate system of coal records, will go farther toward insuring a high and continuous state of efficiency than any other plan that can be adopted.

Legislation and Engine Accidents

Many of the States have factory-inspection boards, whose duty it is to inspect factories and to call attention to conditions inimical to health and safety. The duties of these inspectors are often laid out with a precision which leaves them little, if any, discretion, and in most cases, beyond calling attention to actual violation of the law, they have no power to enforce their recommendations.

A matter which naturally receives general attention is the placing of guards about moving machinery, the prohibiting of projecting set screws upon revolving shafts, etc. One of the provisions directed at the reduction of injury from accidental entanglement with shafting, or from a machine gone wrong, is the requirement of a clutch upon each floor, by means of which the motive power may be cut off in case of accident. While this may occasionally serve its purpose, although the damage has usually been done before the clutch can be thrown, it has in it the possibility of aggravating trouble and precipitating a catastrophe which might otherwise be averted. If the engine commences to race and the machines to run wild, the natural impulse of somebody on every floor will be to throw the clutch, taking the load off from the engine and aiding it in its race to destruction. The fragments of a big flywheel ploughing their way through the several floors may be the result.

A much more logical and a safer arrangement is a number of reliable circuit closers or other arrangements conveniently distributed throughout the building, by the use of which the engine may be shut down in case of accident. The mechanism by which this is effected may be, and usually is, arranged to be operated automatically by a device attached to the engine itself and independent of the governor in case the speed increases beyond a fixed limit.

In some of the States automatic engine stops are required by law, but the law is not always sufficiently explicit to require an engine stop to the true sense. It might be established, for instance, that the usual safety cams on a Corliss engine constitute an "automatic engine stop," preventing as they do the hooking on of the valves and the admission of steam when the governor balls fall below a certain plane. But this is really a part of, an attachment to, the primary governor and subject to derangement with that governor. If the governor belt breaks and the balls drop, it will act; but if the belt slips, so that the governor runs slowly enough to permit a late cut-off, but not so slowly as to bring the safety cams into play, there may be an accident. It is a too common practice, moreover, to leave in place, while the engine is running, the pin which holds the safety cams out of action while starting up, although most modern engines are fitted with latches which automatically drop out of the way when the governor collar rises away from them.

A rider upon the governor belt, arranged in any of the usual ways to shut off the steam when the belt breaks and the rider falls, might be construed as satisfying the requirements of the law; but it is far from a positive safeguard.

The law should require specifically, and every provident engine owner should install whether the law requires it or not, a device entirely independent of the main governor, which will positively cut off the supply of steam when the speed becomes excessive. The danger in a mass of swiftly rotating metal is very real, and destructive explosions of flywheels not uncommon. There were twelve reported in January, and four each in February and March of the present year. Such an explosion may be far-reaching in its effects. The fragments of a wheel fly for hundreds of feet and are ugly and destructive missiles. People who live and pass near industrial establishments, as well as people who are obliged to pass their working hours within the range of flywheels, should have the assurance that something more than a two-inch belt and a fallible ball governor stands between them and eternity.

The Laborer Is Worthy of His Hire

The manager of a small hotel where an isolated plant has been in operation for some time says that if he had it to do over again he would install central-station current and go back to his old low-pressure heating system.

The plant in question is a model little installation which is saving the company twenty-five or thirty dollars a day net, and paying about twenty-five per cent. on the investment. It is not owing to financial considerations that this manager is so much dissatisfied. He claims that it is impossible to get competent help to operate his plant and that the petty labor troubles to which he is subjected are causing him more gray hairs than the money saved will warrant.

He is always worrying for fear the night engineer will get careless and explode the boiler, causing heavy damage suits as well as property loss. All manner of imaginary calamities haunt his mind and he claims to have a constant load of anxiety which he would be glad to pay twenty-five dollars a day to get rid of. This is one of the strong arguments of the central station. It seems to work out to perfection in this case.

As a matter of fact, he is trying to run his plant with the same wages and class of help that he formerly paid for janitor service with his old low-pressure heating system. It cannot be done. An electrical plant delivering twenty-four-hour service must have supervision of a higher order.

If this manager would take two dollars and a half a day out of his savings of twenty-five dollars a day and add it to the wages of his day and night engineers, dividing it in proportion to the money they are now receiving, he could get men who would operate his plant in a first-class manner and there would be no necessity for him to lie awake nights waiting for something to happen.

And, incidentally, he cannot get rid of that worry by putting in central-station current, for he will have to have boilers in operation all the time for hot-water service, and a "low-pressure" boiler can raise as much fuss as another when its pressure accidentally becomes "high."

Technical Graduates and the Public Service

A recrudescence of the disposition of examining boards to look rather to where a man got his knowledge than to what he actually knows appears in an advertisement by the Municipal Civil Service Commission in a New York daily announcing an examination for the position of mechanical engineer in the office of the Commissioner of Public Works.

Candidates must be graduates of a technical school and have had drafting room experience on details of mechanical appliances, together with at least three years' experience in assembling and erection of units connected with steam plants. They must show a familiarity with the details of complete mechanical equipments of public buildings—plumbing, elevators, heating, electric lighting, pumping and power systems.

We submit again that it should be no concern of a civil-service commission or other examining board whether a candidate got the knowledge requisite for the position at an institute of technology or at home on the kitchen table *so long as he has got it*. It is for them to know the kinds and degrees of knowledge which he should possess and to determine by examination whether or not he possesses them; and if he does possess them and can prove it, he ought to be as eligible to the position as another of equal attainments, whether he has gained a degree in the classic shades of a university or won competence in the school of experience.

Duplication in the Power Plant

To insure continuity in the operation of steam plant it is necessary to install considerably more apparatus than is actually necessary.

Naturally, the character of the load carried by the plant has much to do with the character and arrangement of its machines. A manufacturing plant generally contains just enough power units to operate the works. No idle engines are seen, the boilers are all under steam and there is just enough auxiliary apparatus to keep the plant in operation with everything working satisfactorily. If, due to an accident, such a plant is shut down, it affects comparatively but a few people.

But, if the plant were used for electric-lighting or street-railway service, a more exacting service would be required. In this case the public is to be served and a shutdown becomes a serious matter.

Many of these plants were formerly fitted with duplicate units throughout, duplicate feed-water and steam lines and apparently every precaution taken to guard against a possible shutdown. This practice, although expensive, has been the means of preventing a tie-up of the service, and accidents to the machinery have been tided over by the duplicate units without a break in the service.

Probably the weakest part of a modern power plant is its piping system. Exposed to varying degrees of temperature in the steam main, the action of acids and other deteriorating elements in the feed-water mains, together with water hammer and strains due to other causes, the pipe lines of a power plant should claim the particular consideration of the designing engineer.

Formerly it was considered good practice in the larger plants to install duplicate piping connections to the main units. Due to the large initial expense, increased radiating surface, double the number of joints and valves to keep in repair, the present-day engineer has reverted to the single pipe line, both for boiler feeding and for supplying steam to the engines.

To insure continuity of service, such a system requires good material, careful designing and placing of valves so that a break at any point in the header will not interfere with the operation of a single unit, for, if proper provisions are made, steam may be obtained on either side of the break. Although the single pipe line has its disadvantages, it is now considered preferable to the older method of duplicate piping.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Union Clam Shell Buckets

The Union clam-shell bucket is designed for handling hard and soft coal, sand, gravel, crushed stone and earth excavations.

The bucket is designed so that the closing drum does not sink into the substance being dug, but revolves in fixed bearings.

The advantages of this type of bucket are as follows: First, the weight of the drum adds to its momentum when falling, and exerts a downward force. Second, the drum cannot sink into the material being handled, thus insuring a full load, and third, the bucket does not spill its contents when in transit, due to the shields over the top of each section.

The design of the bucket shown in Figs. 1 and 2 is known as class A and is rigged with a fixed frame and flexible head. This is used mostly for handling coal and loose material. It has an unusually large reach, is light and takes up very little head room.

Class B has movable supporting arms and the bowls are manipulated by a link motion, and is designed for handling crushed stone, sand, coal and light excavation.

Class C is built on the same principle as class B but is heavier in construction. This style of bucket is used for heavy work. Teeth are furnished with this bucket when desired.

The drum is made of a steel casting of the self-oiling type and holds approximately one quart of oil. The bowls are made of flanged steel with flanged corners only. The arms are of iron and are built to withstand heavy strain. The shoes are made so that they may be easily removed and are of steel.

These clam-shell buckets are made by the Union Iron Works, Newark avenue, Hoboken, N. J.

Governor Valve Oil Relay

An oil-relay system, for large high-pressure turbines, has been developed for operating the primary and secondary admission valves of the largest size of Westinghouse high-pressure turbines.

The operation of this relay will be understood by referring to the accompanying illustration, in which sections through the operating cylinder *A* and valve *B* are shown. Attached to the operating cylinder is a safety release valve *C* that is under the control of the speed-limit device.

The governor operates the rock shaft *D*, and its motion is transmitted to the pilot valve *B* through the arm *E*, link *F* and the floating lever *G*. According to whether the governor weights move in or out with increase or decrease in load, the pilot valve will either be raised or forced downward from its neutral position, admitting the oil (under pressure from the chamber *H*) underneath or above the relay piston, as the case may be, at the same time opening the ports at the opposite end of the cylinder to exhaust through the passages *I*. The oil-pressure chamber is located between the exhaust passages so that leakage escaping from the relay pistons is prevented. A drain pipe is provided to entrap the small leakage past the relay-piston rod.

As soon as the operating piston has traveled a short distance, it returns the pilot valve to its closed position, by means of the floating lever *G*, immediately restoring equilibrium, and thus holding the admission valve in a fixed position. The floating lever *G* first turns about the point *K* as the position of the governor clutch which imparts the governor travel to the rock shaft *D*, changes, and thus swings

Fig. 1. Bucket Open

Fig. 2. Bucket Closed

about J as the relay piston A begins to move. As soon as the governor gives the pilot valve B one direction of travel, the following motion of the operating piston will immediately reverse it, closing both ports and locking the valves in a fixed position until further movement of the governor takes place.

The motion of the relay piston A is transmitted to the primary valve O and the secondary valve P through the levers M and N. The arrangement of the two levers for the two valves will be found the same, with the exception that the secondary-valve linkage is provided with an adjustable backlash at R so that the time of opening of the secondary valve may be changed by the operator. Ordinarily, this valve is regulated to open at the moment the primary valve P has reached its maximum port opening. To overcome the friction of rest provision is made for the fixed oscillation of the plunger, which causes a very slight up and down motion of the main operating piston, and the main poppet valve. This, however, is not sufficient to cause any observable fluctuation in the flow of steam to the relay system. A spring-loaded bypass valve is provided in the pipe line so that the oil in excess of that required by the relay escapes through this valve. This surplus oil together with the exhaust from the relay is led to a cooler and thence to the bearings as usual, whence it is again returned to the reservoir and back to the pump.

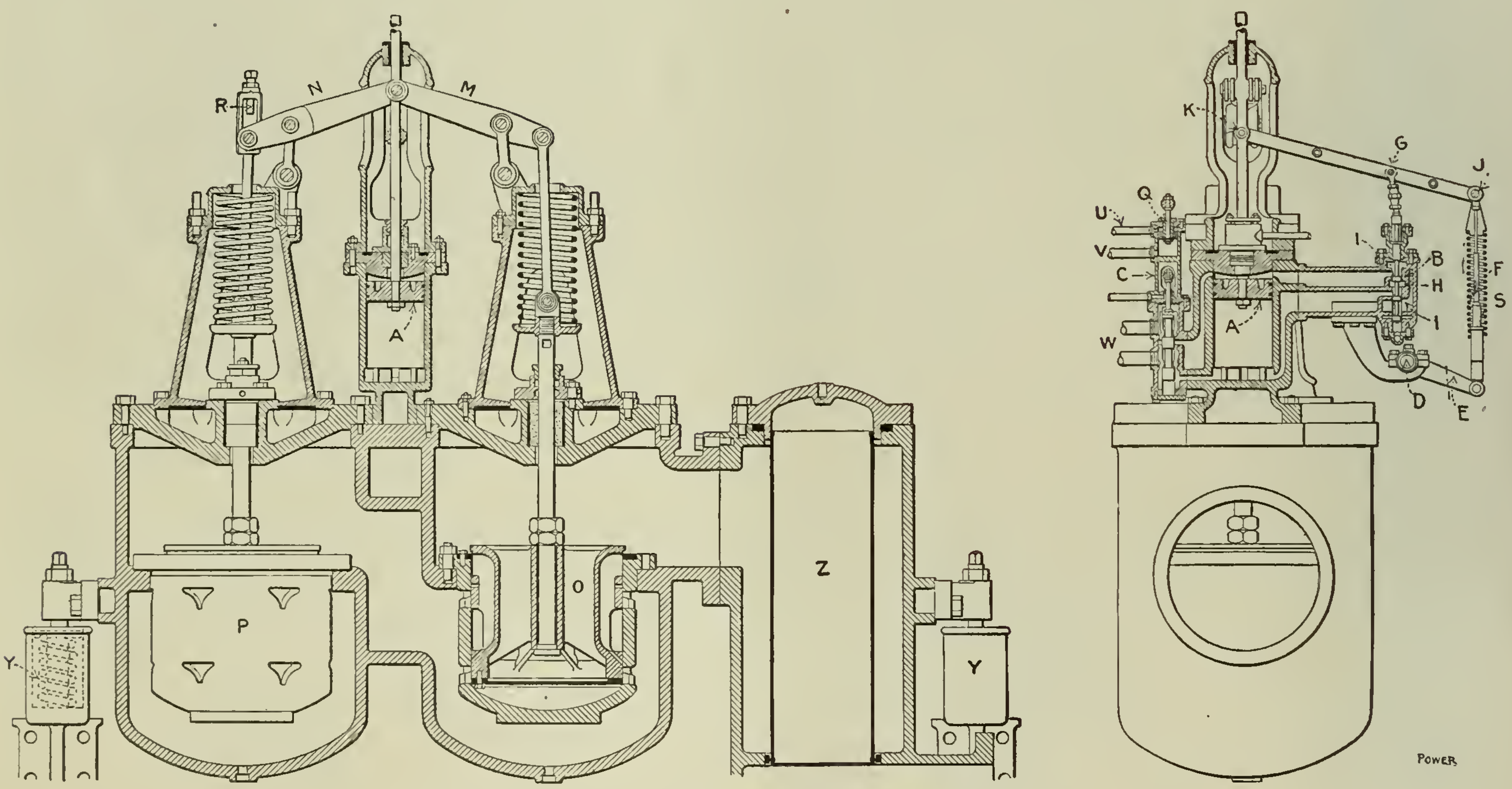
The poppet valve possesses some novel features.

The valve is essentially a combination of a poppet valve and piston valve, the poppet-valve feature being in effect only when the valve is closed, or nearly so. When the valve is partially closed, the opening past the valve seats is at all times very much greater than the passage through the ports. Hence wire drawing of the steam will take place at the latter point, where it can do no harm. The valve ports are all of a peculiar form, so as to admit constant increments of steam for constant increments of valve lift.

In addition to the automatic throttle, an auxiliary safety steam valve Q is provided, receiving live steam at U. With leakage of steam past the piston, it is by heavy coil springs, as shown at Y and Y.

Steam is supplied to the valves through the strainer Z and the secondary receives its supply through the primary valve. The governor link F is provided with a compression spring S. On shutting down the machine, relieving the oil pressure, the effort of the governor weights to come together would tend to raise the primary valve, which tendency would be resisted by the main spring on the primary valve. This would put a serious strain on the governor linkage, but the interposition of the comparatively light spring S in the linkage absorbs the governor travel without imposing any undue strain on the regulating mechanism.

Should the oil supply to the relay fail, the main spring would bring the valves to their seats, raising the relay piston to the highest position. The governor would then have a tendency to open the valves through the lever G. But as the spring S is unable to operate against the more powerful main-valve springs, it collapses and prevents the lifting of the main valve by the governor.



Sectional Views of the Governor-valve Oil Relay

to the turbine. The advantage of this method is that the governor becomes more sensitive, and the least move of the governor produces its consequent change of steam distribution.

The oil-relay apparatus will use more oil than the steam-relay system, but this oil is afterward used in the bearings. The oil required for this apparatus involves nothing additional in the turbine system beyond the oil-relay mechanism. The same pump is, as heretofore, pumping the oil at a somewhat greater pressure, and delivering a constant supply held in a raised position due to the unbalanced pressure. When the automatic trip operates, the steam from underneath this piston is exhausted through the outlet V. Through external linkage, an oil valve W is then operated which relieves the pressure above the relay piston and admits the pressure beneath, correspondingly forcing it to the top of the cylinder, thereby closing the valve.

In order to relieve the turbine casing of any strains due to the operation of the oil-relay system, the steam chest is mounted on the bedplate and supported

This oil relay is manufactured by the Westinghouse Machine Company, East Pittsburg, Penn.

Pete Blowoff kum inter my ingin room tother day an' sed thet th' exhoust uv my ingin sounded jist like th' pants uv a fat pug dorg thet hed bin tryin' ter ketch wun uv them Kansas jack rabbits. It sorter riled me an' I landed on 'im with wun uv my number tens jist ez he wuz gettin' out uv th' door. Pete sez thet he's bin havin' trouble with his main bearin' ever sence.

Meeting of the American Association of Refrigeration

The second annual meeting of the American Association of Refrigeration was held in the east assembly room of the La Salle hotel, Chicago, May 9 and 10, Theodore O. Vilter, president, presiding. In opening the meeting the president gave an account of the visit of the American delegates to the second international congress of refrigeration, at Vienna, and urged upon members of the American association the importance of making the coming international congress in this country in 1913 a success. After the report of the secretary and treasurer the meeting adjourned in a body to the blue room of the La Salle hotel, where a luncheon was served to all those in attendance, as guests of the association.

AMERICAN ASSOCIATION OF REFRIGERATION IN SESSION AT LA SALLE HOTEL, CHICAGO

The following session was occupied largely with the reports of standing committees and with the consideration of cold-storage subjects. Another subject which engaged considerable attention was that of the adverse legislation which is being introduced in many States. Special committee reports were made on this subject and means for obtaining proper consideration of cold-storage interests were discussed in detail.

One of the principal objects of the meeting was to decide on the place and time for holding the third international congress of refrigeration, which, as noted above, will be held in this country by special invitation of the United States Government. A spirited contest developed between New York and Chicago for the honor of entertaining the foreign delegates and American representatives of the coming congress. The discussion of this subject was carried over until the following day, when, after repeated ballots on motions and amendments to motions, it was finally decided to hold the international meeting in Chicago. The plan as tentatively outlined by the Chicago Association of Commerce, in connection with the executive committee of the American Association of Refrigeration, is to have the foreign delegates gather at New York, leaving that city September 14, 1913, for Washington, where, on September 15, the opening exercises will be held and participated in by the President of the United States. After the exercises at Washington have been completed the delegates will be taken on special trains to Chicago, where the business sessions of the congress will be held and where the delegates will have the opportunity of inspecting the application of refrigeration to the enormous packing industries of the city.

Following the Chicago meeting it is proposed to have the special trains return East by way of Niagara Falls, holding the closing exercises in New York City.

Officers of the American association for the following year were elected as follows: William J. Rushton, president, Birmingham, Ala.; vice-presidents, E. O. McCormick, San Francisco, Cal.; Thomas Shipley, York, Penn.; Jacob Ruppert, New York City; Homer McDaniel, Cleveland, O.; Joseph Allerdice, Indianapolis, Ind.; George L. Flanders, New York City; Frederick H. Taft, St. Louis, Mo. John S. Field, Chicago, was elected treasurer and J. F. Nickerson, editor *Ice and Refrigeration*, Chicago, was reëlected secretary.

An organization to take care of the arrangements for the coming international congress was perfected and two general officers were elected as follows: J. B. Forgan, First National Bank, Chicago, treasurer-general, and J. F. Nickerson, Chicago, secretary-general. Election of the other officers was left until later action by the executive committee.

N. E. L. A. Convention

The executive committee of the National Electric Light Association held on May 11, at the New York offices, a final meeting before the coming convention. The report of the secretary showed a flourishing state of affairs. Over 1800 new members were admitted, showing the gross gain since the last meeting about two months ago, and a net gain of over 1000.

Although the convention was three weeks off, it was stated that the registration had already reached about 1750, which would indicate an actual attendance of at least 3500 to 4000. Additional facilities for the meeting have been secured in the Engineering Societies building which will assist in distributing the throng over several floors. On the ground floor the ingenious idea has been adopted of supplementing the foyer by inclosing the entire large driveway around the building so that the members can also sit and lounge in the open air. The three largest meeting rooms will be devoted to the regular sessions and on the floor above another meeting room has been appropriated as headquarters for the New England section, the Eastern New York section, the Pennsylvania section, the Sons of Jove and any other affiliated or auxiliary body applying for such accommodation. The exhibition committee will also have its headquarters on this floor and the subcommittee on theaters, which will distribute the tickets for the three theaters which have been engaged for Thursday evening of the convention week, May 29 to June 2.

The Public Policy meeting is to be held on Wednesday evening, May 31, at the New theater, when Secretary Nagel will represent President Taft and deliver an address. The report will be presented by Past President Samuel Insull, of Chicago.

The baseball game will take place on Wednesday afternoon at the baseball grounds in Brooklyn, which are very accessible from headquarters; the competing teams will be those of the Brooklyn and Philadelphia companies.

The regular meetings have been arranged to occupy some sixteen sessions extending throughout Tuesday, Wednesday, Thursday and Friday.

A Memorandum Booklet

Charles C. Moore & Co., engineers, of San Francisco, Cal., are getting out a memorandum booklet for distribution among the engineering fraternity and managers of plants. The book, 3¼x7 inches, is bound in black leather, with a pocket on the inner side of either cover, and the pages are perforated into five squares, each of which is large enough to jot down a specific note or engagement. As soon as the matter has been attended to, the square may be torn out regardless of any of the others. This in itself is a great convenience as it saves the trouble of wading through a miscellaneous collection of notes of no current value to find what is wanted, and for the same reason the live material is more readily found. When the pages are all used, new inserts, as they are called, may be obtained by application to the nearest branch office of the company.

The A. O. S. E. to Meet at Philadelphia

The twenty-fifth annual convention of the American Order of Steam Engineers will convene at Philadelphia from June 5 to 10. Every available foot of floor space in the large auditorium of Odd Fellows' Temple has been assigned to the various firms in the engineering line for the display of their goods and appliances. The committee are putting forth their best efforts in devising ways and means to accommodate the many late applicants, who are now anxious to secure exhibit space, and it is feared that it will be impossible to locate all of them. The several sessions of the delegates will be held in an upper hall in the same building.

The dealers and engineers, and, in fact, everybody interested in the power-plant industry in Philadelphia and vicinity, have been invited to attend the convention, and there is an assurance that the exhibit hall will be well patronized at all times.

An excellent program of entertainment has been arranged, and taken altogether, the outlook favors a most successful meeting.

A Correction

In the May 9 issue, page 718, the word Keeler, instead of Kellogg, was inadvertently used in specifying the make of the 175-foot radial-brick chimney for the municipal pumping and power plant of Orange, N. J.

PERSONAL

Gordon C. Keith, managing editor of *Canadian Machinery, The Power House* and *Canadian Foundryman,* has resigned to join the editorial staff of *The Canadian Manufacturer.*

E. Heinrich, M. E., who, with Doctor Junge, has been writing a series of articles for POWER upon "The Steam Turbine," has given up his position upon the designing staff of the Fore River Ship Building Company to fulfil an assignment of two years in the research department of the technical high school at Stuttgart, Germany, under Doctor von Bach.

John F. Wallace, formerly chief engineer of the Panama canal, who retired after inaugurating the American work on the canal and afterward designed the new Chicago & Northwestern passenger terminal at Chicago, which has just been completed at a cost of $25,000,000, has assumed active charge as president of Westinghouse, Church, Kerr & Co., replacing H. H. Westinghouse upon the latter's recommendation to the board of directors.

SOCIETY NOTES

At the regular monthly meeting of the Internal Combustion Engineers, of Chicago, held on the evening of May 12, at Fraternity halls, 19 West Adams street, officers for the following year were elected as follows: Charles Kratsch, president; Wallace V. Pye, secretary, and I. J. Babcock, treasurer.

On Thursday evening, May 11, Branch No. 1, District No. 2 of the Institute of Operating Engineers, New York City, held its regular monthly meeting, at which F. L. Johnson presented his paper on the "Needs for Industrial Education." The paper drew forth considerable comment from the members and the discussion was both lively and interesting. About 50 members of the branch were present and the interest in the Institute seems to be growing constantly.

On Saturday evening, April 22, the seventh bimonthly meeting of the Colonel Goethals branch was held. A paper on the "Theory and Operation of Hydraulic Laws" was given by R. V. Madden and a short paper on "Water in Pipes" was delivered by W. R. Vernon.

On account of the interest manifested on the subject of "Fuel Testing," considered at the meeting of the American Society of Mechanical Engineers in Philadelphia on April 22, when a paper by J. C. Parker of that city on the "Work of the United States Fuel Testing Station" was presented, the meeting on June 3 in that city will be given up to further discussion of the same topic. The Engineers Club, of Philadelphia, will cooperate in the meeting.

The annual convention of the New Jersey State Association of the National Association of Stationary Engineers, will be held at Newark, N. J., June 2, 3 and 4. The several meetings of the delegates will take place in the New Auditorium, on Orange street, and in the main hall of the same building the mechanical exhibit will be shown. On Saturday evening, June 3, there will be a banquet at the Continental hotel, and several prominent speakers will address the diners.

NEW PUBLICATIONS

ELECTRIC POWER PLANT ENGINEERING. By J. Weingreen. Published by the McGraw-Hill Book Company, New York, 1910. Cloth; 431 pages, 6x9 inches; 291 illustrations; numerous tables. Price, $5.

This book was written to fill the want of a treatise upon present practice in the electrical equipment of power plants. The subject is divided into two groups: direct-current apparatus and alternating-current apparatus. In the first group are taken up dynamos, synchronous converters, mercury rectifiers, storage batteries, direct-current motors and switchboards. The second group deals especially with high-tension transmission, switching equipment and remote control. In each case the standard types of apparatus are illustrated and explained, various types of construction are shown, and complete wiring diagrams are submitted. A considerable portion of the text is devoted to illustrations of a number of large central stations and substations now in actual operation.

The book is in no sense a textbook and does not go into any theoretical considerations of electricity. On the other hand, it represents present power-plant practice and as such should prove of great service to consulting and constructing engineers.

POWER

NEW YORK, MAY 30, 1911

SOME years ago, so the story goes, a certain uptodate storekeeper hired two boys and set them to work undoing rolls of cloth in a rear room.

One of the boys was thrifty by nature and training; so was the other, but in a different way.

The first boy untied the cords that were around the rolls of goods he was working on, and carefully and painstakingly wound them up in a ball to save for future use. The wrapping paper was precisely folded and also tenderly lain aside.

That boy was saving the cost of the cord and wrapping paper for his employer.

When the second boy began undoing his bundles, he got out his pocket knife, slashed the cord with one deft stroke and while placing the unwrapped goods in a pile with one hand gave the wrapping paper a fling that sent it on the floor behind him.

That boy was saving the cost of the cord and wrapping paper also, and then some.

Careful, painstaking methods of doing work are all right in their place, but the first boy, although saving the cord and paper, cost his employer more than it was worth in so doing. His output of useful work was reduced just the amount that could have been accomplished while wasting his time saving strings and brown paper.

The other boy expended his energies in useful work and left the paper and cord for the janitor to look after.

Now what does all this amount to to the engineer?

The same principle will apply to his work.

There is no saving in spending time picking coal out of the ash pile while air leaks are allowed to exist in the boiler setting.

The first boy might do it, but the boy with the knife would get after the leaks and let the ash handler look after the ash pile.

It is a waste of time to spend energy in stopping up a pin hole leak in a steam pipe and allow the valves of the engine to be so set that the machine would run backward if given half a chance.

Fussing with the ash pile and the pin hole leak will make a show toward economy, but attending to the real point of saving is what counts.

Can you imagine a ditch digger carefully selecting the exact spot where he intended to deposit each shovelful of earth?

But there is just as much sense in such a procedure as for the fireman to carefully spread green fuel over the fire and then leave the furnace doors open.

One procedure is a waste of time, the other a waste of money; both amount to the same in the end.

There are several methods of producing economy in a steam plant, as elsewhere. It is better to do things that produce results than to save paper and string.

A Remodeled Street Railway Plant

By Warren O. Rogers

This power plant contains the largest horizontal seven-stage Curtis turbine that has been put into service and also four of the largest Edge Moor boilers in New England. The station has been remodeled and provision made for future expansion.

One of the difficulties which the designing engineer encounters is that of looking ahead and providing for future growth and demands upon the steam plant. Frequently a power plant will be designed with such a capacity that, seemingly, it will be sufficient to meet all demands made upon it for years to come, when in reality two or three years finds the plant overloaded and incapable of economically carrying the load.

That is what occurred at the plant of the Worcester Consolidated Street Railway Company, which has recently been remodeled to meet the greater demands placed upon it. It is now constructed in such a manner that from the present plans its capacity can be increased threefold.

Prime Movers

The new power plant, shown in Fig. 1, is situated on Providence street, Millbury, Mass., a few miles out of Worcester. It contains two 300-horsepower reciprocating engines, direct coupled to generators; these two units comprised the original power plant. There is also one 5500-kilowatt horizontal Curtis turbine and generator, which furnishes electrical energy at 13,200 volts. Space has been provided for four additional units of the same capacity, as demands may be made. At the present writing, this is the largest seven-stage horizontal steam turbine that has been installed in a power plant by the General Electric Company, although several of larger capacity are being constructed; it is illustrated in Fig. 2. With the exception of the seventh stage, the machine is built along similar lines to the five- and six-stage turbines.

The unit is self-contained. Oil is kept in circulation from an oil tank cast in the base of the turbine frame and is supplied to the bearings at a pressure approximating 15 pounds per square inch. The bearings are cooled by water circulating in copper coils which are embedded in the babbitt bearings. The turbine is connected to a Worthington surface condenser which has a cooling surface of 10,000 square feet. It is located in the basement under the turbine and connection is made by the usual copper expansion joint. Water is supplied by gravity from a canal by means of an iron flume and escapes to a stream below the power house through a concrete flume. This eliminates the expense and trouble of operating a circulating pump.

On the turbine-floor level are located the exciter and air-pump units. The exciter set consists of a Curtis turbine di-

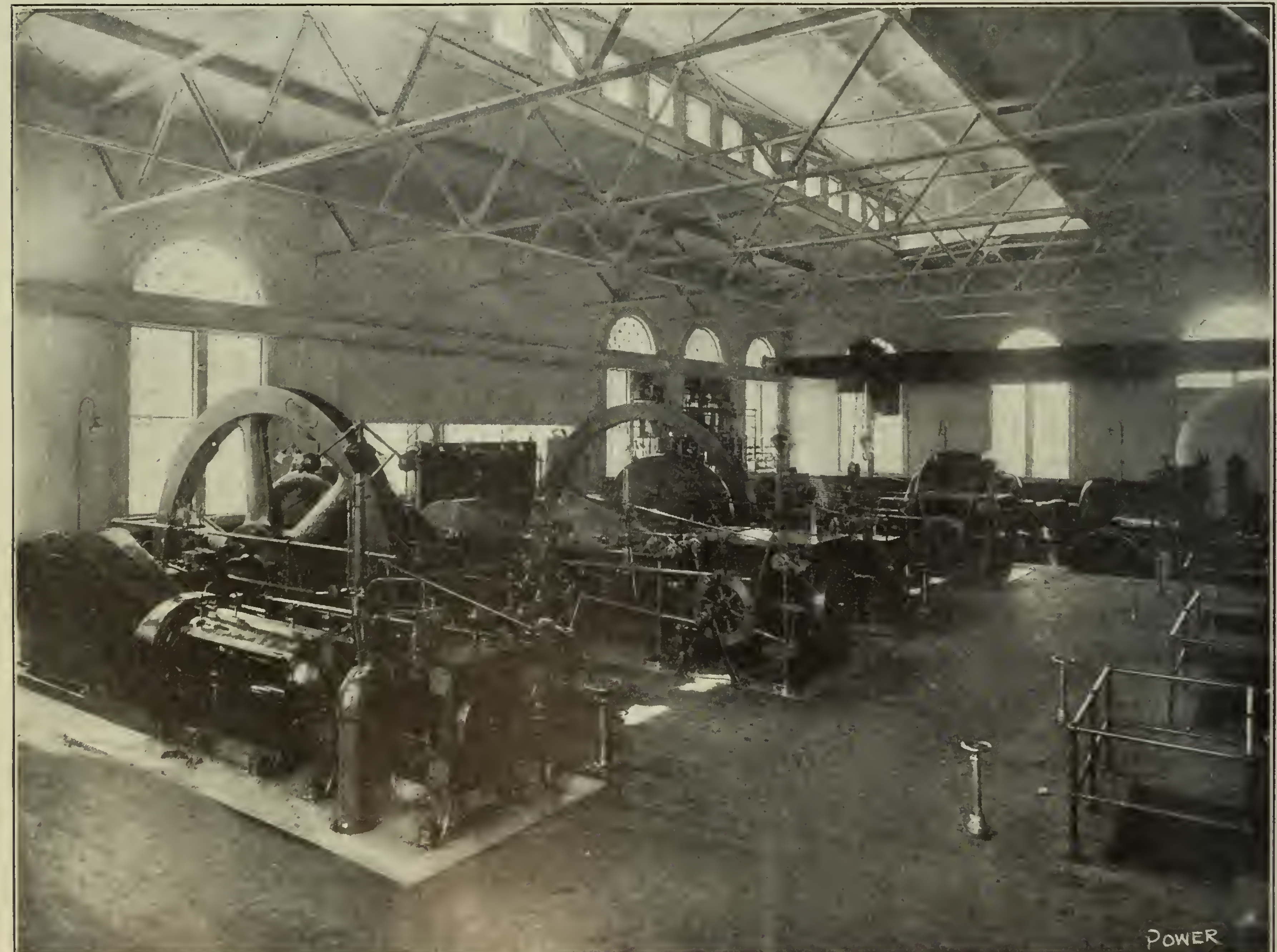


Fig. 1. Engine Room of the Worcester Consolidated Street Railway Company's Plant

rect coupled to a General Electric 125-volt direct-current generator. The turbine is of 75 kilowatts capacity and operates at a speed of 3300 revolutions per minute. The air-pump unit has 10 and 22 by 18-inch cylinders and main-

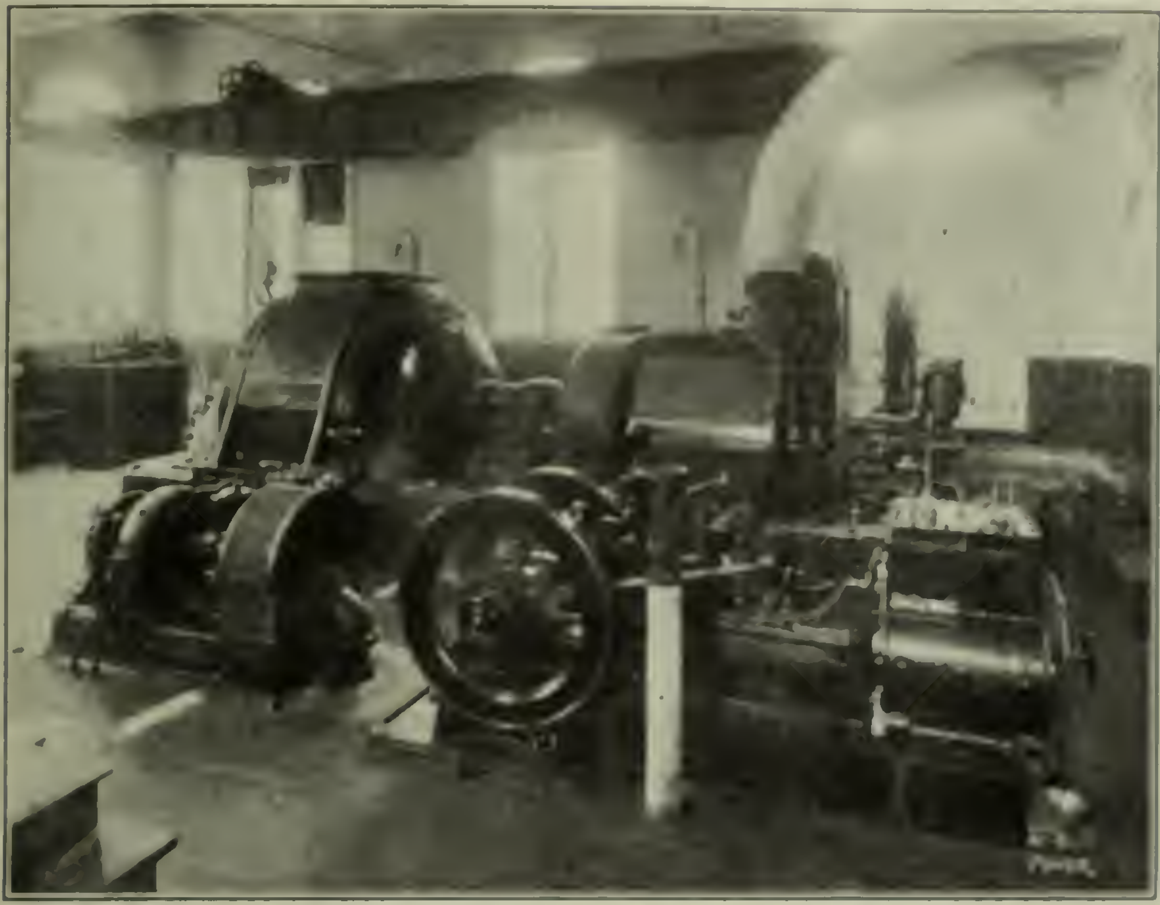


Fig. 2 View of Turbine Unit and Auxiliaries

tains a vacuum of 29 inches on the condenser.

The turbine generator is of the standard type, three-phase alternating current. The rotor is ventilated by means of fans secured to the revolving field. Air is taken from the outside of the building through a concrete duct built in the foundation and is carried to the machine at as low a temperature as possible. The high-tension switchboard is located on a raised platform at one end of the turbine; the main switch is electrically operated. On the switchboard is mounted the necessary indicating devices and recording instruments. Back of the switchboard are the choke coils and lightning arresters.

Boiler Room

The boiler room has been altered and enlarged. The old return-tubular type of boilers has been removed and four 850-horsepower Edge Moor boilers are now installed. Each is fitted with a Foster superheater, which superheats the steam 150 degrees. The steam pressure carried is 200 pounds per square inch. Each boiler is fitted with two Murphy stokers.

These boilers are housed in a building that is 100 feet long, 15 feet 6 inches wide, and 40 feet high, and has a monitor roof. Under the boiler-room floor there is an ash tunnel 115 feet long, which is constructed of reinforced cement. This tunnel terminates in an ashpit that is 25 feet deep and 10x10 feet inside dimensions. Fig. 3 shows the arrangement of the boilers.

Incidentally, it may be said that these Edge Moor boilers are the largest of the type ever installed in New England. They are of the four-pass type. These boilers are not equipped with economizers, but provision has been made for installing them on top of the concrete smoke flue which extends from the back of the boilers to the brick stack. This concrete flue, contrary to the general practice, is placed on the floor level, which gives ample opportunity for installing economizers later on. This flue is lined with firebrick and connects the boilers with a 225-foot Kellogg sectional radial-brick chimney having an internal diameter of 12 feet.

Double piping is supplied in the boiler room, and both the feed pipes and the steam lines are designed, not only with a view of extending the length of the boiler plant, but also of connecting to a second row of boilers at some future time. The feed water to the boilers is passed through a Wheeler heater of the closed type, and is pumped by means of two Wheeler heavy-duty boiler-feed pumps.

Fuel

Coal is delivered to the yard in carload lots, and is dumped in a pile under a high trestle that is 350 feet in length. An electric locomotive draws the cars 1500 feet over a siding from the main railroad track, and after the coal is dumped, it is hoisted by means of a two-ton bucket operated by a McMyler traveling locomotive, which dumps the coal into a hopper of a crusher that has a capacity of 125 tons. The arrangement is shown in Fig. 4.

From the lower hopper of the crusher the coal descends into a Larry coal car, which operates on a track extending over the top of the furnaces. The car discharges the coal wherever needed. The ashes from the grates drop into a concrete tunnel under the furnaces into a car which deposits the ashes into a revolving pit outside of the building. It is then taken by the bucket of the locomotive crane and deposited in cars on the trestle and is then drawn away.

Fig. 3. Arrangement of the Four Edge Moor Boilers

Transmission

The transmission lines are carried a distance of six miles to a substation that is located at Worcester, Mass. There consist of two three-phase lines of No. 0 stranded wire. These lines are capable of carrying a voltage of 33,000. The transmission lines enter a brick lightning-

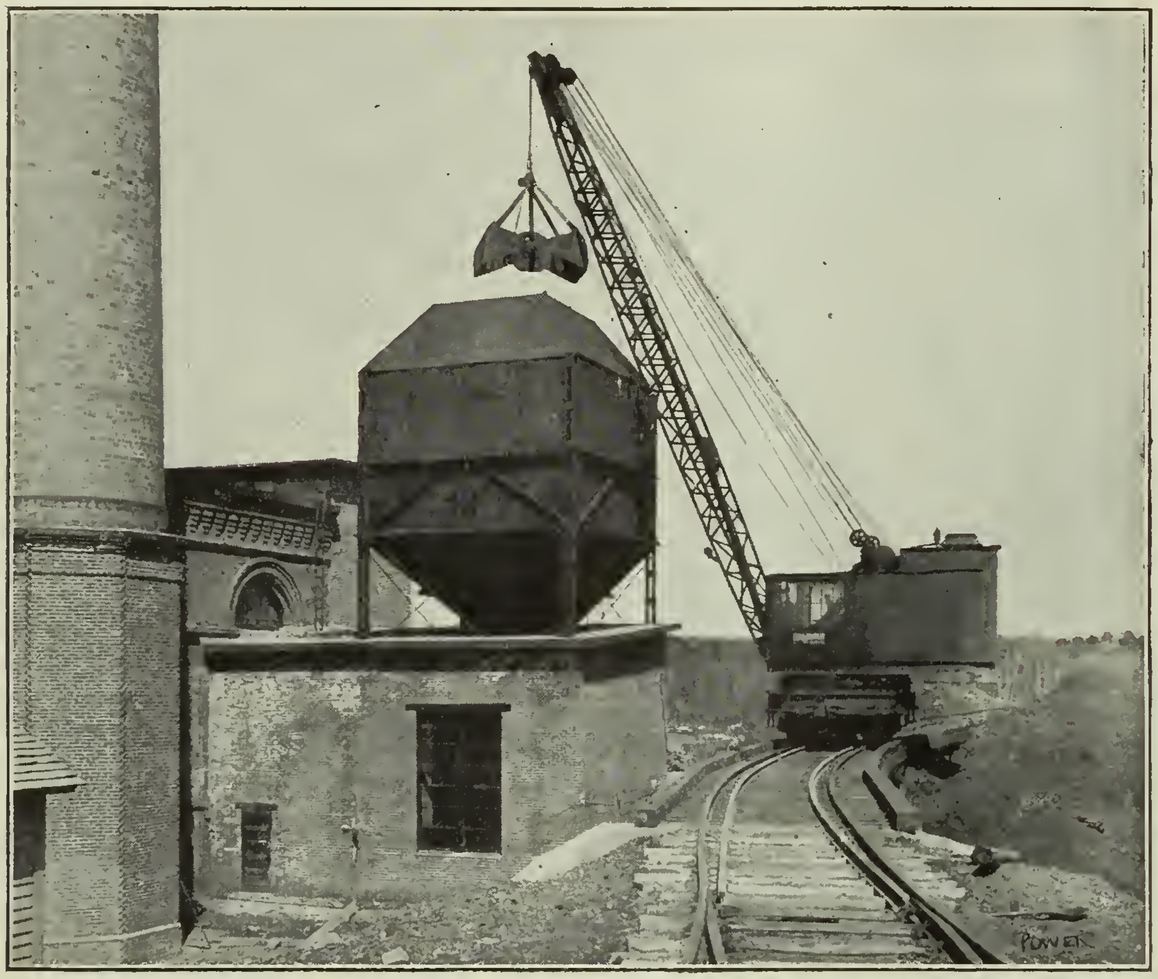


Fig. 4. Coal-handling Traveling Locomotive

arrester tower, where choke coils, disconnecting switches and lightning arresters are located. From the tower the wires pass under Madison street through underground ducts to the substation, which is made fireproof throughout and is constructed with a skeleton of steel with walls of brick and concrete. The win-

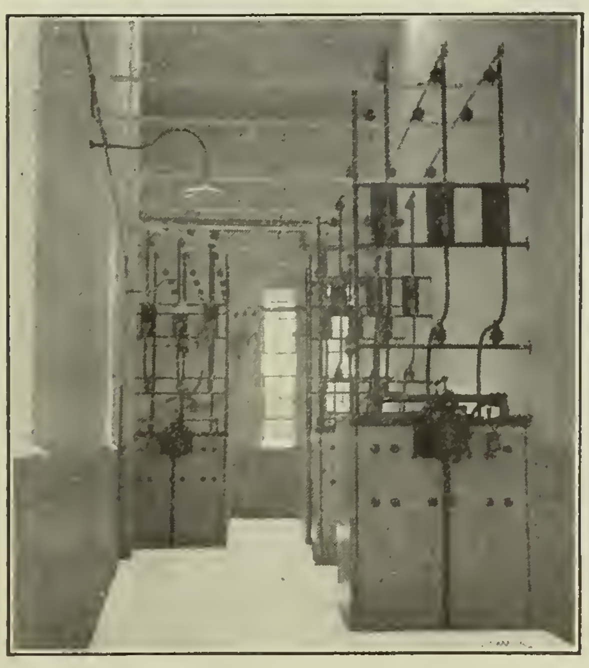


Fig. 5. Lightning Arresters and Oil Switches

dows, sashes and casings are also of steel, no wood being used in the construction of this building.

This is said to be the largest substation in New England. The building is 144 feet long, 35 feet wide, and is 60 feet in hight. There are two floors and a basement, the first floor being 27 feet high, the second floor 26 feet. A 20-ton electric crane has been installed in the converter room, and one of 10 tons capacity in the second story. The supply circuit from the lightning-arrester tower enters the basement in two insulated lead-covered cables, which are carried to the

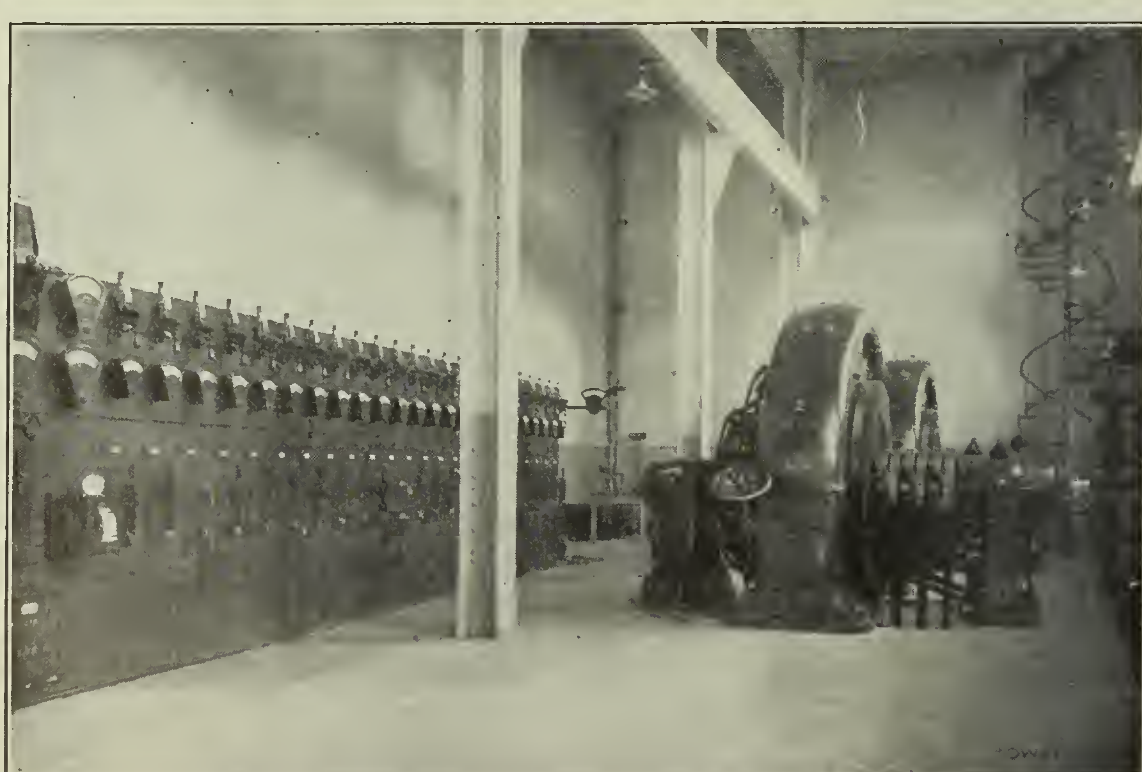


Fig. 7. Converter Room, Showing the Two 1500-kilowatt Rotary Converters

top of the building where they connect with the busbars. In this same room there are four oil switches, which are operated from the switchboard. These are shown in Fig. 5.

A separate room on the second floor contains the transformers, which are shown in Fig. 6. They are arranged in banks of three over a large concrete duct. Each rotary converter is served by one of these banks. Each is connected to a motor-driven blower which draws air from the duct below and drives it through the transformers to cool them. Each transformer has a capacity of 500 kilowatts and steps the voltage down from

Fig. 6. Section of the Transformer Room

13,200 to 430, the potential at which it operates the rotary converters.

These two converters are located on the ground floor, as shown in Fig. 7. They are each of 1500 kilowatts capacity. Space has been provided for the addition of three more converters with the necessary transformers and oil switches. Each machine has its separate starting switchboard, which is on the opposite side of the building from the main switchboard. This panel contains the main rotary switch, the reacting switch and the push button controlling the oil switch. A constant voltage of 600 is transmitted from the busbars to the outgoing lines.

The main switchboard has 27 panels: One station-instrument panel, two main rotary panels and a separate panel for each section of the feeder system, the city wiring having been rearranged for this purpose. This substation is the center of distribution, as the outgoing current from the rotary converters and the incoming current from the Freemont street power station are connected in parallel at the switchboard and switched onto the various lines.

Directly under the rotaries, in an open space in the foundation in the basement, the negative and equalizer buses are placed. Several lines of underground return wires enter through the basement walls and are connected to the negative busbar.

The substation is located at a point practically in the center of the city, which makes the distribution of current with but small loss a possibility.

The Effect of Vacuum at an Altitude

In a recent issue of POWER the question was asked, "At a hight of a mile is the vacuum in an engine cylinder as effective as at the sea level?"

And answered, "It is."

In an effort to be laconic the editor who wrote the answer failed to put himself into the mental attitude of the man who wrote the question. If the question asked no more than if a given force is just as effective to move a piston in Colorado as in New York his answer is right, but the question is not worth answering. Adding twenty inches of vacuum will add, in round numbers, ten pounds to the mean effective pressure, and this wherever the engine may be, but this is too obvious to be taken as the point in the question. The atmospheric line from which it is reckoned has slipped downward at the higher altitude.

Suppose an engine with an initial pressure of 100 pounds gage and a vacuum of 20 inches to be run, first with a 30-inch barometer, as there might be at the sea level, and then with a 25-inch barometer, as there might be at the altitude of a mile. To simplify the matter, since we are not after absolute results, assume 2 inches of mercury to be equal to one pound pressure.

Then at the sea level with the 30-inch barometer the atmospheric pressure would be 15 pounds and the absolute initial pressure 115 pounds per square inch.

With a 20-inch vacuum the absolute back pressure in the cylinder would be 30 − 20 = 10 inches of mercury, or 5 pounds.

The ideal diagram would be *A B C D E* of Fig. 1, which, with a ratio of expansion of 6, gives a theoretical mean effective pressure of 48.5 pounds.

On the mountain, with the 25-inch barometer the atmospheric pressure would be 12.5 and the absolute initial pressure 112.5 pounds. With a 20-inch vacuum the back pressure in the cylinder would be 25 − 20 = 5 inches of mercury, or 2.5 pounds absolute.

The ideal diagram would be *a b c d e*, represented by the dotted lines, and, with six expansions as before, would give a mean effective pressure of 49.8 pounds; 2.7 per cent. more than in the case of the same engine with the same initial pressure (gage) and the same vacuum at the sea level.

The effect of the condenser is to reduce the lower temperature level, to increase the head or fall of the heat between the temperatures of entry and rejection. A 20-inch vacuum on a mountain means a lower absolute pressure and a lower temperature of rejection than does the same vacuum at the sea level.

In the diagram, Fig. 2, hights represent temperatures instead of pressures, as they do in Fig. 1, but the area represents energy just as does the area of the other diagram. The diagram should be plotted with absolute temperatures, so that its real base is 460 + 338 = 798 units below the level *A B* and the area of the whole diagram would represent the energy in the form of heat which must be put into a pound of water to make it into a pound of dry saturated steam at the given pressure. The area *A B C D* shows how much of this heat a perfect engine, working in a Rankine cycle between the limits 338 and 162 degrees (100 pounds initial and 20 inches vacuum at 30-inch barometer), could convert into mechanical energy as against that convertible by a similar engine working between the limits 338 and 135 degrees (100 pounds initial and 20 inches vacuum with 25-inch barometer), as shown by the area bounded by the dotted lines.

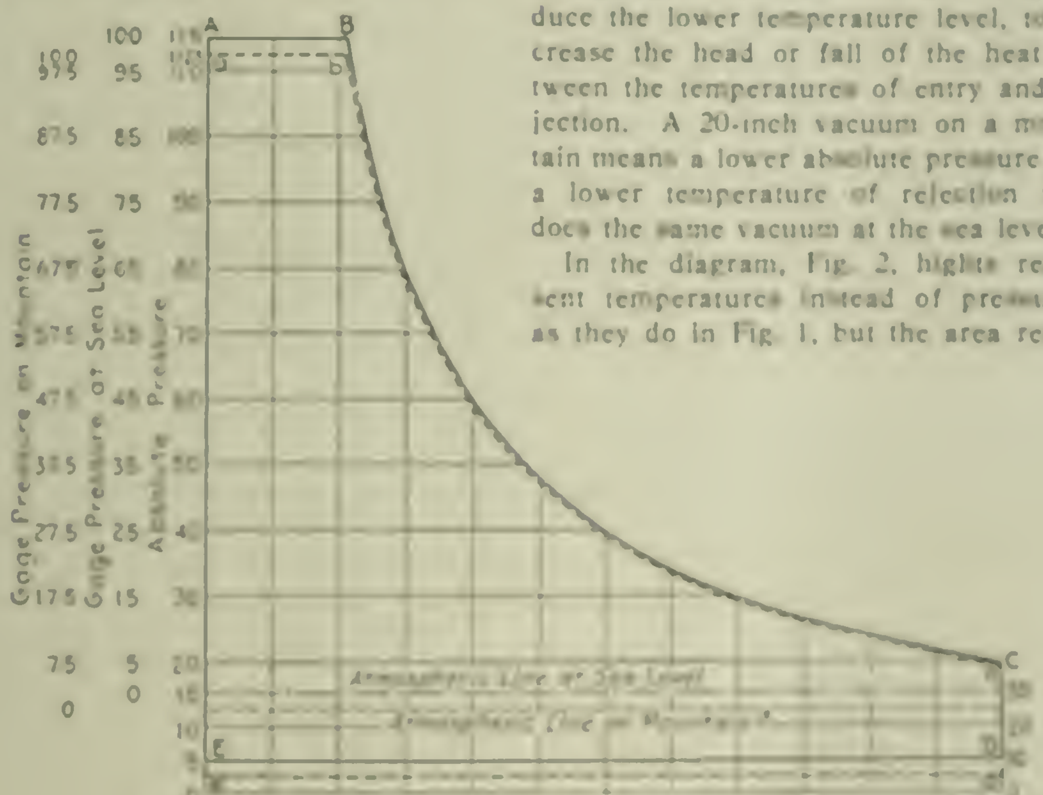


FIG. 1

A Dangerous Bag

By [illegible] T. Hume

A venerable engineer recently related the following interesting incident of a dangerous case of bagging:

In taking charge of an old plant that was considerably run down, the boilers were found to be badly scaled. A barrel of good boiler compound was procured. Orders were given the fireman to use it sparingly until after the first or second cleaning; then to increase the amount until the scale should be removed. Instead of paying attention to these directions, the fireman got the order of proceeding reversed and for the first few days fed the compound in large amounts.

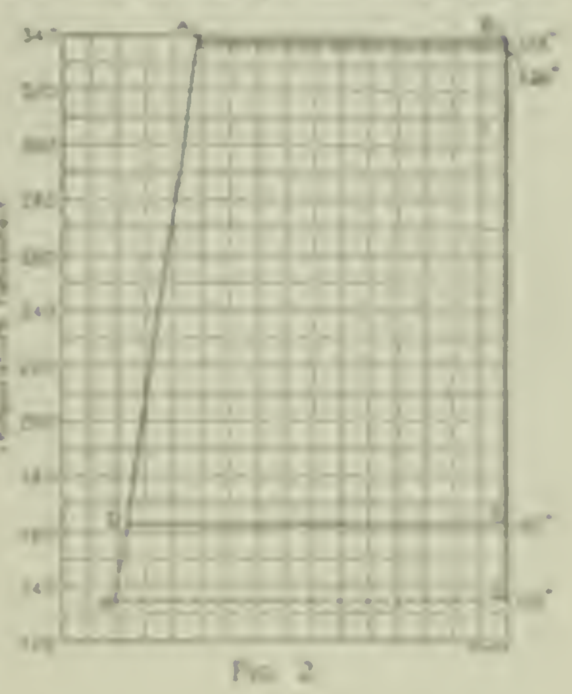


FIG. 2

At the end of the third day he called the attention of his chief to what seemed to be a leak in the boiler plate over the fire. An effort was made to run the boiler until Sunday but, the leak growing worse, it became necessary to shut down the boiler. Upon opening it, an accumulation of scale sufficient to fill a nail keg was found directly over the fire. The plate under this deposit had burned and bagged to a distance of 9 inches and over an area about 15 inches in diameter. The metal was drawn out to the thinness of brown paper and several small openings through the metal were in evidence. While the accumulation of scale caused the burning, it apparently stopped the leaks for the time being and saved the boiler.

A horseshoe patch was put on and the old boiler is still in service.

Letters Patent for Inventions*

By D. Howard Haywood

A general discussion of patent rights and the protection they afford; also some useful hints as to the scope of the claims to be made in applying for a patent.

*From a paper delivered before the American Society of Mechanical Engineers, at New York on May 9.

There is much confusion in the mind of the average man as to the nature of the rights conferred by letters patent of the United States. Upon their face they grant to the holder, for a specified term of years, "the exclusive right to make, use, and vend" the invention claimed therein. This would seem to grant to the owner the right to make, use, and vend the invention, coupled with the right to exclude others from so doing. Such, however, is not the meaning at all. Letters patent grant no right to make, use, or vend an invention, but only the right to prevent others from doing so, the so-called exclusive right being merely the right of exclusion. If the grantee has the right to make, use, and sell the invention, at the time he receives the patent, then the patent grant makes that right an exclusive one; but if he does not have that right at such time, the patent does not give him such right, but merely the right to exclude others therefrom.

This will be understood best by citing a concrete example. Assume A to be the original inventor of the steam engine; he has a natural right to make, use, and vend the same, regardless of any patent right. He, however, applies for and obtains a broad patent thereon and receives the right to exclude others from exercising the right which they would otherwise have had of making, using, or selling steam engines. Now assume that B at some time later invents a specific form of rotary steam engine, for the novel features of which he obtains a patent. At the time of obtaining the patent, however, A's patent is in force; hence B has no right to make, use, or vend a steam engine of any kind. B's patent gives him no right in this connection, for if it did the effect would clearly be in abrogation of A's rights of exclusion, already acquired. B's patent grants him the right to exclude everyone from making, using, or vending the specific form of rotary engine invented by him, and nothing more; he can prevent others, including A himself, from making, using, or selling the rotary steam engine, but having no right to the exercise thereof, he obtains none in his patent. It is to be noted also that B's right to exclude A from making the rotary steam engine that B invented, is in no way inconsistent with A's patent right.

The result of the foregoing may seem somewhat anomalous, but it is no less true that during the life of A's patent, neither A nor B can make, use, or sell rotary steam engines, except by permission of one from the other. Failing such permission B can only wait until A's patent right has expired, whereupon he will be free to exercise his natural right, and for the remainder of the term of his own patent will likewise be able to exercise his legal right of restraint against others.

Novelty Distinguished from Infringement

When application is made to the Government for letters patent of the United States, a search is made by the Government solely upon the question of novelty. The applicant for a patent right describes and claims what he considers he has invented, and the Government, through its officials in the Patent Office, proceeds to search through prior publications, records and patents, in an endeavor to find anything upon which such description and claims can be read, and if found, B's application is refused. In the example just given, however, there is no disclosure by A of any rotary steam engine, but merely (say) of a reciprocating steam engine, and it being assumed that no disclosure of a rotary steam engine is found elsewhere, the patent sought for by B is granted to him. The fact that A in his application claimed, and in his patent was given, an exclusive right in relation to all forms of steam engines, is not taken into consideration by the Patent Office at all. A search is made for the specific thing that B has disclosed and is claiming and as this is not found, a patent is granted to B.

Patent Rights Transferable in Whole or in Part

The holder of a patent may remit that right to one or more persons, firms or corporations at will. There are in general three ways of accomplishing this result: (*a*) by assignment, (*b*) by territorial grant, (*c*) by license. Assignments may be of the entire patent right held by the original grantee, or of a part thereof If of the entire right the situation is simple, the assignee merely being substituted for the original grantee, in which case the assignee assumes every right the original grantee had at the time he made the assignment. There is provision made for recording such assignments, and a statute provides that when recorded within a specified period, they become and constitute constructive notice to all of the transfer of title of the patent. If, on the other hand, the assignment conveys only a part of the right granted by the patent, the situation is not nearly so clear and is very often misunderstood.

Assume that *A*, the original grantee, assigns to X an undivided one-half interest in the patent, such assignment being unaccompanied by any partnership agreement. A has now broken up the complete right of exclusion and is sharing it with X. But as the right of exclusion necessarily carries with it the right of remission thereof, it follows that A and X can now, each of them, and the one independently of the other, remit that exclusion so far as anyone else is concerned, and that neither can interfere with the action of the other in this respect. The "exclusive right" or right of exclusion is thus utterly broken up and lost unless A and *X* act in concert. Furthermore, in an assignment unaccompanied by any restrictions as to a partnership agreement, it does not matter what proportion of the patent right is nominally assigned. An assignment of a one-hundredth part conveys exactly the same right in this respect as one-half or ninety-nine hundredths.

But few words need be said in relation to territorial grants and licenses. These instruments do not convey an undivided interest in the patent right, but the exact nature of the interest conveyed is dependent in each case upon the wording of the particular instrument, the nature of such interest usually being set forth in specific terms therein.

Part ownership of a patent right may also result from joint invention. In such a case application must be made in the name of the joint inventors and the patent is granted to them jointly. Each owner may operate independently of the other and may grant rights under the patent without the consent of the other.

As it is the claims which determine the breadth and scope of the patent protection granted, it follows that their wording is of extreme importance. It is upon the skilful drawing of the claims that the whole value of the patent depends. They should, where the nature of the invention permits, be broad and comprehensive, so that mere variations in structure will fall within them; yet they must not be ambiguous, uncertain or vague, for they would then be liable to be declared invalid by the courts. Also the claims must not touch upon any previously invented structure, for in such case they would be anticipated thereby and would have no validity. The first requisite, then, in the drafting of a claim, is an accurate knowledge of what has been previously accomplished in the same or similar lines, a knowledge, as it is aptly called, of the state of the art.

The next requirement is a true appreciation of the problem that the inventor has solved. It is not sufficient that one drawing a claim shall merely understand the specific structure for which patent protection is to be acquired, for in such case he would not be in a proper position to distinguish between the essential and nonessential features thereof. To illustrate this, conceive an appliance placed upon an engine such as would operate in connection with the valve mechanisms for both the inlet and the exhaust of steam. For convenience the inventor might apply it in this way, yet actually his problem is completely solved by the application of the device to the means for admitting steam. A failure to appreciate the fact that the application to the means for controlling the exhaust of the steam was mere surplusage, or at best a convenience, might lead to the drawing of claims in a way that would prevent others only from applying the mechanism to both inlet- and exhaust-valve mechanism, leaving them free to place it upon the inlet-valve mechanism alone, and thereby actually to attain the benefits of the invention.

After broad claims have been drawn such as comprehensively cover the invention generally, in such terms as to include all reasonable variations of the structure, it is then wise to insert specific claims: First, to the general specific structure shown, and, second, to any specific part of the structure such as may be deemed to be of particular importance.

Letters patent for inventions may cover: First, an apparatus, machine, structure or a device; second, a process or method; third, a composition of matter, such as a chemical compound, and, fourth, a design.

Under the first heading come such combinations of elements as are included, for instance, in steam-heating systems, steam engines, automatic machinery, etc., including practically everything which comes under the term mechanical arts. Claims drawn to these structures are in form for a combination of elements.

The Supreme Court of the United States has laid down the doctrine that the elements of claims must combine together to a single unitary result in order that the claims be patentable. The most famous case perhaps in this connection is the Faber pencil case in which a claim covering the ordinary form of lead pencil in use today, with the rubber tip thereon for erasing purposes, was held unpatentable. A patent had been actually granted upon this device but the Supreme Court of the United States declared it to be invalid. The Court said in effect that the pencil and the rubber each operated independently of the other as each had theretofore operated and that the mere assembling of them together was for convenience only, and did not constitute an inventive act. When so aggregated, the pencil was still used as a pencil and the rubber as an eraser, the pencil and eraser did not combine together for any single unitary result but, on the contrary, were separately employed for independent and individual results. Hence for a claim to be valid, all of its elements must combine together for a final result which is different in kind from that which would have resulted from the use of these elements individually or in individual subcombinations.

Under the second heading come processes or methods, and in this connection it is quite difficult to say with any degree of certainty what is capable of being protected by a patent right, and what is not. Anything new in which there is an elemental or chemical action is capable of this protection; while going to the other extreme, anything which is the mere function of a machine is not capable of such protection, the only possible way of protecting the process or method carried out in a machine being to patent the machine itself.

The requirement for patents under the third class, other than novelty, is that they constitute something more than a mere mixture of known ingredients, with no new result other than that which would naturally follow from such a mixture.

Design patents are granted for something new in ornamental configuration. Parts that have a new form merely for some mechanical purpose are not capable of protection under the design branch of the patent law, the requirement being novelty in ornamental configuration without regard to utility.

Fatal Economizer Explosion

By John S. Leese

An explosion of a Green's economizer resulting in the death of one man, recently occurred at the Pilkington Tile and Pottery Works, Clifton Junction, England.

The economizer was connected to a Lancashire boiler for which it heated the feed water and was installed in 1897. It had been periodically examined since its installation by the representatives of the makers and was apparently in good condition up to the time of the explosion. In the engine room was hung a list of instructions issued by the makers and the following paragraph was printed thereon in red ink under the caption "Repairs:" "When these are being executed it is imperative that the pressure be taken off and the economizer shut down by closing the inlet and outlet dampers and feed valves, allowing the heat to pass through the spare flue. Under no circumstances should any of the joints be interfered with while under pressure."

Howard was the night and Horsfield the day attendant of the boiler and economizer and the circumstances of the accident resulting in the death of Horsfield were as follows: At 11 p.m. on the day before the explosion Howard, who was on duty, noticed that the second cover joint from the inlet end of the lower branch pipe was leaking. He thereupon disconnected the economizer from the boiler and emptied it by means of the blowoff valve. He then removed the cover and remade the joint with rubber and canvas, and, after replacing the cover, reconnected the boiler to the economizer. At five o'clock the next morning he relieved the economizer of pressure by lifting the safety valve, and, with a spanner 18 inches in length, tried the nuts on the remade joint. He then placed the spanner on a branch pipe near the cover and lowered the safety valve. Howard was relieved at six o'clock by Horsfield to whom he related what he had done to the cover, telling him where he could find the spanner in case it should be again necessary to tighten the nuts. At a few minutes past seven the explosion occurred and Horsfield was found in the space occupied by the lower branch pipe of the economizer. The spanner was found 8 feet away from the place where Howard had left it, the cover referred to was on the ground and one of the two bolts which had held it was found to be broken.

The cover was held by two [illegible]-inch bolts. About three years ago Messrs. Green replaced, as standard on their economizers, two [illegible]-inch bolts with four [illegible]-inch bolts and later still these four bolts were replaced by four [illegible]-inch bolts. The boiler was worked at a pressure of 100 pounds per square inch and the economizer at a pressure of 110 pounds per square inch. According to the statement of the head of the inspection department of Messrs. E. Green and Sons, the number and thickness of the bolts had not been increased on account of any doubt as to the safety of using two bolts, but simply to guard against the possibility of employees ignoring the rules. He stated that two bolts were strong enough to withstand the pressure, but that, if one of them was sheared off, the other would not suffice to hold the cover on. With four bolts, in the event of one of them being broken, the other three would hold the cover in place. The above mentioned instructions had been issued to all economizer users in [illegible] as a result of an accident that had occurred in [illegible] to an economizer.

The cause of the fatality was, apparently, the breaking of the [illegible]-inch bolt by tightening it with the 18-inch spanner. The moral of the accident is, therefore, "When rules are issued by the manufacturers of power-plant apparatus, stick to them. They are [illegible] to know more about what it is safe to do and when to do it than you are and they will not put obstacles in the way of their sales department by [illegible]."

Symonds—Emergency Engineer

By F. L. Johnson

Some of the experiences of a bright young engineer who opened a "first aid" to injured machinery consulting office from which he directed personally conducted repair and replacement jobs.

John Symonds had a small office near the business center of a New England manufacturing town. On the glass of the single large bow window, by which he used to sit and think, or just sit if he had no thinking to do, was written in modest gold-leaf letters,

JOHN SYMONDS
EMERGENCY ENGINEER

I had known Symonds a number of years. In early manhood he was one of the engineers in the fire department of his city. I called on him to renew an acquaintance which had been interrupted by my absence from the East. He had not changed much, and except for a sprinkling of gray in the hair about the temples, twenty years had not altered his appearance. Of medium hight and rather lean, he looked like an athlete in perfect condition and his keen, alert glance was friendly and somewhat inquiring as we shook hands. After the usual greeting had been exchanged I said, "Emergency Engineer, what is that?"

"Oh," he said, "it is really a long story but I can make it short by just touching the high spots for I do not think you will care for the minor details. The fire department is no place for a live engineer. It is a soft job at fair pay, but the average man will go down hill both mentally and physically from the day he enters the service. I recognized this early in the game and got out. There was no job waiting for me so I advertised in a small way among the englneers and owners, that I was ready to substitute in engine rooms during the vacation, sickness and emergency absences of the regular man. I got plenty of work at the prevailing rate of pay. In many plants I found many opportunities to improve the operating conditions, to do quick repair stunts and a lot of first aid to injured machinery work.

"Somehow I got the nickname of Emergency Engineer, which stuck and as I had some ability in getting out of close corners I began to get calls to look after repair jobs, make changes and the like, which, with substituting, kept me pretty busy. I rather liked the title of Emergency Engineer and determined to earn it, so I stopped substituting and opened this office.

"Owners wanted advice and wanted work done. I was long on doing work but short on giving or selling advice. I loved to do things my own way a great deal better than telling how they should be done and though I could do a fair business as a consulting engineer within my limits I prefer that work which gives me physical exercise and trains my hands along with my brain. I have my office, congenial work and make a good living. What more can life offer?"

"But," said I, "what work do you do? What kind of jobs come your way?"

"I do anything which anybody wants done in a hurry in a steam plant. Why! last week—" Just here the telephone bell rang. After answering it he said,

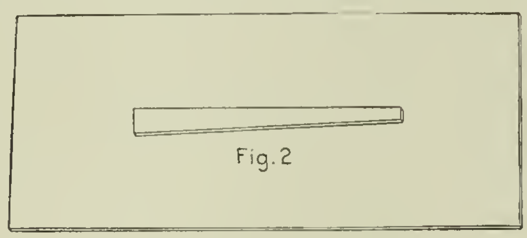


Fig. 2

Fig. 1

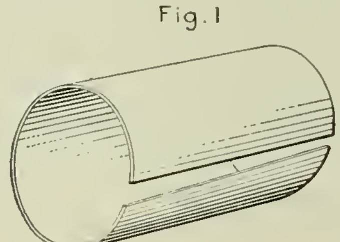


Fig. 3


Fig. 4

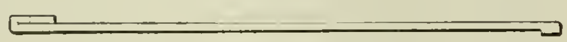


Fig. 5

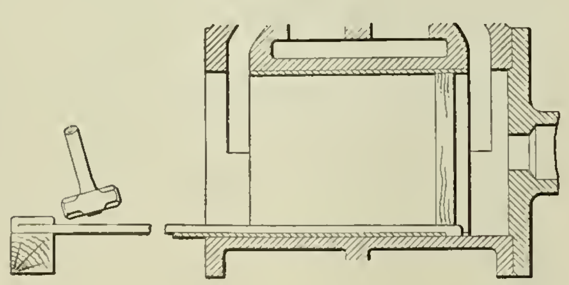


Fig. 6 POWER

"You asked what I do. A call has just come from Brown's that the air pump on the surface condenser has stopped. The engineer cannot start it and the engine will not carry the load noncondensing. I do not know what is wrong but as it is only around the block you can go with me and see what is wrong."

We went. The piston had stopped at about two-thirds of the stroke. Symonds pushed the valve to the other end of its stroke and opened the throttle slightly. The piston moved back to the end of the cylinder, the valve reversed and the piston started on the return stroke.

"Steam end apparently all right," he said softly, as he closed the throttle. He directed the engineer to take off the cylinder head on the water end. This showed why the pump stopped. The water piston was and probably had been for some months guiltless of packing. One of the set out segments had dropped to the bottom of the cylinder and had ploughed through the bushing near mid stroke and a sliver had rolled up, against which the piston struck and stopped.

Whistling, "It Beats All What You See When You Don't Have a Gun," Symonds got into overalls, cut out the obstruction, dismantled and took out the piston. Finding a short crowbar he drove it between the bushing and the cylinder wall at the worn part crimping it so that it was easily pulled out. He then calipered the cylinder. Next he went to a near-by carpenter shop and selected some soft-maple stock of about ½ inch thickness, from which with the band saw he made three packing rings for the piston. These he took back to the plant, put the piston on the rod, put in the wood packing, closed the cylinder and started the pump.

When the exhaust from the engine was turned into the condenser and everything seemed to be going along all right he said to the engineer, "This will run in good shape for months but I will be here Saturday at twelve o'clock to put in a new bushing and I will need one man with a sledge hammer to help."

On the way back to the office he said, "this is an example of the kind of work I have to do. It is my first call to handle a job of this nature. It goes without saying, however, that if all places were filled by first-class men I would not have much to do beyond a little substituting. But there are not enough, first-class men to go around and so long as such miserable wages are paid for engineers' services there will be little inducement for anyone to become an engineer."

I did not reply, but instead I said, "that pump was made out in Wisconsin and you promised to put in the new bushing Saturday. Today is Thursday. Do you expect to get it by telephone?"

"Well, not exactly, but I expect to make it tomorrow afternoon. Come around and take lunch with me and then we will make the bushing together if we can find any sheet brass suitable for the job."

After luncheon the next day he said, "that pump cylinder is 12⅜ inches in diameter and the piston is about 1/32 of an inch less than 12 inches, which shows that the bushing should be 3/16 of an inch thick and 16 inches long. It will take a strip about 39 inches long to go around the inside of the cylinder. It will take up some in rolling so we will go over to the boiler shop and see what we can find."

At the boiler shop some sheet brass 3/16 inch thick was found and from it he had two pieces cut. One piece 16 inches wide and 37½ inches long, one end of which was afterward trimmed diagonally, see Fig. 1, and another 20 inches long by 1 inch at one end and 1½ at the other, see Fig. 2.

The larger piece he had rolled to approximately a diameter of 12 inches, Fig. 3, and had the two pieces sent to the plant. While at the boiler shop he also had made from a bar of inch octagonal steel the two tools shown in Figs. 4 and 5.

After leaving the boiler shop we parted at the corner after he had said that if I still felt interested I would do well to come around to the plant the next day and see the job finished.

As Symonds suggested I arrived at the plant soon after 12 o'clock and found him already at work. The pump had been dismantled and he was driving the split bushing into the cylinder with a hide-faced hammer. When in place there was a tapering slot or gap where the sheet had been trimmed. Into this slot he drove the wedge-shaped strip until the rebound of the hammer showed that it was solid. This forced the side of the bushing outward against the cylinder wall. Then with a light hammer he "sounded" the bushing in several places to determine whether the contact between the bushing and the cylinder was perfect. Every spot touched gave forth the same sound, proving that the wedge had driven the bushing outward and that it was really expanded into perfect contact.

He then measured the distance from the small end of the wedge to the inner end of the bushing, which proved to be about an inch. He then took the bar shown in Fig. 4 and put the hook over the end of wedge and drove a strut of wood between it and the side of the bushing, as in Fig. 6, and with a block under the outer end of the bar to support it, the helper with the sledge struck on the gib of the bar which, with a few blows, pulled out the wedge.

This, after a thorough inspection, was dressed along one edge, narrowing it about a thirty-second of an inch which, according to Symonds' calculations would allow it with the same amount of driving to enter three-quarters of an inch further, leaving a quarter of an inch for the final driving. It was then narrowed slightly at the wide end to allow for the upsetting effect of the final driving. It was smeared on one side and both edges with a mixture of white lead and graphite to reduce the friction of driving.

After accurately locating the bushing and preventing a possible endwise movement from the effect of driving by a couple of distance blocks placed between the ends of the bushing and the inside cylinder head, the wedge was pushed into the slot and driven home with the drifting tool and sledge, Fig. 6. When the small end of the wedge came flush with the inside end of the bushing, the wide end was cut off flush with the end of the bushing.

The hard driving had raised a little bur or ridge along the joints which Symonds removed with a scraper. The parts were reassembled with new hot-water packing in the piston and the pump tried, and as everything appeared to be in good working order we walked back to the office.

Seated by the window again Symonds, as he held a cigar in one hand and a match in the other said, "that little job was just what I needed. It gave me the necessary mental and physical exercise which keeps me in condition. Sometimes nothing happens for a week and I have to take a cross-country walk to keep in shape. But that does not often happen. There are 200 steam engines in this town and I am sure to hear from most of them inside of a year. I do not keep a shop and have but few tools. I am always welcome to the use of any tools belonging to the shops in which I happen to be working."

Just here a man came in who wanted some advice about the purchase and repairs on an engine which had been slightly damaged by fire, so I took my departure after promising to look in on my next trip and see some more emergency repair work.

Driving Boilers at Economical Rates

By Alphonse A. Adler

A graphical method showing how the fixed charges, the cost of coal and the total operating cost of the boiler plant vary with the rate of driving.

The most economical rate of driving boilers, from the thermal and commercial standpoints, differ because the fixed charges are some function of the number of boilers in service, whereas the highest thermal efficiency occurs at a certain load per boiler and is independent of the number of boilers in service.

Before proceeding with the topic under consideration it might be well to define some of the terms used. The writer prefers the term "overall" efficiency to denote that efficiency ordinarily termed as "combined boiler and furnace efficiency." The efficiency of the boiler proper may be expressed as

$$\frac{\textit{Heat absorbed from combustible burned}}{\textit{Heat in combustible burned}}$$

and this ratio may be limited to one pound of combustible as its value is unaffected by the weight. The furnace efficiency may be expressed as the

$$\frac{\textit{Heat in the combustible burned}}{\textit{Heat in the combustible fired}}$$

This latter expression evidently indicates the combustible that is lost through the grate and that disposed of in the ashes. The product of these efficiencies gives the overall efficiency, or

$$\textit{Overall efficiency} =$$

$$\frac{\textit{Heat absorbed from combustible burned}}{\textit{Heat in combustible burned}} \times \frac{\textit{Heat in combustible burned}}{\textit{Heat in combustible fired}} = \frac{\textit{Heat absorbed from combustible burned}}{\textit{Heat in combustible fired}}$$

From the foregoing it will be seen that the overall efficiency is easy to measure as it is the ratio of the total heat in the steam to the total heat in the combustible fired. The overall efficiency is the one plotted in Curve 1, which is the characteristic curve for water-tube and probably, fire-tube boilers, under carefully guarded commercial conditions.

This curve shows the thermal efficiency of the boiler increasing to a maximum at about 3.25 pounds evaporation per square foot of heating surface per hour, then slowly dropping at higher rates of evaporation. Were only the thermal efficiency of importance, the most economical rate of driving would evidently be an evaporation of 3.25 pounds per square foot of heating surface. Consider first the heat absorption of the boiler, the heat transmission being a function of the time. At low rates of driving, the movement of the gases is slower, hence the transmission per unit of time is greater than at the high rates of driving. The water and the gas speeds are slow at low rates of driving, and the consequent absorption is low with a tendency to increase at higher rates of driving. The furnace operates at low efficiency at low rates of driving, increasing [illegible] as the rate of driving increases, due to better control of the air supply and consequent higher temperatures. The [illegible] of the [illegible] is more marked at the low rates of [illegible] bustion, as each particle has a well defined path through the boiler, and the formation of CO in the presence of O is readily detected. As soon as the speed

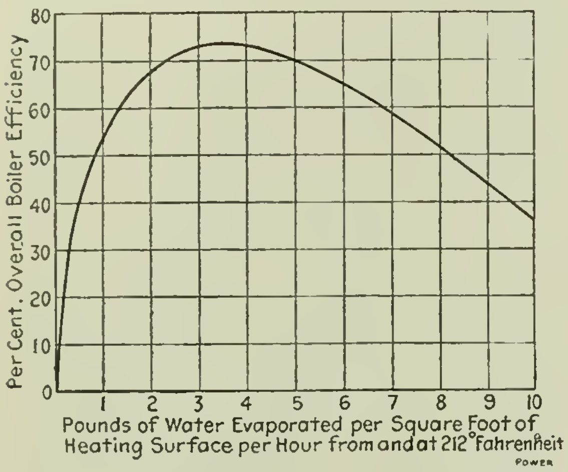


FIG. 1. EFFECT OF DRIVING UPON OVERALL EFFICIENCY

of the gas increases, the eddies formed give the gas a turbulent action and a more intimate intermingling results. The overall efficiency is the sum of these individual factors, some of which increase as the rate of driving increases, while others decrease under the same conditions.

In the analysis for a given plant, a curve similar to curve No. 1 might be drawn if accurate results are desired; otherwise, the one shown may be assumed as typical. For example, assume the following values:

Boilers at $15 per horsepower, or $4500 for a 300-horsepower boiler; floor space, 600 square feet per boiler; fixed charges on boiler house,* $1 per square foot, or $600 per boiler per annum; interest, depreciation, maintenance and labor at 20 per cent. of cost of boilers, $900 per boiler per annum; coal at $3 and $6 per net ton; heat value per pound of combustible, 14,600 B.t.u.; steam consumption, 24,000 pounds per hour; steam pressure, 150 pounds gage; feed-water temperature, 200 degrees Fahrenheit.

Service and conditions of operation as follows:

Coal at $3 per ton, 8 hours per day of 300 days per year; coal at $3 per ton, 4 hours per day of 300 days per year; coal at $6 per ton, 8 hours per day of 300 days per year; coal at $6 per ton, 4 hours per day of 300 days per year.

*These values represent the upper limits and are much higher than those met with in the average plant. In the curves, however, the actual conditions for any plant may be found by interpolation.

Adding the $900 for interest on the boilers, to the $600 for fixed charges on the building, the total fixed charge is $1500 per boiler of 300 horsepower. The assumptions are somewhat crude due to the 4- and 8-hour schedules, thereby ignoring coal for banking and variations in efficiency with variations in load. Present central-station practice indicates that reasonable results are arrived at by granting these assumptions, refinements in figures being a matter of personal taste. For convenience in plotting the curves, the fixed charges are reduced to

$$\frac{1500}{300} = \$5.00 \textit{ per boiler horsepower}$$

or

$$\frac{5.00}{10} = \$0.50 \textit{ per square foot of heating surface}$$

The total steam per hour from and at 212 degrees Fahrenheit is

Steam at given pressure and feed temperature × *factor of evaporation* = 24,000 × 1.0615 = 25,476 *pounds*

The number of boilers required at the most economical rate of driving from the coal standpoint alone is found from the expression

$$\frac{25{,}476}{3.25 \times 300 \times 10}$$

which figures out to be three boilers, allowing the customary 10 square feet of heating surface per boiler horsepower.

By reference to curve No. 1, the efficiencies at the different rates of driving can be tabulated as follows:

TABLE 1

Rate of driving in pounds of water evaporated from and at 212 degrees Fahrenheit per square foot of boiler heating surface....	1	2	3	4	5	6	7	8	9	10
Boiler efficiency.....	0.54	0.6775	0.73	0.73	0.70	0.65	0.5875	0.5175	0.44	0.36

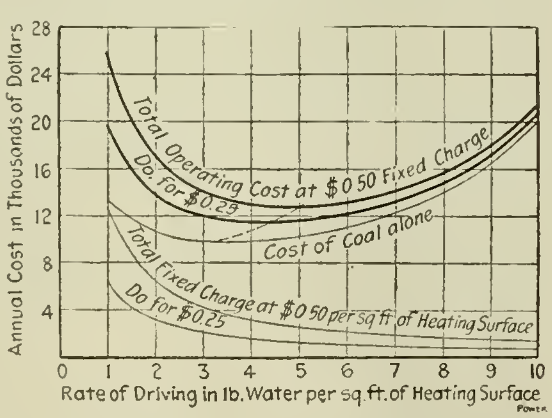


FIG. 2. EFFECT OF DRIVING UPON TOTAL OPERATING COSTS. SERVICE, 2400 HOURS, COAL $3 PER TON; SERVICE, 1200 HOURS, COAL $6 PER TON

The annual cost of coal for a given plant will equal

$$\frac{\left(\textit{Steam per hour} \times \textit{B.t.u. per pound of steam} \times \textit{hours of service per annum} \times \textit{cost per pound of combustible}\right)}{\left(\textit{Heat value per pound of combustible} \times \textit{boiler efficiency}\right)}$$

This for eight hours operation per day, and coal at $3 per ton, is expressed in Table 2.

TABLE 2

Rate of evaporation, pounds of water per sq.ft. of heating surface per hour	Cost of Coal per Annum
1	$\frac{25{,}476 \times 970.4 \times 2{,}400 \times 0.1765}{14{,}600 \times 0.54}$ = $13,300
2	$\frac{25{,}476 \times 970.4 \times 2{,}400 \times 0.1765}{14{,}600 \times 0.6775}$ = $10,600
3	$\frac{25{,}476 \times 970.4 \times 2{,}400 \times 0.1765}{14{,}600 \times 0.73}$ = $ 9,830
4	$\frac{25{,}476 \times 970.4 \times 2{,}400 \times 0.1765}{14{,}600 \times 0.73}$ = $ 9,830
5	$\frac{25{,}476 \times 970.4 \times 2{,}400 \times 0.1765}{14{,}600 \times 0.70}$ = $10,200
6	$\frac{25{,}476 \times 970.4 \times 2{,}400 \times 0.1765}{14{,}600 \times 0.65}$ = $11,000
7	$\frac{25{,}476 \times 970.4 \times 2{,}400 \times 0.1765}{14{,}600 \times 0.5875}$ = $12,200
8	$\frac{25{,}476 \times 970.4 \times 2{,}400 \times 0.1765}{14{,}600 \times 0.5175}$ = $13,900
9	$\frac{25{,}476 \times 970.4 \times 2{,}400 \times 0.1765}{14{,}600 \times 0.44}$ = $16,300
10	$\frac{25{,}476 \times 970.4 \times 2{,}400 \times 0.1765}{14{,}600 \times 0.36}$ = $20,000

In doubling the cost of coal it is necessary only to double the costs in Table 2, or, halving the hours of service, will be equivalent to dividing these costs by two.

TABLE 3

Rate of evaporation	Cost of coal per annum	Fixed charges at $0.50 per sq.ft. of heating surface	Total annual cost fixed charges at $0.50 per sq.ft. of heating surface	Fixed charges at $0.25 per sq.ft. of heating surface	Total annual cost fixed charges at $0.25 per sq.ft. of heating surface
1	$13,300	12,740	26,040	6,370	19,670
2	10,600	6,370	16,790	3,185	13,785
3	9,830	4,250	14,080	2,125	11,955
4	9,830	3,185	13,015	1,593	11,423
5	10,200	2,548	12,748	1,274	11,474
6	11,000	2,125	13,125	1,062	12,062
7	12,200	1,825	14,025	912	13,112
8	13,900	1,593	15,493	796	14,696
9	16,300	1,417	17,717	708	17,008
10	20,000	1,274	21,274	634	20,634

The annual cost of coal given in Table 3 is taken from Table 2. The fixed charges are determined as follows: At the rate of evaporation of 1 pound of water per square foot of heating surface from and at 212 degrees Fahrenheit, 25,476 square feet of heating surface are required. At a fixed rate of $0.50 per square foot of heating surface the annual charges become

$$25{,}476 \times 0.50 = \$12{,}740$$

For an evaporation of 5 pounds of steam per square foot of heating surface, the number of square feet of heating surface is

$$\frac{25,479}{5} = 5,095$$

Again, at the fixed rate of $0.50 per square foot of heating surface the annual charge becomes

$$5,095 \times 0.50 = 2,548.$$

In this way all the values in the third column have been computed. By halving these values those in the fifth column are arrived at, this amounting to a fixed

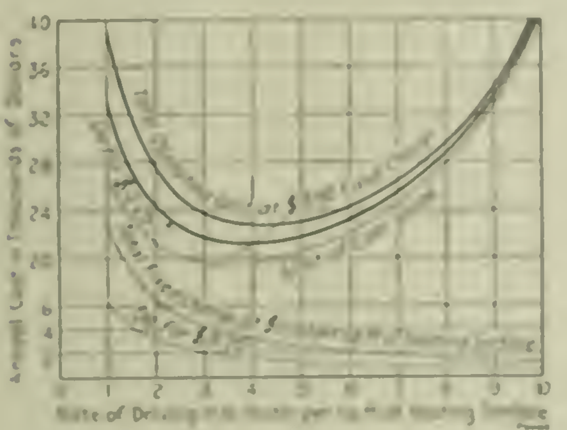


FIG. 3. EFFECT OF DRIVING UPON TOTAL OPERATING COSTS. SERVICE, 2400 HOURS, COAL $6 PER TON

charge of 0.25 per square foot of boiler heating surface.

By adding the fixed charges to the cost of coal the values in the fourth and sixth columns are obtained, these representing the total annual operating costs. The values in Table 3 are plotted in curve No. 2.

By doubling the cost of coal and using the same number of hours of service, the values in the second column, Table 4, become just double those of the second column, Table 3. The fixed charges remaining the same at rates of both, $0.50 and $0.25 per square foot of heating surface, the values are arrived at as before. These figures have been plotted in curve No. 3.

Assuming 1200 hours of service per year instead of 2400 hours, with the coal costing $3 per ton, the values in the second column, Table 5, are obtained; these are one-half the values of those in the second column, Table 3. As before, the fixed charges remain the same, and their addition to the cost of coal results in the fourth and sixth columns, which are the total annual operating costs. Curve No. 4 shows this in its final form.

Some attention might profitably be directed toward the change in the most economical rate of driving. When the coal cost and hours of service are low the rate of driving should increase. On the contrary, should the cost of coal be high and also the hours of service, then the point of maximum boiler efficiency should be approached. Curve 1 shows that there are two points that can have exactly the same efficiency at altogether different rates of driving. For instance, 60 per cent. efficiency is attained when evaporating 1.3 pounds and also 6.8 pounds of water per square foot of heating surface per hour.

TABLE 4

Rate of evaporation	Cost of coal per annum	Fixed charges at $0.50 per sq.ft. of heating surface	Total annual cost fixed charges at $0.50 per sq.ft. of heating surface	Fixed charges at $0.25 per sq.ft. of heating surface	Total annual cost fixed charges at $0.25 per sq.ft. of heating surface
1	26,600	12,740	39,340	6,370	32,970
2	21,200	6,370	27,570	3,185	24,385
3	19,648	4,250	23,898	2,125	21,773
4	19,660	3,185	22,845	1,593	21,253
5	20,400	2,548	22,948	1,274	21,674
6	22,000	2,125	24,125	1,062	23,062
7	24,400	1,820	26,220	912	25,312
8	27,800	1,593	29,393	796	28,596
9	32,640	1,417	34,057	708	33,348
10	40,000	1,274	41,274	637	40,637

TABLE 5

Rate of evaporation	Cost of coal per annum	Fixed charges at $0.50 per sq.ft. of heating surface	Total annual cost fixed charges at $0.50 per sq.ft. of heating surface	Fixed charges at $0.25 per sq.ft. of heating surface	Total annual cost fixed charges at $0.25 per sq.ft. of heating surface
1	6,650	12,740	19,390	6,370	13,020
2	5,300	6,370	11,670	3,185	8,485
3	4,912	4,250	9,162	2,125	7,037
4	4,915	3,185	8,100	1,593	6,508
5	5,100	2,548	7,648	1,274	6,374
6	5,500	2,125	7,625	1,062	6,562
7	6,100	1,820	7,920	912	7,012
8	6,950	1,593	8,543	796	7,746
9	8,160	1,417	9,577	708	8,868
10	10,000	1,274	11,274	637	10,637

The dotted lines on curves 2, 3 and 4 pass through points of maximum economy. The dotted line is also useful in estimating the most economical rate at other than these assumed values for fixed charges. Furthermore, should the max-

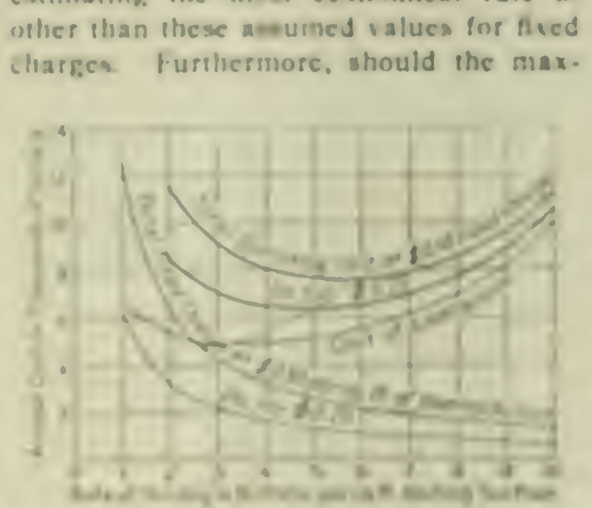


FIG. 4. EFFECT OF DRIVING UPON TOTAL OPERATING COSTS. SERVICE, 1200 HOURS, COAL $3 PER TON

imum boiler efficiency occur at, say, 4.25 instead of 3.25 pounds evaporation, the rate of driving would move in the same direction, that is, it would be about 1 pound higher than values obtained in curves 2, 3 and 4. Hence, even though the curves do not tell exactly the condition for any given plant, still with a little judgment, they may be of service in locating approximately the rate of driving for any plant.

In conclusion it may be said that the curves apply only to such cases where no spare boilers have been installed. When this is the case, the interest on the investment goes on, whereas there may be somewhat of a reduction in the labor charge. Also, it is better to keep boilers in service when light loads are being carried, as the variation in furnace temperature affects the life of the settings and may thus increase the maintenance charge.

Danger of Fire from Steam Pipes

The quarterly of the National Fire Protection Association of Great Britain recently presented some interesting notes on the danger of fire from steam pipes. It is generally admitted that steam pipes in contact with wood will cause an occasional fire. There is considerable diversity of opinion as to the circumstances under which such fires may be expected to occur, but the conclusions drawn by a number of investigators who attempted to produce fires by bringing steam pipes into contact with various combustible materials were, that any steam pipe, no matter how low the pressure, would in the course of time produce charcoal and that when this stage was reached, positive danger existed. Charcoal is unquestionably subject to spontaneous ignition due to its peculiar ability to absorb from the air many times its own volume of oxygen. The combination of this oxygen with the carbon may take place with sufficient rapidity to raise the temperature to the ignition point. Furthermore charcoal formed at a low temperature is known to have a low ignition point.

Some investigators seem to think that there is less danger from this source where steam is kept on a system continually than where it is on intermittently. The reason advanced is that when allowed to cool the charcoal has a better opportunity to absorb oxygen than if kept hot at all times.

There are two general methods of keeping steam pipes free from contact with combustible material, the first being through the use of an insulator, such as pipe covering, and the second by supporting them rigidly at a safe distance. Wherever pipes pass through concealed spaces the covering should preferably be carried for the entire length to avoid future contact with substances which may get into these spaces. On new installations solid covering and collars can be used; where the piping is already in place, split covering wired together and split collars make the partial taking down of piping unnecessary. If desired, metal supporting plates can be used at the ceiling instead of a collar.

The Cost of Industrial Power

By Henry D. Jackson

A rational discussion of the charges to be included in figuring the cost of industrial power, with special reference to the attempts of central-station men to boost these charges, as shown by Mr. Hibner's paper which appeared in the March 21 issue of Power.

It seems rather peculiar that all of the information available on power costs in industrial plants comes from the industrial engineers or sales engineers of the central power stations. It may be that these figures come from such sources because these people are the only ones sufficiently interested to go into the matter carefully and dig up figures which they can submit to a manufacturer and show him how enormously expensive his plant is and how much more it is costing him than it would cost if they were allowed to furnish power.

In Mr. Hibner's paper the statement is made that "Sometimes manufacturers retain consulting engineers on the basis of a percentage of the cost of the plant if it is installed. The dangers of such a practice are quite evident, as it is asking a good deal of human nature for a man to lose a neat commission on the sale of a plant by recommending the purchase of power." Yet Mr. Hibner would not hesitate to recommend this manufacturer to go to the sales agent or industrial engineer of a power company for the same information. Is not this latter method a far more dangerous practice? The consulting engineer does a large amount of work for his money. He not only determines whether or not it is advisable to install a plant, but if to his satisfaction and to the satisfaction of his client he has proved that it is advisable, he lays out the plant, supervises its installation and sees that it meets the requirements of the manufacturer. Does the sales agent of the power company do anything in this line?

The figures given by Mr. Hibner would not lead one to believe that his figures are as convincing or as nearly correct as would be likely if the figures were submitted by an engineer who was not biased in either direction, and no good engineer would be biased any more than would a good doctor. A man with a broken leg would not go to a carpenter because the carpenter has all of the tools necessary and knows how to saw off the leg or knows how to make the splints. He would go to a surgeon.

The question of whether to purchase power or to generate it, depends entirely upon the relative cost of the two methods. In most cases it is a question not only of power, but also of supplying steam for heating and other purposes in addition to the power, resulting in the plant operating noncondensing with more or less back pressure during the winter months. The steam economy is not as good as would be expected from a condensing plant, but there is no reason why the steam consumption should be excessive or an uneconomical type of engine purchased.

Taking up the specific points of the discussion, Mr. Hibner considers a shoe factory of approximately 250x60 feet general dimensions, four stories high and built of brick. In the portion of the country selected, that of Toronto, heat is required for approximately seven months in the year; and, according to his figures, an average of 45 boiler horsepower is required, with 90 horsepower during zero weather and probably considerably over this during exceedingly cold weather. According to Table 1, the coal required for heating alone is 475 tons.

TABLE 1

Heating Plant Investment		
Boiler, piping and auxiliaries (*A*)	$1500.00	
Building and stack (*B*)	2500.00	
Total investment	$4000.00	
Fixed Cost		
Interest at 6 per cent. on $4000	240.00	
Insurance and taxes, 2 per cent on $4000	80.00	
Amortization on *A*, 4½ per cent., 15-year life	67.50	
Amortization on *B*, ½ per cent., 50-year life	12.50	$400.00
Operating Cost		
Coal, 475 tons at $3	1425.00	
Fireman at $15 per week	780.00	
Supplies and repairs	100.00	2305.00
Total cost		$2705.00

TABLE 2

Complete Power Plant Investment			
Capacity, 100 kilowatts			
Engine, generator, switchboard, wiring (A)	$5,500.00		
Boilers, steam piping, auxiliaries (B)	5,000.00		
Building, foundations, stack (C)	5,000.00		
		$15,500.00	
Steam-heating plant		4,000.00	
Additional for power		$11,500.00	
Fixed Cost of Power Plant			
Interest, 6 per cent. on $15,500	$930.00		
Profit, 5 per cent. on $11,500	575.00		
Insurance and taxes, 2 per cent. on $15,500	310.00		
Amortization on (A) 2 per cent. (20-year life)	165.00		
Amortization on (B) 4½ per cent. (15-year life)	225.00		
Amortization on (C) ½ per cent. (50-year life)	25.00		
Fixed charge on heating plant		$2,230.00	
		400.00	
Additional for power		$1,830.00	
Operating Cost of Power Plant			
240,000 Kilowatt-hours			
Coal at 7.39 pounds per kilowatt-hour, 887 tons at $3	$2,661.00		
Banking, 181 tons at $3	543.00		
Night heating, 202 tons at $3	606.00		
Engineer at $18 per week	936.00		
Fireman at $15 per week	780.00		
Water	100.00		
Oil, waste, supplies	150.00		
Repairs	200.00		
		$5,976.00	
Operating cost of heating plant		2,305.00	
Additional for power		$3,671.00	
Total additional for power		5,501.00	
Cost per kilowatt-hour		0.0229	
Cost per horsepower-year		51.40	

In Table 2, however, it will be noted that 202 tons are allowed for night heating, leaving a total of 273 tons for day heating. If it requires 202 tons of coal for heating a plant which is entirely closed, as a plant is at night, and where no changes of air take place other than leakage, it certainly would take more than 275 tons of coal to accomplish the same results where there is at least one change of air per hour as well as open windows, doors, etc. It would be better to figure 475 tons of coal for day heating and 202 tons of coal for night heating, making a total of 677 tons of coal for heating during the year. Therefore, it will be noted that in estimating the cost of heating alone, Mr. Hibner has neglected the heating during the night, which he has been very careful to consider in estimating the heating in connection with the complete power-plant equipment. In Table 1, the investment and fixed costs may be left as they are, but the operating cost will increase in the ratio of 677 to 475 on the coal, making a considerable difference in the operating cost of the heating plant. Table 1-A would represent the revised figures.

TABLE 1-A

First Cost and Fixed Charges Same as 1

Operating Cost	
Coal, 677 tons at $3	$2031.00
Fireman at $15 per week	780.00
Supplies and repairs	100.00
	$2911.00
	400.00
Total operating and fixed charges	$3311.00

There might also be added to this operating cost, according to his own paper, the cost of the coal required to generate the steam which is required at high pressure during the entire year, for which no allowance has been made, although the time of the fireman has been figured for this period. Besides, it is advisable to note that since steam at a high pres- [illegible] is required for industrial purposes, [illegible]e boiler plant, piping, etc., must be purchased for high-pressure service.

Now consider what it will actually cost to install and furnish power from a power plant.

TABLE 2-A

100-kilowatt generator and engine	$[illegible]
Boiler, piping and auxiliaries	[illegible]
Buildings, stack and foundations	4,000.00
	$11,000.00
Steam heating plant	4,000.00
Additional for power	$7,000.00
FIXED CHARGES	
Interest, 6 per cent. on $11,000	$660.00
Insurance and taxes at 2 per cent.	220.00
Amortization, 3 per cent. on total	330.00
Profit (to help out Mr. Hibner)	[illegible]
Fixed charge on heating plant	[illegible]
Additional for power	$1,100.00
Total fixed charges	$1,840.00
OPERATING CHARGES	
Coal, 6 pounds per kilowatt-hour, 720 tons at $3	$2,160.00
Night heating, 150 tons at $3	450.00
Engineer at $20 per week	1,040.00
Fireman at $15 per week	780.00
Oil, waste, water, repairs, supplies	[illegible]
	$[illegible]
Operating charges for heating	2,210.00
Additional for power	$[illegible]
Total for power, fixed charges	1,100.00
	$3,730.00

Table 2-A gives the first cost, fixed charges and operating charges according to my estimate. There certainly seems to be no reason why a 100-kilowatt plant using noncondensing engines and apparatus moderate in price, should cost over $110 per kilowatt; and, although these figures may appear small to Mr. Hibner, I have recently installed a 200-kilowatt plant at very nearly these relative figures, as well as a number of 100-kilowatt plants.

The profit item shown in these tables requires explanation. If the profit is to be considered at all, it should be considered on everything that a manufacturer owns; and if taken in this light, very few manufacturers would own anything; they would prefer to rent everything. Therefore, it would seem that this item should not be taken into account in the fixed charges on the plant. I should prefer to use this item as an item of profit in favor of utilizing my own plant, and not as a charge against my plant, using it to pay off in a greater or less time the total cost of the installation, thus making the installation entirely a profit from an operating standpoint. Therefore, I should deduct this 5 per cent. from Table 2-A and make the fixed charges $1210 instead of $1840, making the additional charge for power $810 instead of $1100. This would make the total fixed and operating charge for power additional over what is required for heating, $3380 instead of $3730, or 1.41 cents per kilowatt-hour.

An explanation may be necessary for the reduction of coal from 7.30 to 6 pounds per kilowatt-hour. While an evaporation of 7 pounds is not bad for a heating plant, it is probable that a power plant which is in continuous operation would do better than 7 pounds; hence, an evaporation of 8½ or 9 pounds is not excessive. It would have been better had Mr. Hibner given some idea as to the quality of the coal, as good coal would probably do better than 7 pounds and poor coal might do much worse.

I have under observation three plants requiring a maximum of 140 horsepower and an average of about 110, all operated by Corliss engines which, in spite of their age, something over 15 years, are in good condition. These plants operate noncondensing with a back pressure during the winter months of approximately 2 pounds. The buildings are of wood and heat is kept on all night during the winter, yet the coal bills are something less than $2400 for the year, in spite of the fact that the coal costs $4.50 a ton instead of $3, as given by Mr. Hibner. It might be well to add, however, that there is more or less leather burned in all of these plants, and the same would be true in the factory under discussion by Mr. Hibner, unless he has some means of disposing of this leather more profitably, which is doubtful.

It is hard to account for the necessity of the 181 tons of coal which Mr. Hibner has assumed for banking purposes. For about seven months of the year there is night heating, for which he has allowed 202 tons of coal. During the other five months of the year he would not require over 300 pounds of coal a night for banking purposes, should it be found advisable to bank the fires, which is by no means true in all cases, for the plants referred to find it is cheaper to allow the fires to go out each night. Mr. Hibner figures 1.45 tons of coal per night for banking purposes. I would like to ask how he succeeded in getting this coal upon the grate; and further add that a good-sized plant can readily be operated on 1.45 tons of coal per day.

Such figuring as this would lead one to believe that it is far safer to trust to the consulting engineer for figures, even although he be paid upon the percentage basis, than upon the figures of the sales engineer of a central power plant, for it is apparent that the latter does not take average conditions but extreme cases. The consulting engineer, however, figures on a conservative basis from plant tests and results obtained in actual practice on good plants.

The great difficulty most manufacturers have in taking up the matter with the central-station man is in getting fair figures. Everything is given an artificial value, in order to make the power cost as high as possible; and, as Mr. Hibner states, when the manufacturer is not an engineer, he has great difficulty in determining where the central-station man is at fault, or in translating the contract of the central-station man so that it means anything to him. It is true that the load factor has an important bearing upon the cost of power, not only as generated by the manufacturing plant, but also when purchased from the central station. Very few power-company contracts give a flat rate regardless of the load factor, and most of them are on a sliding-scale basis, so arranged that the cost of power as purchased increases far more rapidly as the load factor decreases than would the cost of power if generated. Particularly is this true when there is a fixed charge per horsepower of motors installed, and other methods of charging which call for a fixed monthly rate regardless of the power used.

The consulting engineer is by no means adverse to so laying out a plant that it can be operated by purchased power for a sufficient length of time to prove to the manufacturer that his estimate of power cost under conditions of purchased power is correct, and at the same time so arrange the plant that a power installation can be later installed, if necessary. This arrangement gives the central station a fair chance, and by a proper arrangement of the buildings it will enable the new power installation to be installed with no excess cost over what would have occurred had it been installed at the same time the plant was laid out for purchased power.

Emergency service is more a theoretical necessity than a practical one. The central-station man claims that such service is absolutely necessary. A study of the conditions existing throughout the industrial world would hardly bear out this opinion, as for years the majority of manufacturing plants have been operated from a single unit, some of these operating 24 hours a day for six days out of the week, with hardly a shutdown in the entire life of the plant. A good reliable engine and boiler plant, well installed, is more free from the possibility of breakdown than is power from any central station. There are hundreds of factory plants which operate six days out of the week without a breakdown or shutdown, year in and year out; but I do not believe there is a single central station in the country that has not had power off its lines for a greater or less period of time at least once a year, ever since it was installed, and I know of a number of plants that have been off from three to five such times, varying in length from 15 minutes to 3 hours, in the last few years. In one case, that of a large central plant, power was off nearly all day, and in every case the transmission lines were short and most of the trouble was with the lines. There was also trouble in the plants themselves.

Central-station service is, as a rule, good, but as regards reliability and continuous service, it is not to be compared to that of the individual power plant if the apparatus purchased is good and properly installed.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

An Endurance Test of Aeroplane Engines

An official 24-hour test of aëroplane gasolene engines was made recently by the National Physical Laboratory, which is under the control of the British government, though not relying entirely upon government support. All the research work of the official advisory committee of aëronautics is carried out at this place, where a very fine testing plant is gradually being amassed. Originally six builders entered the competition, but only three actually presented their motors for test. Two of these failed in the endurance test, leaving a single competitor to complete the full schedule of the trials.

To prove the trustworthiness of the engines it was stipulated that they should make a run of 24 hours at full load with not more than three stoppages nor a total duration of stoppages exceeding 30 minutes. While the engine was running the only adjustments permitted were those that could be made by the levers for ignition and carbureter control. Handling of the engine for any other purpose was forbidden. Oiling by hand, for instance, was not permitted.

An additional test had to be undergone to determine whether the motor would work satisfactorily when tilted about an axis transverse to the shaft. Two runs of one hour each were made at an angle of 15 degrees, first one end and then the other being elevated.

The motors had to be designed to give 35 brake horsepower and not to weigh more than 245 pounds; that is, 7 pounds per brake horsepower. The weight, however, included not only parts necessary for ordinary running, but also the cooling apparatus with its accessories, such as fans, etc. Neither gasolene, water nor oil was reckoned as motor weight, nor was the gasolene tank.

Among the most interesting and practical conditions were those relating to the air current and the propeller thrust. The test was made without propellers, but to represent the thrust an artificial load of 175 pounds was applied to the thrust bearing. To represent aërial conditions the tests were made in an artificial air current of 30 miles an hour delivered from a horizontal pipe six feet in front of the motor and 4x4 feet in cross-section.

In order that no possible bias may be allowed to enter into the description of the engine trials, the results are given herewith as they appear in the official report just issued (Government Booklet Cd. 5453).

Wolseley Engine: After a preliminary run the test was commenced at 1:11 p.m. on September 12. The engine ran very smoothly, doing 36 brake horsepower at 1443 revolutions per minute for two hours. It was then discovered that a copper oil pipe leading from the pump to the oilwell was leaking. The maker's representative decided not to stop, and, after 20 minutes, disconnected and blanked off this pipe while running. It appears, however, that this change interfered with the oil supply to the bearings, for the engine commenced to run irregularly and finally stopped at 4:13, when it was found that the white metal of one of the connecting-rod bearings had melted. In accordance with the regulations, the engine was therefore disqualified.

The representative of the maker, however, expressed the desire to repair the engine that it might again undergo a 24-hour trial. In view of the nature of the failure and the value of having as complete a test as possible of the engine, it was considered desirable to accede to this request. A new bearing was accordingly fitted and another trial was started at 9:50 a.m. on September 15. The engine ran very well for four hours and then began to run irregularly. After five hours of the test a stop was made and a new spark plug was fitted to one cylinder. This was repeated after another hour's run but without improving matters, the trouble being apparently due to faulty action of the radiator.

After six hours of the test there was a stop for 50 minutes. The radiator was emptied and refilled. After restarting, the engine ran for six hours and then failed. After three more short runs, of

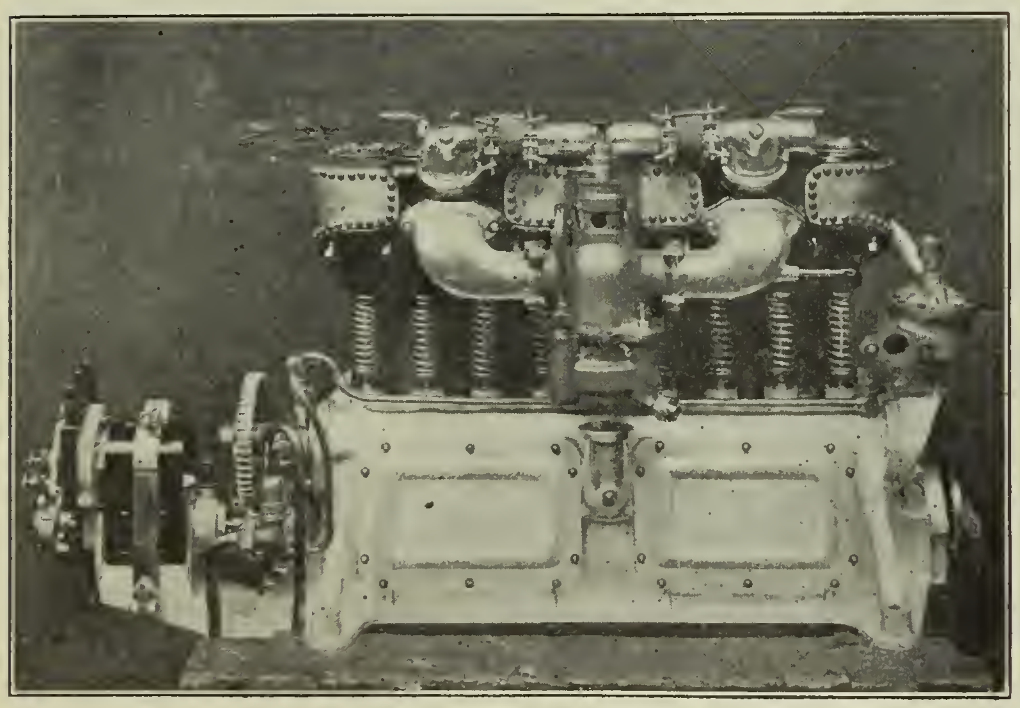


Fig. 1. The Wolseley Engine

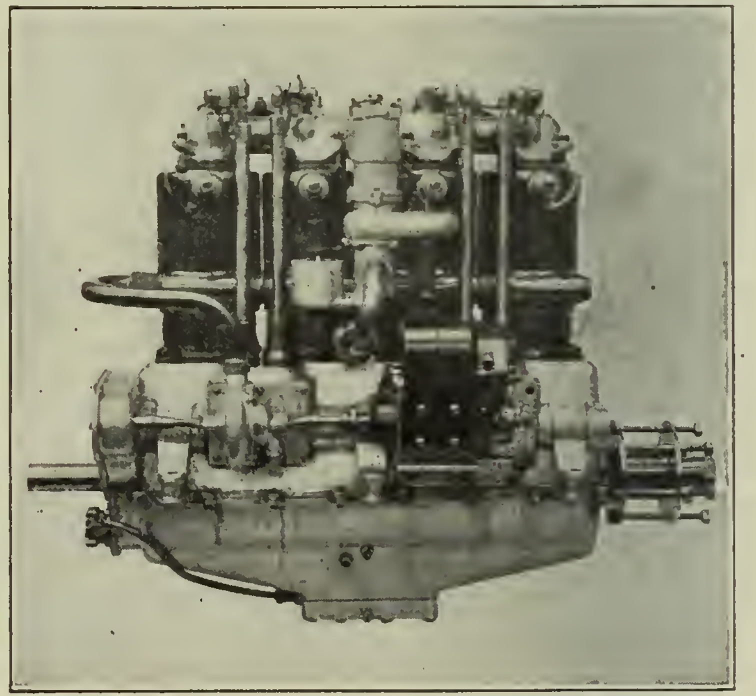


Fig. 2. The Humber Engine

23 minutes, 92 minutes and 38 minutes, respectively, it was observed that the cooling water was rapidly disappearing. The engineer in charge then decided to stop and examine the cylinders. On applying water at about five pounds pressure to the jackets, it was found that the water was making its way into all four cylinders through cracks in their upper ends. The test was therefore discontinued after a total run of 17 hours and 41 minutes, including seven stops aggregating 2 hours and 18 minutes. The cylinders were taken to the works the next day, September 16, and on September 17 the Wolseley company withdrew from the competition.

Humber Engine. The erection of this engine was commenced on September 19 and a preliminary run was made on September 21. On September 22 the maker's representative asked for permission to install another radiator, as the one sent with the engine was inadequate. He was informed that the committee might take a serious view of such an alteration and that the company must make any alteration on its own responsibility. On September 23 another radiator was put on and, after a preliminary trial, the endurance test was commenced on September 26, at 9:45 a.m.

After running for 16 minutes, as the ignition in one cylinder was not satisfactory, a stop of two minutes was made and a new spark plug put on. The engine then ran steadily, doing 37 brake horsepower at 1224 revolutions per minute for 11¼ hours, when the engine suddenly failed; on inspection it was found to be completely wrecked, with one of the cylinders broken off. The only attention to the engine during this period was the addition of 12 pints of oil seven hours after the commencement of the trial and 50 pints an hour later. On the following day the engine was examined more in detail and it was found that, in addition to the fractured cylinder, two connecting rods were buckled and the big end caps torn off, several holes were made in the crank casing and the crank shaft was damaged. This accident, of course, brought the test of the Humber engine to a conclusion.

Green Engine. A preliminary run of the engine was made on October 17 and the endurance test was commenced at 10:30 a.m. on October 18. The engine did not run very satisfactorily during the first hour, owing to difficulties with the ignition, and after one hour's run a stop of ten minutes was made, during which new spark plugs were fitted. On restarting, the engine ran much better and continued running at approximately 31.5 brake horsepower at 1213 revolutions per minute, until the completion of the 24 hours' run on October 19. The only attention to the engine during this period was the addition of 42 pints of oil 17 hours after the commencement of the trial and an additional 21 pints five hours later.

The maximum horsepower which could be maintained for seven minutes was determined on the same day without any overhauling of the engine, except grinding in the valves. The horsepower obtained was 36.4 at 1380 revolutions per minute.

To determine whether the engine would work satisfactorily when tilted about an axis transverse to the shaft, two runs of an hour each were made on the engine when tilted at an angle of 15 degrees, first one end and then the other being elevated. The makers did not wish to run the engine at full load during this test and maintained the load at approximately 18 brake horsepower throughout both trials. The engine ran steadily in both cases, but it was noticed that the exhaust was decidedly smoky, apparently indicating overlubrication.

The general steadiness and freedom from vibration of the engine when running were so marked that it was not considered necessary to test it when running on elastic supports.

On the completion of the trials the engine was dismantled and the working parts thoroughly examined. Very little wear could be detected in the crank-shaft and connecting-rod bearings and the state of the cylinders and valves appeared to be quite satisfactory. The ball races of the thrust bearing at the propeller end of the crank shaft were, however, considerably worn. In the crank-shaft bearings one of the aluminum caps was cracked right through for about one-third of its length. It was not certain that this crack had originated during the tests, as there was some evidence that it existed before these trials began, but it appeared probable that the crack became larger during the tests. It was found that the sleeve inside the small end of one of the connecting rods had rotated so that the oil way to the pin was blocked up; also, that the gudgeon pin had shifted endwise and had been rubbing against the side of the cylinder.

The Engines

A beautiful piece of work indeed was the Wolseley engine. It had, of course, been especially designed for aeroplane work, but the main consideration kept in mind has been not the reduction of weight, but the production of a reliable motor. The engine which was entered for the contest had four cylinders of 3¾-inch bore by 5½-inch stroke and was rated at 30 brake horsepower at 1100 revolutions per minute or 37 brake horsepower at 1400 revolutions per minute. The weight was 205 pounds complete with magneto, carbureter and all piping, but no flywheel. The cylinders are cast in pairs with each head and liner in one piece. All the valves are on the same side of the motor and operated by hardened-steel tappets, as shown in Fig. 1. A special feature is the use of four water jackets of planished sheet metal.

In appearance, the Humber engine is strongly reminiscent of a motor-car engine, the copper water jackets being the only apparent feature of difference. The cylinders are of cast iron, machined all over, with a bore of 4.33 inches and a stroke of 4.725 inches. Both the inlet and the exhaust valves are overhead and operated by concentric push rods from a single cam shaft in the upper half of the crank case. The outer push rod carries at its upper end a light bracket, by means of which the rocker arm for the inlet valve is moved. The carbureter is of the single-jet type with an automatic auxiliary air valve opened by the usual adjustable spring. The crank shaft is hollow and supported on ball bearings of large diameter; one bearing is provided between every adjacent pair of cranks. The connecting rods are of chrome-nickel steel of very light section, and the pistons are turned from solid bar steel. Forced lubrication is provided through the hollow crank shaft to the big-end bearings of the

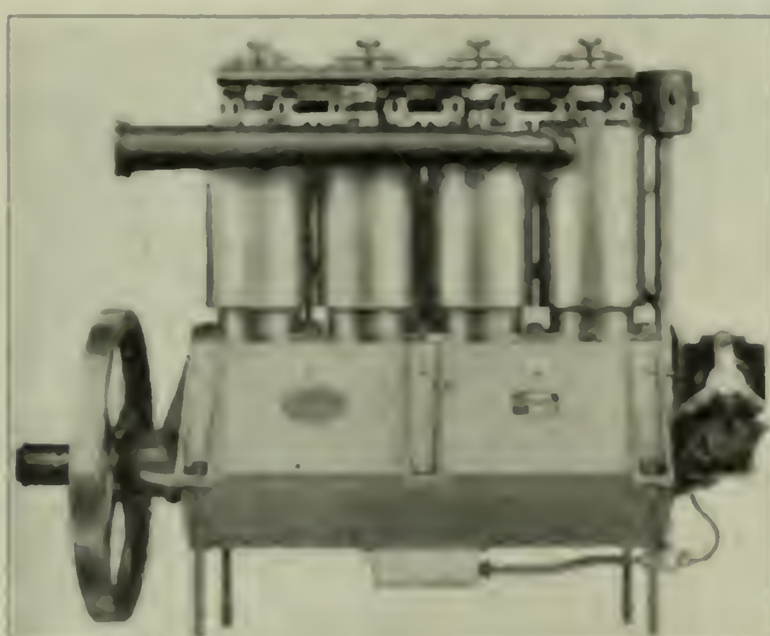


Fig. 3 THE GREEN ENGINE Fig. 4

connecting rods; the oil pump is of the gear-wheel type. Complete with its piping and magneto the weight of this engine is 232 pounds, and 42 horsepower is developed at 1200 revolutions per minute; the weight per horsepower is, therefore, 5.5 pounds.

It is an odd fact that the Green engine, which made the best showing in the contest, was designed and built before the recent developments in aëroplanes. It was

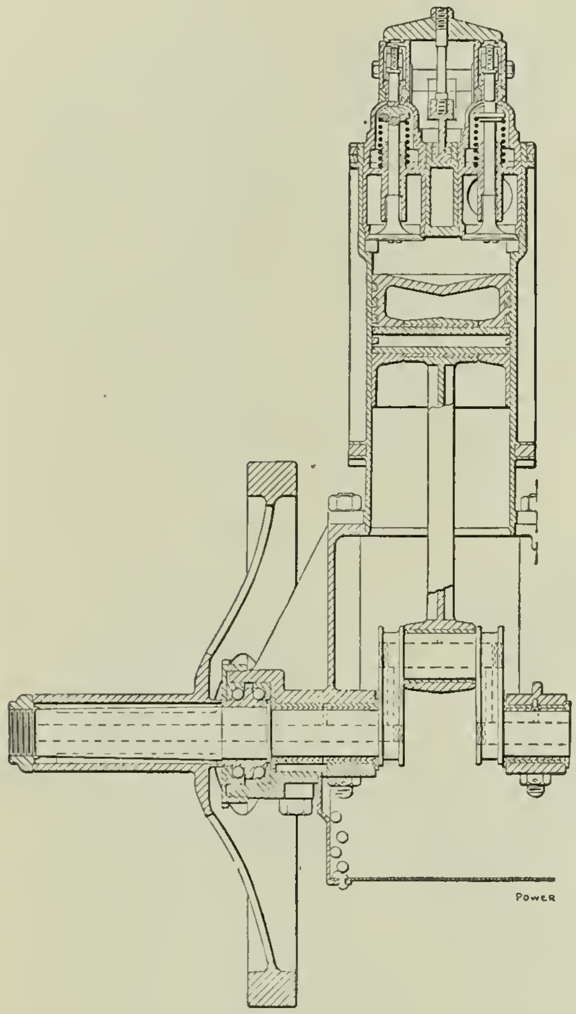


Fig. 5. A Green Cylinder

shown at a small exhibition as long ago as 1905, but at that date was, of course, regarded as a freak. It does not come within the category of extra light engines. The contest model, which develops 32 horsepower at 1220 revolutions per minute, weighs 181 pounds with all pipes, connections, carbureter and flywheel, but excluding ignition apparatus; that is almost 5.7 pounds per brake horsepower.

Unlike the majority of aëroplane engines, the Green motor is practically of orthodox automobile design, the weight being reduced by the judicious choice of material and not by ingenuity in the arrangement of the working parts. Each cylinder, with its head, is cast in one piece of steel and is machined inside and outside. The water jacket is made of thin polished copper and the greatest body of water is distributed unobstructed around the valves and the head. The cylinders are offset with respect to the crank shaft and the latter is provided with five bearings. The lower part of the crank case is made of sheet aluminum and makes a tongue-and-groove joint with the upper part of the crank case, which is a casting.

The crank shaft is made hollow for the sake of lightness; for the same reason the crank cheeks are grooved in an unusual manner (see Fig. 5). One end of the crank shaft receives the propeller and from the other end the pump and magneto are driven through spiral gears. A vertical shaft inclosed in an aluminum oil-tight case takes the drive to the overhead cam shaft and down to the oil pump, as indicated in Fig. 4. The cam shaft is driven through bevel gears and runs in four bearings in an oil-tight case; each cam with its rocker arm is also completely enclosed. The valves are in removable cages and are prevented from falling into the cylinder by ledges below the valve seat, as may be seen in the accompanying section of one of the cylinders, Fig. 5.

One of the most interesting features of the engine is the floatless carbureter, designed to work equally well at all angles. The supply of gasolene and air is controlled by the engine suction. Fig. 6 is a sectional elevation of the carbureter. There is a small clearance between the head of the choke cone *D* and the head of the gasolene valve *Y*. This permits a tight joint between the gasolene

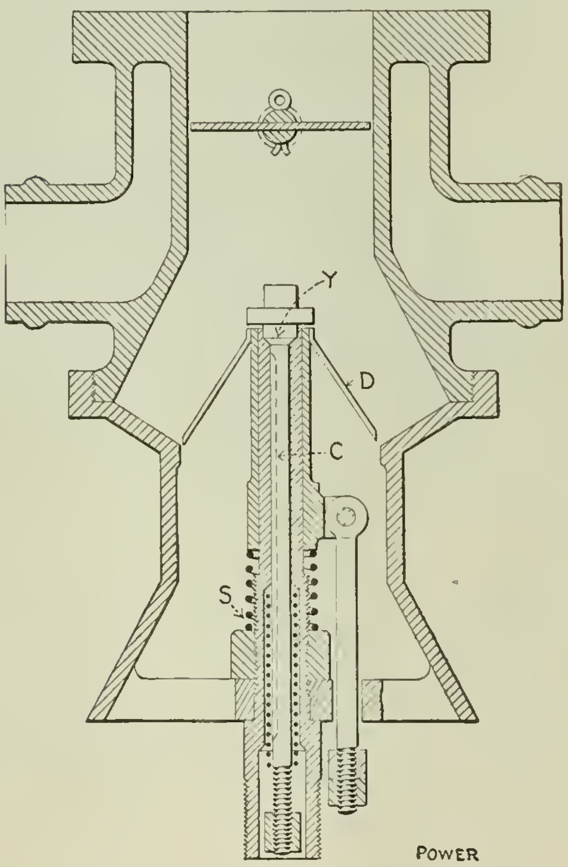


Fig. 6. Green Carbureter

valve and the end of its casing when the valve is down. As soon as suction takes place the choke cone, after taking up the clearance, commences to lift the gasolene valve from its seat, the force of the suction determining the extent of the lift. The gasolene is fed through the milled channel *C* in the side of the valve stem; this channel diminishes toward the seat of the valve and therefore passes more gasolene at high suction than at low, but beyond a certain point there is no increase in the opening. The spring *S* acts in the capacity of a flexible stop for the choke-cone sleeve when it drops.

Engineers for Gas Engines

By M. W. Utz

Mr. Hamilton's article on this subject in the April 25 issue was especially interesting to me, possibly because I happen to be familiar with a typical case of the no-engineer fallacy. A small manufacturing establishment was formerly equipped with a 65-horsepower slide-valve steam engine supplied from an 85-horsepower tubular boiler, the excess boiler capacity being used for steaming raw material before manufacturing. This plant was not very economical in operation, so when a gas-engine salesman began to quote figures on the cost of installing and operating a gas engine, the owners were all attention, especially as to the claims made by the salesman that "the labor cost would be practically nothing, because they would not need an engineer; an ordinary laborer could fill the oil cups and start the engine in a few minutes, and this was all that would be necessary till time to shut down again." The salesman was also rash enough to promise that the exhaust of the gas engine would evaporate enough water to steam the raw material.

The steam plant was taken out and the gas engine installed in its place and when everything was ready for operation the steam engineer was discharged and one of the owners undertook to look after the gas engine and do the office work. A man from the builder's shop started the engine, which seemed to run very satisfactorily, but the exhaust would not evaporate enough water for their requirements, so they had to buy and install a 10-horsepower boiler. After a short time trouble began, and finally the engine could not be started at all, the compressed air going straight through. A man sent by the builder promptly found the exhaust valve stuck open. Later on, the cooling water stopped circulating and the engine got hot, of course. When the water was turned on again the cylinder cracked; that meant a new cylinder. When cold weather set in, the jacket of the small engine which drives the air compressor was not drained, so it froze up and burst; the rotary pump which supplied the jacket cooling water did likewise. At another time, after putting in a new exhaust valve, the engine failed to give the required power and when a man from the factory was called to see what was wrong, all he did was to grind-in the exhaust valve, which they had put in without grinding. So it kept on, a man from the shop being called on to adjust or correct some small matter which a good engineer would have handled without difficulty and saved his salary in doing it.

The service became so uncertain that the central station was appealed to and motors were installed to drive the most important machinery; the arrangement is such that when the engine balks the motors can drive these machines only, leaving the rest of the plant idle until the engine can be started again. It looks as if the central station will soon be running the entire plant.

Now, this engine is of a well known make and would give good service if properly taken care of as it could be by a capable engineer. The man who attends to it now, or tries to, is inexperienced and is the fourth one in about a year. He has so many other duties to perform that if anything goes wrong with the engine it is generally shut down before he can get to it.

If this firm had kept the old steam engineer, who was a practical man and would have no doubt made a good gas engineer, and not burdened him with so many other duties that he could not have given the engine proper attention, it would have doubtless been a success and the central station would not be supplying motors there today.

In most cases, the steam engineer makes a success with the gas engine, having the advantage over the common laborer of a general knowledge of machinery and experience gained in the engine room of his steam plant.

Over 75 per cent. of the successful gas engineers that I have met were formerly steam engineers, and enthusiastic ones at that, which, I think, leaves little doubt as to who will be the coming gas engineer.

Gas Engineering in the Oil Fields

By H. H. Daniel

About the time when the gas engine was being introduced in the oilfields of Pennsylvania for pumping purposes, we were called upon to make repairs on all sorts of engines, and some of the experiences we encountered were comical; others were far from entertaining. A complaint came in to our shop once to the effect that a two-stroke engine which had been recently installed did not work satisfactorily. When I arrived at the engine house, a couple of pumpers from neighboring wells were on the job and had built a nice hot wood fire under the cylinder of the engine "to warm her up so she would start." We dispensed with the warming-up expedient and after a brief investigation found that the spring on the automatic inlet valve had been screwed up so tight that it was necessary for one of the men to relieve the tension by pressing on the valve stem with a lever in order to get the engine started.

The tension of the spring was relaxed to the proper point but it was found that the gas pressure was too low to furnish the engine with the necessary amount of fuel to carry the load, so we advised the pumper to look over the line for leaks. Following the line, he arrived at an abandoned shanty which stood between the engine house and the wells and, as the room was rather dark, he struck a match. Three very noticeable events occurred at exactly the same time: a loud report, an elevation of the roof of the shanty about six feet above the walls and the projection of a dark object through the door of the shanty. Upon examination we found that the dark object was the pumper, not hurt much but badly scorched and more badly scared. We went into the shanty (without a light) and found that the side outlet of a ¾-inch tee was open and out of this the gas was freely flowing. A stove had been used in the shanty and when it was removed, the detail of plugging the tee had been ignored. After we plugged it the engine was started and ran very nicely.

An Ingenious Crank Pin Oiler

The accompanying engravings illustrate the method finally adopted for de-

Fig. 1. Crank-pin Oiler

livering oil to the crank pin of a Lammert & Mann 8x10-inch gas engine after trying almost everything else that could be found.

The arrangement consists merely of a pair of telescopic tubes attached at one end to a Nugent swivel joint on the crank end of the connecting rod and at the other end to a similar fitting mounted on the cylinder housing. A stuffing box is provided on the end of the large tube where the smaller one enters it but no packing is used on the swivels; the joint between the fixed and oscillating members is closed by a ground metal-to-metal joint and is held in contact by a flat spring. This construction is more clearly shown in Fig. 2. Oil is delivered to the stationary end of the arrangement by a force-feed pump.

The speed of the engine is 300 revolutions per minute and we are informed that this made it impracticable to use a wiper cup; most of the oil was distributed impartially over everything within range except the crank pin. The application of

Fig. 2. Crank-pin Oiler

the telescopic feeder here illustrated is said to have effected an amazing reduction in oil consumption and to keep the crank pin thoroughly lubricated. It was made by W. W. Nugent & Co., Chicago.

LETTERS

Wanted: Suggestions for Distilling Water

The plant under my charge includes a suction gas-producer equipment of two 100-horsepower units and three 100-horsepower engines driving dynamos which are used to charge storage batteries. The proposition has been put to me to find out whether or not I can make distilled water with the apparatus now in use. Can some other reader of Power suggest a practical method of doing this?

Albert A. Simony.

Washington, D. C.

[Whether there is sufficient exhaust heat to distill all the water required depends, of course, upon the work done by the engines, the efficiency of the still and the quantity of water to be distilled per day or week. Suggestions from other readers as to the quantity of water that can be distilled with exhaust heat per brake horsepower-hour of engines' work will be welcome.—Editor.]

We are reliably informed that Diesel engines are being built by the Krupp works, in Germany, and by Schneider & Co., of Creusot, France, which develop as high as 1000 horsepower per cylinder. Multi-cylinder engines of about 10,000 horsepower are under construction for the equipment of war vessels.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Changing Generators from Compound to Shunt Wound

By H. R. Mason

In a large power plant in the West which supplied a three-wire system at 120 + 120 volts through a number of shunt-wound rotary converters of a combined capacity of about 1500 kilowatts, the peak load increased recently until it required the full capacity of the converters and left no reserve to be used in case of trouble.

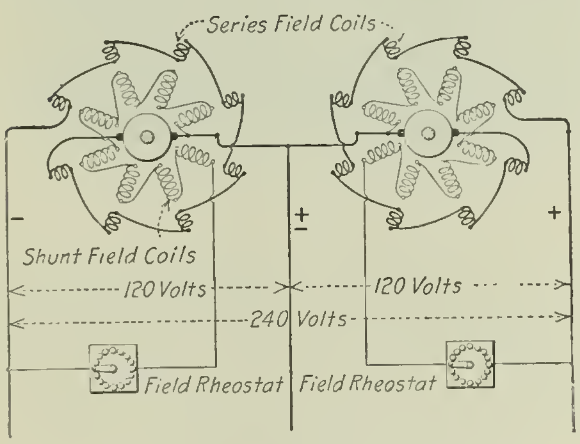


Fig. 1. Original Connections

Before the converters were installed, the system had been supplied by engine-driven compound-wound dynamos and one of the units was left in the station, but it was found impossible to operate this unit in parallel with the rotary converters; it would either pick up load until it was dangerously overloaded or else drop all of its load, when it would reverse its polarity and knock out the entire system. The unit consisted of a 14x24-inch twin Corliss engine direct connected to two 200-kilowatt, 120-volt direct-current dynamos mounted on a common shaft. A diagram of the electrical connections as originally installed is shown in Fig. 1.

In an attempt to make use of the twin unit, the series field windings were disconnected and a load put on the generators, using the shunt field windings only, but it was found that the field had insufficient strength to maintain the voltage with more than one-quarter load. It was found impossible to operate the unit at a high enough speed to produce the necessary voltage, so in its present condition it was of no practical use. As it became imperative that it be put into operating condition, the construction of the dynamos was investigated with a view to making changes in them. The shunt windings were found to contain 370 turns of No. 6 wire on each of the eight poles and passed a current of 40 amperes at 120 volts when all of the field resistor was cut out, making 14,800 ampere-turns on each magnet core. The expedient of connecting the shunt winding of each of the dynamos across the outside wires of the system, at 240 volts, with additional resistance in series, was tried, but it was found that the increased current necessary to maintain the desired voltage overheated the coils excessively.

The series windings had four turns each and carried 1600 amperes at normal load, making 6400 ampere-turns on each magnet core in addition to the 14,800 furnished by the shunt coil adjoining it. Upon measuring the space occupied by each coil of the series winding, it was found that additional shunt coils could be substituted for the series coils (see Fig. 2), each containing 370 turns of No. 8 wire. It was calculated that each coil would contain 1480 feet, making 11,840 feet on each of the 8-pole field magnets, and the wire table indicated that about 20 amperes would flow through that length of No. 8 wire at 120 volts, allowing for the same temperature rise as in the old coils. This would afford 7400 ampere-turns per pole to take the place of the 6400 formerly supplied by the series fields and would accomplish the double advantage of enabling full voltage to be maintained at all loads and reducing the speed somewhat.

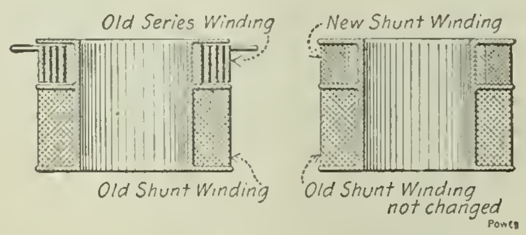


Fig. 2. Old and New Windings

Accordingly, all of the series coils were removed and additional shunt coils substituted, connected in parallel with the old shunt winding, as shown in Fig. 3. As the total field current was increased from 40 amperes in the original winding to 60 in the two, the field rheostat had to be remodeled and this was done by using standard street-railway motor resistor grids connected to the old faceplates. Of course, care was observed to connect the extra shunt field winding in such a manner that the current through it flowed in the same direction as in the old one. When the unit was started it fulfilled all expectations; it could be caused to carry as much as 30 per cent. overload at the maximum required voltage and one further experiment was tried upon it.

Occasional interruptions of the three-wire service were caused by short-circuits or by converters flashing and it was thought that the service could be resumed with less delay if this unit could be caused to take up the entire load upon starting, avoiding the delay necessary to restart and synchronize the rotary converters. The engines were capable of carrying 200 or 300 per cent. of their rated load in an emergency and, as the generators seemed liberally designed, it was thought that the load of 3000 to 3500 amperes would not damage them during the few minutes they would be called upon to carry that load, though 1600 amperes was their normal rating. The 120-volt field windings were again connected across the 240-volt busbars with additional resistance in series, but it was found impossible to maintain the voltage with a load of more than about 2500 amperes, or about 60 per cent. overload, as the field-magnet cores were then practically saturated and further increase of current through the coils had little effect on their magnetism.

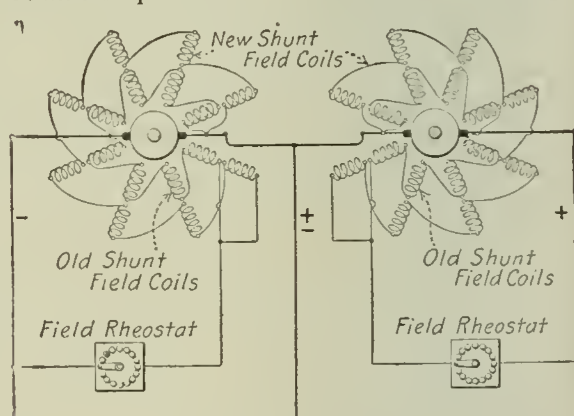


Fig. 3. Additional Shunt Coils Connected in Parallel with Old Winding

The unit has served to prevent several serious interruptions to the service since these changes were made and has been used to improve the station economy by taking part of the load from the rotary converters at times, allowing less efficient units to be shut down earlier.

Regulation of Rotary Converters

By R. A. Cultra

To allow the direct-current voltage of a rotary converter to be altered by adjusting the field rheostat or automatically by field compounding, a reactance coil is usually connected between the low-tension terminals of the transformers and the collector rings of the converter. Without such a reactance the maintenance of the same voltage at full load as at no load entails excessive leading and lagging currents and consequently excessive heating in the converter armature, unless the resistance drop from the source of constant potential is small, or the natural reactance of the circuit is unusually high. If the converter field is weakened a lagging current is set up which causes a voltage drop in the reactance coil. If the field is strengthened a leading current is set up which gives a rise of voltage in the reactance coil. Under a heavy load, the series winding of a compound-wound converter tends to produce leading currents, which tendency is practically balanced by the reactance, improving the power factor of transformers, lines and generators when loaded. The standard reactances are rated in kilovolt-amperes and are usually equal to 15 per cent. of the kilowatt rating of the converter.

The heating of converter armature conductors is greatly increased by the presence of leading or lagging currents. The series field winding of a compound-wound converter considerably increases the excitation at full load over that at no load; for this reason compound-wound converters should be adjusted to take a considerable lagging current at no load, which will be corrected by the action of the series field winding at normal load, thereby giving a good power factor and cool running when loaded.

For interurban railway service with low load factors, the converter should take about one-fourth of the full-load current at no load and this current should be lagging. The character of the current can be determined by the adjustment of the field rheostat. If the weakening of the field by cutting in more of the rheostat increases the alternating-current input, the current is lagging; if it diminishes the alternating-current input the current is leading. If the converter does not give the desired direct-current voltage with the desired setting of the field rheostat, the alternating-current impressed voltage should be altered by adjustment at the power house if possible; if not, by changing the primary taps of the step-down transformers feeding the converters.

For compound-wound converters with steadier loads having a high average load factor, the lagging alternating current at no load should be greater than 25 per cent. of the rated full-load current; somewhere around 35 to 50 per cent.

The no-load current of a converter should be measured when the equalizer switch is open if other converters are in operation in the same station; otherwise the current from the other machines will affect the excitation of the machine under investigation.

Rotary converters must not be operated above their rated voltage without proper adjustment of the transformer taps and alternating voltage. Overheating of the armatures is almost certain to occur with compound-wound converters run above normal direct-current voltage if a high average load is carried.

The ratio of the voltages at the alternating- and direct-current brushes of a converter varies slightly in different machines, due to differences in design. The best operating conditions exist when the desired direct-current voltage is obtained with unity power factor at the converter terminals when loaded.

Three-phase and six-phase converters require different voltages from the transformers on account of the difference between the connections of the armature taps. The no-load alternating voltage delivered from the transformers best adapted to compound-wound converters designed to carry variable loads is 61½ per cent. of the direct-current voltage for a three-phase converter or 71¼ per cent. for a six-phase converter. These ratios give a lagging alternating current at no load, a leading current on overloads and unity power factor at about the average load.

CORRESPONDENCE

Paralleling Two Phase and Three Phase Alternators

In the April 11 issue of Power I noticed an inquiry from D. M. Grove as to the operation of three-phase and two-phase alternators in parallel. I have charge of two power stations, one of which supplies two-phase currents at 2200 volts and the other three-phase currents at 13,200 volts, both at 60 cycles. The generating equipment at station No. 1 consists of two 180-kilowatt machines with closed-coil revolving armatures, similar to those described by Mr. Grove, and with compensating field windings and rectifiers, one 150-kilowatt revolving-field alternator, and one 300-kilowatt revolving-field machine. At station No. 2 there are two 600-kilowatt, three-phase machines with Y-connected armature windings. The transmission line from this station extends 17 miles to a substation which is three miles from station No. 1. Here the two lines are put in parallel through Scott-connected transformers, wound for 13,200 to 2200 volts.

These two stations operate in parallel without any trouble and with very little cross currents. Of course, it is necessary to adjust the field rheostats very carefully and in the case of the machines having compensating windings the adjustment of the rectifier brushes requires a good deal of care, otherwise cross currents may run up very suddenly and blow the fuses or open the circuit-breakers. The accompanying diagram shows the circuit connections between the machines just described. There is also a 300-kilowatt alternator at the substation which is operated as a rotary condenser (overexcited synchronous motor), and this is a great help in keeping up the power factor.

Where trouble is experienced in operating alternators in parallel it is usually found to be in the speed regulation of the motive power. To avoid "hunting," the governors should not be too sensitive; in some cases it is found necessary to dampen their action by means of dashpots. In the case of slow-speed engines it may be found necessary to increase the flywheel weight in order to absorb the impulse received at each stroke.

Diagram of Circuit Connections Between the Machines of Each Station

Thomas Hynes

West Chicago, Ohio.

The Electrical World states that the energy from Niagara Falls, including the stations on both sides of the falls, is used at the rate of 125,000 horsepower for electrochemical process, 58,000 horsepower for railway service, 38,000 horsepower for lighting and 54,840 horsepower for various industrial services, the total being 275,840 horsepower. Since the water of Niagara Falls represents probably 7,000,000 horsepower, it would seem that only about 3.9 per cent. of the available power is being utilized at present.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Inspectors Disagree

The conditions that prevail in Massachusetts, whereby old boilers are allowed to be operated so long as they hold their shape and comply with the requirements of the Massachusetts Board of Boiler Rules, are again illustrated in the case of a boiler owned and operated by a manufacturing company in that State.

The boiler is of the vertical tubular type and is described by the inspection certificate hung in the boiler room as follows: "Pressure allowed, 90 pounds; age, 21 years; length, 17 feet 6 inches; diameter of base, 60 inches; diameter of waist, 43 inches; tensile strength, 60,000 pounds; number of tubes, 96; diameter of tubes, 2½ inches; length of tubes, 14 feet; longitudinal joint, double-riveted lap; per cent. of strength of joint, 61 +; location of fusible plug, in tube."

On April 15, a State inspector visited the plant and ordered the boiler out of service until the following repairs had been made: A new ring in the frame of the furnace door; all tubes renewed and beaded; two patches put on, one on each side of the furnace-door frame; and the changing of the steam-gage pipe connection, which was tapped into the shell of the boiler slightly above the ogee seam, to be run from a tee at the top pipe connection of the water column.

The owner, believing that the extent of the repairs ordered by the State inspector was excessive, submitted the boiler as a risk to the steam-boiler insurance company whose inspector inspected the boiler on April 22 and recommended the following repairs to be made before the boiler could be accepted as a risk by the company: Ten tubes renewed; the ring in the furnace-door frame strengthened by fastening a flat piece of iron across the bottom (similar to a dead plate); one patch near the furnace door and the changing of the steam-gage pipe connection as was ordered by the State inspector.

These repairs being completed, the certificate of inspection was issued and so far as the parties directly interested are concerned the incident is closed.

In view of any possible failure that may occur to the boiler it looks as though the State inspector had all the best of the argument, inasmuch as he was endeavoring to give the owner and the public the benefit of the lesson taught by a recent disastrous failure of a boiler of this type. It is regrettable that when two eminently competent inspectors disagree as to the extent of repairs necessary to put a boiler in a safe working condition, that the law should be so worded as to allow the least of the recommendations to be accepted.

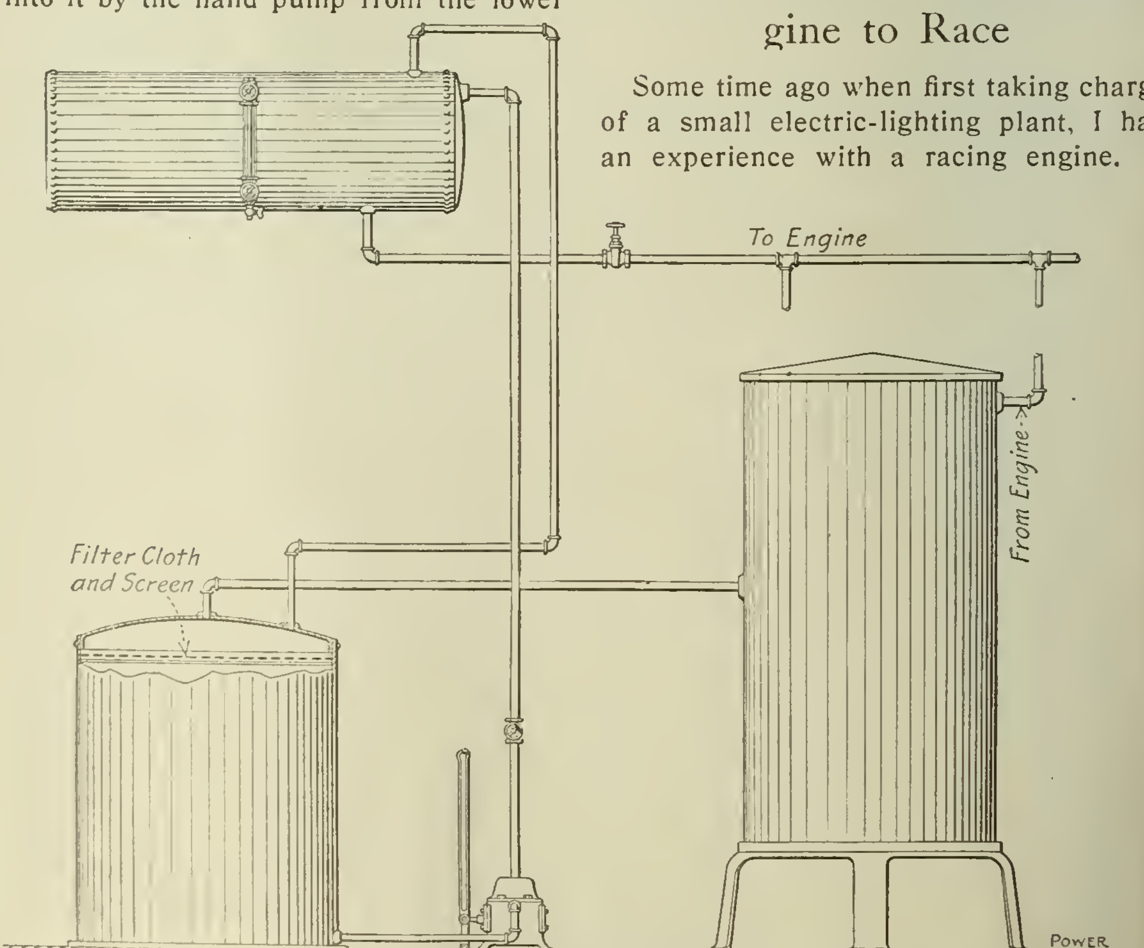
A rule that is printed in large type in the instruction book issued to railroad trainmen, "When in doubt, take the safe course," might well be followed by boiler inspectors when determining needed repairs.

JOSEPH KING.

Boston, Mass.

Clogged Overflow Pipe Caused Trouble

The accompanying illustration shows an oiling system that gave trouble. The gage glass on the overhead tank would fill to overflowing when oil was pumped into it by the hand pump from the lower tank. As it was known that there was not enough oil in the system to fill the tank it was concluded that there must be something wrong. In about 15 or 20 minutes the gage glass would be completely empty, although the oil was flowing freely to the engine bearings.



PIPING TO TANK AND FILTER

The chief finally investigated and found that the pipe leading from the overhead tank to the lower tank, which serves the double purpose of overflow and air relief, had become stopped up by the oily filter cloth that was on the screen in the lower tank, thus making the overhead tank air tight except for the little vent hole in the cap of the gage glass. As the oil was pumped up in the overhead tank a slight pressure was created which forced the oil up into the gage glass, and made it overflow through the vent hole; then, as the oil flowed to the engine, a partial vacuum was created in the tank, which caused the oil in the gage glass to flow back into the tank, completely emptying the glass. Upon taking down the overflow pipe and shortening it about 3 inches so it would clear the filter cloth, the trouble was cured once and for all.

FREDERICK M. PERRAS.

Mansfield, Mass.

Loose Setscrew Caused Engine to Race

Some time ago when first taking charge of a small electric-lighting plant, I had an experience with a racing engine.

This plant ran from dusk in the evening until the next morning. During the first few evenings the engine ran nicely; then, one evening there came several sharp pounds from the front end of the engine, and suddenly it began to race. By the time I had reached the throttle the voltage had got so high that the circuit-breaker tripped, leaving the building and town in darkness. This, of course, relieved the engine of all load, which had been gaining speed with every revolution. I thought there was a yard of threads on that throttle-valve stem before I got the valve closed and it seemed an age before the engine began to slow down.

By the time the engine came to a standstill and two-thirds of the population of the town had rushed to the plant, I had found that a setscrew which held a pin in place in the link of the governor had worked loose, allowing the pin to work out of the link. This put the governor out of commission, which allowed the engine to take steam full stroke.

The governor was soon adjusted and the engine started again, but the next morning, after shutting down, the setscrew was found to be loose again. This, I was told, had occurred before, so I hunted up a setscrew a little longer than the old one and put on a lock nut, after which there was no more trouble. However, I never started that engine again without first inspecting the governor, to be sure it was in good working condition.

M. W. UTZ.

Minster, O.

Draft Regulation

A 125-horsepower horizontal tubular boiler furnishes steam for a small factory. The fire is burned out at 6 o'clock each night, and the setting on one side and the rear end is exposed to the outdoor temperature. A fire is started in the morning between 4 and 5 o'clock. During the night the leaking damper allowed a draft of cold air through the furnace and tubes which cooled the setting and the boiler. This reduced the steam pressure to about 25 pounds at 4 o'clock.

In order to prevent this cooling effect, a cleaning door in the flue between the smoke box and the damper is opened each night at closing-up time. This has the same effect as the opening of the flue doors, for the boiler and furnace are kept so hot that now there are about 25 pounds more steam pressure in the morning than there was before this method was adopted. There is also a saving in fuel, less expansion strains on the boiler and setting, which means less repairs.

C. C. HARRIS.

Springfield, Mass.

Feed Water Problem

Here is a problem that recently came to my attention, which may be of interest to readers of POWER.

A boiler has two sources of supply of feed water. Each one is ample for the needs of the boiler for the greater part of the year, but for a month or two during hot weather it is necessary to use water from both sources in order to get the required quantity. One supply is from a stream and the other is from a well. When the water from the stream is in use alone, it is found necessary to clean out the boiler every eight weeks. When the water from the well is used alone, the boiler has to be cleaned out every three weeks. The quantity of water to be used from the stream is 1600 gallons in a given time, and the quantity to be used from the well in the same time and mixed with the stream water, is 900 gallons.

The question is, in how many weeks must the boiler be cleaned out while using the combination water, assuming that quantities of sediment, etc., remain the same for both waters and that no new elements occur from such combination?

At first sight this may appear difficult to some, who might let the problem go because they think it can only be solved by algebra. But it is not as difficult as it looks and it may be solved by arithmetic. There are different ways in which it may be solved, two of which are worked out herewith. The first is as follows:

Assuming that the deposit of material in the boiler is a certain measure when cleaning is necessary, then, in one week, when using the water from the stream, the deposit will be 1/8 measure, and when using the well water, it will be 1/3 measure. The length of the run is not given in the question, but there is the proportion of the two waters which is 16:9, hence, a run of any length of time may be taken in order to find the deposit per week, or the rate of deposit. Therefore, suppose that the stream water is used for 16 weeks and that the well water is used for nine weeks, then the deposit in 16 weeks, using stream water, would be

$$16 \times \frac{1}{8} = \frac{16}{8} = 2 \text{ measures}$$

Using the well water for nine weeks would give a deposit of

$$9 \times \frac{1}{3} = \frac{9}{3} = 3 \text{ measures}$$

This makes a total of

$$3 + 2 = 5 \text{ measures}$$

in 9 and 16, or 25 weeks, or one measure in five weeks. The boiler should therefore be cleaned out once in five weeks when using both waters together.

Perhaps the other solution will appeal to some as being simpler. It is as follows:

Assume that 1600 and 900, or 2500 gallons of water, are required for one week. With the stream water alone, one-eighth of a full measure of deposit will occur in one week, and with the well water alone one-third of a full measure will occur in one week. But when combining the two waters in the proportion of 1600 to 900 gallons, there is for the stream water

$$\frac{1}{8} \times \frac{16}{25} = \frac{2}{25}$$

of a full measure in one week, and

$$\frac{1}{3} \times \frac{9}{25} = \frac{3}{25}$$

of a full measure in one week.

Then

$$\frac{2}{25} + \frac{3}{25} = \frac{5}{25}$$

of a full measure in one week, when using both waters, as $\frac{5}{25}$ equals 1/5 of a full measure the full measure will require five times as long, or five weeks.

How many other ways can the problem be solved? It is of some practical value at least.

CHARLES J. MASON.

Scranton, Penn.

A Soil Pipe Repair Job

There are several large buildings at the institution where I am employed as engineer. We are about 12 miles from any town which can boast of a plumbing shop, so when repairs about these buildings are necessary I make them myself, rather than allow things to get messed up while waiting for a plumber.

One morning the branch pipe of a sewer connection began leaking, due to choking up of the sewer. I took a coil of messenger cable, which was on hand, bent a knock on one end and by this means located the obstruction about 75 feet away from the building and managed to knock it out with the wire cable.

I had supposed the leak in the branch was due to the cap not fitting into the threads tight enough, but upon examination found the pipe itself to be split for about 3 inches. I cut a sheet-iron disk to fit on the inside of the pipe, drilled a hole through both cap and disk for a 3/8 x 1 1/2-inch bolt, on which was slipped an iron washer, to stiffen the disk.

All was put in place and the space between the disk and the end of the pipe filled with putty. The cap was then screwed into place with the threaded end of the bolt extending through the hole in the cap. The bolt nut was then put on and tightened.

Only a few minutes were needed to make the repairs and it proved water and gas tight.

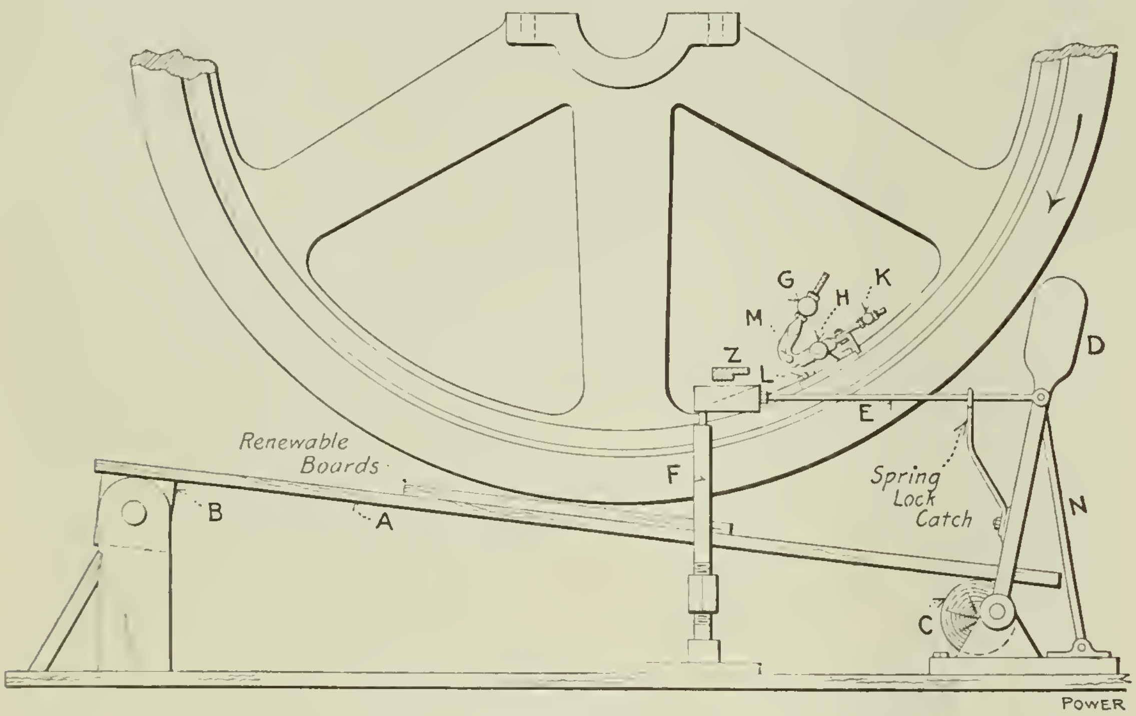
C. JOHNSON.

Columbia Falls, Mont.

Stopping the Engine Off Center

A 24x48-inch single-eccentric Corliss engine, direct connected to a generator, had a habit of stopping on the center, due to a tight piston, leaky steam and throttle valves and lack of judgment on my part. My predecessor had made arrangements with several men in the mill to ring a bell whenever he wanted help to move the crank off the center and, believing the arrangement to have been instituted after other methods had failed, I continued the practice. But no amount of bell ringing would bring anyone to the engine room at shutting down, for the men dashed for home as soon as the whistle blew and would not reappear again until it was time to start up. Thus, about 15 minutes were lost, during which time from 300 to 400 persons were idle.

One day when (from pure cussedness) the engine had stopped with the crank on the center twice in succession, I was



Details of Stopping Device

called to the manager's office and presented with a slip of paper on which appeared a lot of figures arranged, *"à la* Uncle Pegleg," as follows:

"This mill is operated 300 days in the year; the engine is, therefore, started 600 times and stops 24 times on the center. The average time spent in getting started again in 15 minutes; therefore, the mill is idle from this cause a total of six hours in the year. The pay on the average to 300 operators is 20 cents per hour. Each man then receives $1.20 per year without giving its equivalent in work, a total of $360. This is a net loss. The loss in production is many times this amount. Think this over and see what you can do about it."

Think it over I did, and finally evolved the scheme illustrated herewith. The idea was obtained from watching the showman stopping his swings. *A* represents two 7-inch planks laid side by side and connected by a piece of 4x4-inch joist *B*, through which a 1½-inch pipe passes to the upright posts shown to form a pivot. *C* represents two iron-bound wooden eccentrics, the fulcrum shaft of which passes through the bearings, as shown, and is firmly secured to the upright lever *D*. The club end of the lever is hollow and is filled with shot to form a weight. Its purpose is to cause the planks *A* to bear against the rim of the wheel with a certain tension due to the amount of shot placed in the head. It is supported in place by the reach rod *E*, the head of which latches to the upright *F*.

To the inside of the rim of the wheel is attached the automatic detaching mechanism operated by lack of inertia. It consists of a weight *G*, supported at a certain position on a bent arm pivoted at *H*, and more or less counterbalanced by the small movable weight *K*. The position shown is that assumed when the flywheel is in motion. When it is about to stop, the gravity of the weight *G* overcomes the inertia and the arm drops to rest on the pin *L*. It will be easily understood that the rim of the wheel needs to travel but slowly to cause the weight *G* to fly out. Secured to the bent arm is the pin *M*, the purpose of which is to slide under the head of the rod *E* at the proper time and release the weighted head *D* which manipulates the brake. The latch head of the rod *E* is shown enlarged at *Z*.

The right position on the rim for the releasing governor, with reference to the crank pin, was ascertained only after repeated trials. My method of shutting down the engine is as follows: After closing the throttle, a half-inch valve on a drip pipe leading to the valve chest is opened. Then the brace rod *N* which prevents the brakes from being set when starting up the engine is released. When the engine has slowed down to the speed that is just sufficient to keep the weight of the releasing governor in its outward position, the half-inch valve is closed, and the brake does the rest. The number of stoppages on the dead center was greatly reduced and the device, according to the manager's figures, saves the company $270 yearly.

M. Cassidy.

South Framingham, Mass.

Screwed Down the Safety Valve Spring

Recently a large fire flue collapsed in a traction-engine boiler of the Scotch type. The engine had been in service for several years and was of 12 horsepower capacity.

The engineer had been running the engine for several years. Three days before the explosion, he took the safety valve apart to clean and after putting it together he believed that he had turned the screw down as many turns as it took to loosen it. At the same time the steam gage was out of order.

When getting up steam on the morning of the accident, the engineer had turned on the blower and when the safety valve popped he started to shut off the blower. Just then the flue collapsed.

An examination showed that the rivet in the flange and lap seam of the flue had given away and ripped most of the rivet heads.

I got the safety valve and tested it under a pressure of 205 pounds before it opened. The engineer supposed he was carrying about 120 pounds pressure.

C. E. Rudy.

Covington, O.

Engine Ran with Broken Crank Pin

In a large cotton mill in one of the Southern States there is a center-crank engine which is used for driving a dynamo that supplies the lights for the mill. It runs at a speed of 175 revolutions per minute. One morning a short time before the engine-room lights were due to be switched off, the oiler noticed them dying out. Looking over at the small engine, he saw that the drivewheel which was belted to the dynamo had stopped, while the other wheel, containing the governor and eccentric, was running along apparently the same as usual.

He shut the engine down, and on examination discovered that the cast-iron crank pin was broken off flush with the face of the disk on the side next to the driving pulley. The other flywheel, which carried the governor and eccentric, had continued running the same as if nothing unusual had happened, being operated as a side-crank engine with only one bearing. The break was almost square across and flush with the face of the disk. The only damage other than the broken pin was a slightly cracked bed between the pillow blocks.

S. Kirlin.

New York City.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Sulphur for Hot Bearings

In a note on page 639 of the April 25 number, I note that someone recommends sulphur as being good for hot bearings. During a series of bearing-metal tests conducted by the writer, the matter was tried out with results not pleasant under service conditions at least. A bearing was perfectly surfaced, then loaded until the frictional heat developed was about 120 degrees, or about the temperature at which an ordinary operator would commence to get busy. Powdered sulphur mixed with oil was then fed into the box, with the result that the motor was very soon stalled, and when the blue brimstone smoke had cleared away, the condition of the bearing surfaces was the worst I ever saw.

It would seem that the application of a mild abrasive like sulphur is a matter requiring good care and judgment, if a hot box is developed. In such a case, the writer would not attempt to use it without shutting down the machine and starting cold, using the sulphur very cautiously with large quantities of lubricant. I would not use it in any case, unless it was the only thing for the purpose available, on account of its chemical ability to produce tremendous heat, once the boundaries of safety are passed.

A better method, recommended by several erecting engineers of long experience and thoroughly tried out with uniform success in my own experience, is to shave off powder from a cake of sapolio or Bon Ami, whichever is most available, mix it with good oil until a very thin mixture is secured and feed it slowly into the bearing, *after* it has been cooled down, if possible; if not possible to do this at least reduce the speed or pressure, remembering at all times that you are using a mild abrasive; hence while cutting off the high spots you are developing more heat and therefore require more lubrication than usual. This treatment should be applied to bearings one has reason to believe are running warm because of ill fitting or roughness caused by previous overheating.

Sometimes an old bearing will heat because of an accumulation of dirty or gummy oil. In such cases, a liberal application of brine or salt in the oil will cut out an amount of dirt and corruption that will be an eye opener to the novice. Once thoroughly cleaned the bearing will cool down quickly. An application of dilute acid, if available, will often work a similar cure; of course, in all cases, liberal lubrication should be employed.

I should like to read the experiences of others with hot bearings, especially with regard to the use of sulphur. Aside from my own case, I have found men of wide operating and erecting experience very slow to recommend it.

H. B. McDermid.

Minidoka, Idaho.

Feed Pipe Scaled

In looking through the issue of April 4, I noticed a letter entitled "Feed Pipe Scaled," by I. H. Stacey. If Mr. Stacey had arranged his feed pipe to provide two means of feeding the boiler, the trouble he relates would not have occurred. The pipe could have been arranged so that the boiler would receive feed water through the front head and also through the blowoff pipe. Then, should one of the feed pipes become scaled, the other could be used until repairs could be made at a convenient time, thereby preventing a shutdown of the plant.

I have my feed pipe arranged in this way and have not experienced any trouble. The feed pipe which goes through the front head runs above the top row of tubes within 24 inches of the rear head, then runs across the tubes up to the center row of tubes, where the water is discharged.

This boiler has been in service about three years and is practically clean, except where the feed water discharges between the center rows of tubes. In order to prevent any more accumulation of scale at this point I have changed the pipe so that water is discharged between the tube and shell. This was done about six months ago and the scale between the center rows of tubes is peeling off nicely. By the time all this scale has disappeared, there will probably be an accumulation at the new place of discharge, but it will simply mean changing back the piping to the old place.

H. A. Jahnke.

Milwaukee, Wis.

Worn Pump Screws

The reader has noticed an article in Power of May 2, and is rather interested in some points that are not fully explained. The reader has been in charge of a plant containing large triplex pumps and would like to procure information in regard to the screw pump so as to gain some comparison as to the relative upkeep of the two kinds of apparatus.

Is it possible to pack the screw type of pump on ordinary time; that is, not on Sundays or nights when the plant is shut down?

How often is it necessary to pack the screw pump?

What has been your experience in regard to the expense of the packing of this type of pump?

In packing a triplex pump against big pressure it is easy to set the packing down too tight so that the electric power required to drive the pump is very much increased. Do you have the same trouble with the screw pump?

The reader would also be interested to know whether or not this type of pump requires continuous attention in regard to its oiling system.

George H. Thomas.

Glen Ridge, N. J.

Special High Pressure Valve

The valve illustrated by A. Wind on page 574 of April 11 issue of Power is a very good large-size type of valve. A few years ago I operated an engine with a throttle of this type. It was a 10-inch valve, and differed from the one shown, in that the valve stem was reversed. That is, it pushed the valve off the seat instead of pulling it off, with

Valve with Internal Bypass

the advantage that when the valve was closed the pressure came off the valve-stem packing.

Omaha, Neb. S. C. Kinsey.

Specialists

The letter entitled "Specialists," by James Scotch, appearing in the issue of March 21, is, in my opinion, too critical and unwarranted. He blames the engineer in the small plant for exposing the mistakes of the specialists and dubs these engineers as "dinkies."

Mr. Scotch is apparently mistaken in reference to the object these engineers have in writing of such mistakes. I believe they write to warn unwary engineers of such pitfalls and not to pose as pedants or to unjustly criticize any specialist. There is always the young engineer starting in the business who will profit by the simple letters in POWER. He must start at the bottom and read carefully the simple questions asked in POWER every week—simple to those to whom they are familiar.

The fact that the bricklayer or machine erector probably has been doing such work for years, as Mr. Scotch states, does not make him infallible nor does it prevent the little engineer from knowing something about the business that the specialist does not know or happen to notice. To verify these statements I will relate an experience I had with one of these specialists.

An old locomotive-type boiler was to be inspected for the first time after I became engineer of the plant. I gave the boiler a good cleaning out, removed the grates, cleaned all the ashes and iron rust from the furnace sheets and found some very bad cases of rust on the lower parts of the water leg. A light blow with the peen of the hammer would dent the sheets.

This boiler inspector was really an expert, or specialist; he had worked many years at the boilermaking business before he became an inspector. Knowing this, I believed it would not be necessary for me to give him any instructions in his line of business. However, "a hint to the wise is sufficient" and I ventured to tell him to be a little bit particular and he might find something the matter with her.

When he got through he said that the boiler was all right except for some oil on the rear head at the upper row of tubes and told me that when I scraped it off I might run her as usual with 105 pounds to the square inch.

I then called his attention to the water leg. He started to pound it and feel for the thickness of the sheet; then started marking oblong figures on the sheets with white chalk. When he got through he took off his glasses, looked at me and said: "Don't start that boiler until there are seven patches on her and I have inspected her again."

The boiler was not started but was taken out and a new one replaced it.

My advice to all engineers in charge of plants is to keep your eyes open when other men are doing work in your plant, and for your own protection see that it is done right. The men doing the work may be careless or inexperienced, or they may be first-class mechanics but crowded with work and anxious to get at the next job or home on a short visit after an absence of several months. In any case, they are not infallible and will bear watching.

It is not necessary to be an expert in all branches of steam engineering in order to be able to detect whether a job is done right or radically wrong. Common sense, combined with the degree of intelligence that every engineer ought to have, should be sufficient.

JAMES W. BLAKE.

New York City.

Isolated Plant Engineering

The article published in the May 2 issue of POWER under the heading "Isolated Plant Engineering" is undoubtedly the strongest argument yet presented to show the true conditions which engineers in general have to face.

It is indeed a sad state of affairs that a large majority of men employed in steam plants are not permitted to know what the various expenses connected with the plant are, yet there are those who are kept in absolute ignorance of the price that is being paid for coal, oil, waste and supplies in general. Under such conditions as these, what chance has a man to know what it is costing to do certain work?

Furthermore, I would like to say that a big mistake is made when managers or superintendents who are not themselves engineers, but who have the hiring of such men, try to tell these men what to do, because any man who has had the necessary experience to fit him for the position knows far better than this type of manager what his duties as engineer are. Oftentimes much trouble and friction could be avoided if these men would allow the engineer to run his own department, and then if he was not doing his full duty in that respect the cost of maintenance would very soon make it known.

In regard to making suggestions for the betterment of the plant, I would like to say that many good engineering kinks submitted by the engineer are often credited to the manager later on when the work is carried to completion.

A little experience of mine was as follows: I had charge of a very poorly designed one-pipe heating system in an uptodate office building and found that a number of the rooms could not be properly heated on account of poor circulation. After considerable trouble and thought, I concluded that to overcome the trouble with the least expense it would be necessary to run the returns from the risers to a suitable tank and then pump them into the boiler instead of putting them into the sump, as had formerly been the practice. I submitted this arrangement to the agent, who took about a year to consider whether it was worth the expenditure of $100 or not, and after much agitation he consented to let me proceed with the work.

The work was completed just in time for the commencement of the heating season, and from the start the tenants remarked how much more comfortable their offices were.

After the installation had been working long enough to prove its reliability, the agent brought in several of his friends and explained how he had conceived the idea of saving so much good, hot water with a corresponding decrease in feed water as well as coal.

H. H. BURLEY.

Brooklyn, N. Y.

Writing for the Technical Papers

Referring to the advice offered by Mr. Williams, in the issue of April 25, to a recent correspondent on this subject, it would appear that the suggestions, in the main, might be materially improved. When you have a message, deliver it by all means, but in the delivering there is distinctly a right course and a wrong one; wrong, not only in point of view to the journal to which the matter is to be forwarded, but a greater wrong to oneself, inasmuch as each contribution should be an improvement over the one which has preceded it for personal benefit of its author. If one is deficient in some of the functions of letter writing and the like, there is no time like the present to endeavor to correct, and, in exercising a little care in the preparation, one not only has a possibility of having an article accepted, but he has a positive assurance that each one executed is helping to better his natural condition, is assisting in a general knowledge of the proper usage of words, correct spelling and the like.

Mr. Williams' statement, "Do not waste your time in rewriting; simply make all corrections in the first draft—" embodies a wrong principle. All know that "time is money," but time spent in a careful preparation of copy is far from wasted. Editors, as a rule, do not keep a "puzzle department" and one of the most important essentials for a just consideration of a contribution is its readableness, its ability to be quickly deciphered. A rough pencil draft should be made of matter which is to be presented, which one should try and divide into distinct parts, as introduction, or head, description, or body, and end, or tail, instead of a jumbled mass of material entirely out of order. This method is easy and simple and will not only help the writer in collecting what he wants to say, but will help the reviewer for publication in learning if what he has to say is worth while. In writing one should be brief and direct, make the letter read with full common sense in the fewest possible words; this does not mean "telegram" style, but, as steam is usually supplied to an engine by the shortest and best route, so should words be applied to the manuscript.

When matter is so collected in a rough draft, it should be copied plainly, on one side of the paper, of course, and with all neatness possible. This is not time wasted, this is time well spent. A rewriting in this manner shows, many times, how arrangement and wording may be improved, and it all helps; it shows where one can "cut" or add to good advantage. A little reasoning, such as "if I did not know this, would my reading of this article show me plainly," in description work, will oftentimes prove effective in bringing out little points not thought of and which may be necessary for completeness. Sheets should be numbered, as Mr. Williams states, but a title on the first page with a name and address on the last, and the whole held together with a common paper fastener, is far better and simpler than repeating such on each particular sheet.

An entirely wrong idea is obtained from "Do not be afraid of your spelling —," from this letter. Because a man is engaged in power-plant work in the operating end, is it any excuse why such carelessness should be shown in spelling, an elementary study compared with what his occupation demands? Is there any reason why he should not be fully as competent to spell simple words as a clerk or anyone else? A dictionary today is a cheap article, a small one, suitable to all practical purposes, may be obtained for a trifling sum, reference is an easy matter and a continual misspelling of the same word, with no attention given, shows the spirit that one is not alive to a betterment of his condition. Not only for contributions, but in record work and private correspondence to allow this "don't care" manner to predominate is unjust to oneself. When once a proper spelling is known, especially when it is looked up, it will come thereafter very easy.

In a paper such as POWER there is always a place for an article whether it be long or short, if it is worth while, if the matter is interesting or novel, if it is going to help its readers. If one knows something good, a kink, layout or otherwise, that he has not seen in print, he should write it up. Time-worn subjects unless presented in a particularly new and bright dress do not usually find place. Let the contribution work from both ends, make it serve two purposes; if it adds one dollar to the bank account, let it add many times this amount in value in perfecting system, neatness and an appreciation for the simple rudiments of the English language in its author. These are some of the things which help in getting the job higher up.

JOE SMART.

Los Angeles, Cal.

Coal Defined

Mr. Bement has an interesting article on "The Coal Problem Analyzed" in the April 25 number, but I must protest against his definition of the word "coal" as "that part of the fuel minus ash and moisture for which the term pure coal has been devised." It is all right for him to use the term "pure coal," if he likes it, to signify what others call "ash-and-moisture-free coal," since this term is not likely to be used with any other meaning, but it is all wrong to take the word "coal" which has had for hundreds of years a well known meaning, and limit it to mean only a part of what has hitherto been known as coal, and to invent for the latter a new term or terms, such as "fuel mixture" or "coal fuel."

The meaning that technical writers should give to a commonly used word is the meaning that is ordinarily given to it in commerce and literature, and that is found as the common definition in a modern dictionary.

Example: Coal (Century dictionary). "A solid and more or less distinctly stratified mineral, varying in color from dark-brown to black, brittle, combustible, and used as a fuel. Coal always contains more or less earthy matter, which is left behind in the form of ash after combustion. Sulphur is rarely if ever absent."

In other words, coal is the stuff that is called coal in the market. In the "Mechanical Engineers' Pocketbook," page 789, eighth edition, it is said that coal is composed of four different things that may be separated by proximate analysis, viz., fixed carbon, volatile hydrocarbon, ash and moisture. The late Eckley B. Coxe, in one of his papers on coal, once said, "Coal consists of two things, coal and dirt," meaning by dirt the visible pieces of slate and dirt which should be removed from the coal before shipping it.

Mr. Bement's Table 2 reads:

TABLE 2. PROXIMATE COMPOSITION OF COAL.

Pure Coal = Combustible Elements + Non-combustible Elements.
Dry Coal = Pure Coal + Mineral Matter.
Moist Coal = Dry Coal + Water.

I would change it to read as follows:

TABLE 2. PROXIMATE COMPOSITION OF COAL.

Coal = Dry Coal + Water.
Dry Coal = Pure Coal + Ash.
Pure Coal = Combustible Elements + Non-combustible Elements.

WILLIAM KENT.

New York City.

Engineers and Boiler Inspectors

In the April 25 issue I read Mr. Eaton's article on engineers and boiler inspectors. This brought to mind the question asked in an article in the April 18 issue, "Do you ever take time to examine the boilers of which you are in charge?"

Mr. Eaton writes that he does not touch anything inside of a boiler until the inspector has had an opportunity to see it in its operating condition. Would not this naturally lead the shrewd employer to think that the inspector and not the engineer, is the brainy one in the plant? It is because some engineers neglect to make examinations that most of our license laws are passed. These laws are safeguards for the public against explosions.

Some time ago I was in charge of a plant which apparently was in first-class condition. After an examination I found a defective boiler. This fact I made known to the office. The boiler had a number of leaking tubes and over the fire the seam showed up burned for a space of 2½ feet of the circumference of the shell. Stretched rivets and a crack in the plate showed up between two of the rivet holes to the edge of the plate, also a burned and buckled fire sheet which was subsequently straightened out with hot plates, sledges and flatters. The flange and rivets of the head were then calked tight and no trouble from leakage was afterward experienced. The rivets were in such bad condition that I insisted on their being replaced with new ones. Notwithstanding the condition of the seam over the fire, the only satisfaction I got from the superintendent of the plant was the statement that the boilers were insured and that the leakage would probably take up. I, therefore, immediately reported to the Hartford inspector of the district. New tubes were soon put in and a patch put on the defective seam over the fire.

The inspector's task is not always a pleasant one and the salaries of some are less than the salaries of chief engineers. It is unfair, therefore, to compel the inspector to stand four or five hours scraping scale off the seam and tube ends, crawling under boilers full of ashes and soot in search of fire cracks and other defects, which are visible only after every inch of the surface has been cleaned and scraped. Some engineers are in charge of boilers for long periods, without knowing that the feed pipe is partly plugged up or disconnected from the bushings in the front head. I always have our boilers cleaned out regularly. The back connections, tubes and head are cleaned, as well as the bottom of the shell, the seams, flues and stay braces. Thus, I am always ready for the inspector. I am in a position to report all defects as soon as he enters the boiler room. Only in one instance did it require more than an hour for an inspector to examine our boilers.

Inspectors should be cultivated, for they are great aids sometimes in getting unsafe boilers repaired. Engineers should care for their plants and see that the boilers are kept clean and in a safe condition, without having to be told to do so by the inspectors. This is the best proof of their ability and gives them a reputation, not only among the inspectors, but keeps them in good standing with their employers.

R. A. CULTRA.

Cambridge, Mass.

The Benefit of Organization

Mr. Wallace, on April 4, opposing Mr. Gotstein's plea of March 14 for an organization, said, "Organization never raises wages." How, then, would he explain the substantial increases granted to every mechanic, except the engineer, during the last few years? I am positive that men with intelligence, aware of current events, would not honestly say that organization never raises wages. In one city alone, through organization, the wages of 68 engineers were raised $7 a week, for an eight-hour day.

The history of industrial battles for the last 50 years against oppressive methods of employers, proves conclusively that organization alone has reduced the hours of labor and increased wages.

Wherever and whenever an organization has had any semblance of strength, there has been a demonstration of its power. Surely no man is so lost to the trend of the times as to believe that Mr. Rockefeller, Mr. Carnegie, Mr. Morgan and others of their class made their millions by their own unaided efforts. It is a fact that will bear no contradiction that our millionaires now hold their positions by the aid of the most iron-clad organization the world has ever known.

Mr. Wallace states that engineers are not like other mechanics, and work under different conditions. Let us see if he is correct.

An engineer depends upon the sale of his brain and brawn for so many hours a day for wages. With these wages, which is the price paid for the use of that brain and brawn for eight, ten, twelve or more hours a day, he buys food, shelter, clothing, recreation, establishes a home and educates his children. Other mechanics sell the same things for the same price—wages—and purchase the same essentials for a normal working-class life. So far as the sale and the reason for the sale are concerned there is absolutely no difference between the engineer and other mechanics. The wage received is expended in precisely the same manner. Thus, there is a continuity of interests between all mechanics of all classes in both the sale of their brain and brawn and in the expenditure of the price received.

Mr. Wallace states that an engineer receives what he is worth without the aid of organization and quotes a few acquaintances who are receiving high wages. This is not at all a wonderful thing, confined alone to the ranks of the engineer. The same thing is true wherever there are unorganized mechanics.

In all important things of life the material interests of all mechanics are identical. The sole difference between engineers and other mechanics is that 90 per cent. of the engineers are holding down one-man jobs while other mechanics work in groups.

It is true that engineers are expected to cover a wider range of effort than other men, but this is due principally to the isolation of their positions. Oftentimes between whistle and whistle the engineer performs the duties connected with a dozen different trades. If he refuses, or is unable to perform them, he is either no good or lazy, or both.

This isolation, with the constant and insistent calls upon his knowledge and mechanical ingenuity, has bred in the engineer an egotism that is monumental. It is this very isolation that makes organization necessary for the engineer.

To be an engineer—a real one—requires years of study and experience, a close study of new mechanical devices which are day by day being placed on the market, physical strength, a cool, clear head, nerves of steel, the ability to act quickly, the courage to face death or injury in the interest of his employer, the endurance to work hour after hour without rest or sleep and the willingness to do so whenever necessary. And for these attainments he is paid less and is obliged to work longer hours than the members of a dozen other trades which are organized.

Mr. Wallace, to prove the uselessness of organization, points out one man who, when he was not satisfied with his pay, stepped out and secured a $6000-a-year job. This is one man of abnormal ability. We are not, however, dealing with abnormalities, but with the average normal, brainy, everyday engineer. Were all engineers like the gentleman Mr. Wallace cites, possessing just as much push and ability, there would be no $6000-a-year jobs. Wages are not based upon what the highest-priced man receives but what the most needy will consent to accept.

If organization is good for our employers, good for other mechanics, for doctors and lawyers, why in the name of common sense is it not good for engineers?

Therefore, as we are now living in an age of organization, from the lowest to the highest, including billionaires and tramps, it behooves the engineers of this country to keep abreast of the times, and organize.

Let me say to Mr. Gotstein that he need not look around for an organization; it is already at hand. Get into it. Keep your eyes open and help to place your fellow engineers where they belong.

GEORGE G. HALL.

Dorchester, Mass.

Standpipe on Heating System

In the letter published under the above heading in the May 9 issue, the statement is made that "The system is made up of 1-inch pipe." The sentence should have read, "The system is of the one-pipe design."—EDITOR.

Remarkable Overload Boiler Test

Referring to the article in the March 21 number on "A Remarkable Overload Boiler Test," some data are given below on a test of a Parker downflow boiler at the plant of the Colorado Fuel and Iron Company, Segundo, Colo. If the tests published in the March 21 number are considered remarkable for overload, the test of the Parker boiler at 234 per cent. of its rating should be of interest.

Kind of boiler	Parker Water Tube
Heating surface, sq.ft	2,650
Grate, Roney Stoker (8′3″x7′9″) sq.ft	63.9
Duration, hours	7
PRESSURES (Average)	
Barometer, inches	23.3
Steam gage, lb	102.64
Draft gage, inches, comb. chbr	1.119
Draft gage, inches, furnace	0.308
TEMPERATURES (Average)	
Boiler room, deg. F	92.55
Escaping gas, degrees F	506.57
Feed water, degrees F	66.3
FUEL	
Kind of fuel	Frederick slack
Per cent. moisture	1.2
Per cent. ash of natural fuel	19.4
EVAPORATION	
Evaporation from and at 212 degrees, per lb. natural fuel, lb	7.90
Evaporation from and at 212 degrees, per lb. dry fuel, lb	8.000
Evaporation from and at 212 degrees, per lb. combust., lb	10.279
Evaporation from and at 212 degrees per sq.ft. grate, lb. per hour	335.21
Evaporation from and at 212 degrees per sq.ft. heating surface, lb. per hour	8.98
HORSEPOWER	
On basis 34½ lb. from and at 212 degrees	621.16
Builders' rating for boiler, h.p	265
Overload, per cent. rating	234
Efficiency of boiler and furnace, per cent	59.1

No account of steam furnished stoker and fan engines.

The boiler tested is rated at 265 horsepower, having 2650 square feet of heating surface. It is equipped with a Roney stoker 8 feet 3 inches wide by 7 feet 9 inches long, 63.9 square feet. The duration of the test was seven hours, and it was conducted by a representative of the stoker company. Attention should also be given to the fact that the coal used in the test was of an inferior quality.

B. DIECKHAUS,
Parker Boiler Company.

Philadelphia, Penn.

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Longing for Old Times

The relative difference between the standing of the old-time engineer and the man who has charge of the modern steam plant is self-evident, even to the layman. And the steam plants that are operated by the two types of engineers stand apart in a marked degree, showing the difference between the old and the new.

A man who operates a small steam plant, does his own firing and attends to the chores about the place does not and never will hold a very exalted position among his fellow craftsmen. He may be all right for the place, but in the engineering world the place is not recognized.

It is but natural that the modern engineer should tower head and shoulders above the old-time runner, who is altogether too frequently a young man using old-time methods in an old-time plant because he does not bestir himself and know enough to hold a better job.

Although there is no attractive comparison between the two types of engineers, it is exceedingly strange that a correspondent should recently write a letter bemoaning the fact that the old-time men, who only knew how to start and stop an engine and shovel coal, are being ousted by men who understand electricity, hydraulics and the other subjects that are necessary for the successful engineer to know.

Such an attitude is not only unprogressive, but it is foolish. What engineer worthy of the name would go to work in some of the steam plants that boast of one engine and boiler? What incentive can there be for an ambitious man to long for the chance to work in a steam plant, starting an engine and firing coal? Nothing much to do, not much responsibility and very poor pay.

One might as well long for the days when houses were lighted by the flames in an open fire place, when the steam engine was used in its crudest form or when knives and forks were unknown.

No progressive man regrets the fact that he has been obliged to know about a number of engineering branches in order to assume charge of a modern steam plant.

Such knowledge has made him a better man in every way. More liberal and broader minded in his views, more conservative in his opinion and a more observing, careful, painstaking engineer.

All of this has perhaps cost him self-denial and long hours of solid study that might have been spent in pursuit of pleasure. There is, however, no gainsaying that the benefit has been all his own.

It is about time that engineers got away from the idea that they are an overworked and abused set of men. Because the design of the steam plant has been improved faster than some engineers have improved in engineering science is no reason why there should be regrets on the part of anyone that old conditions are passing away.

Let them pass. Get ready to take charge of the new power plant. Throw the old homemade box chair out of the door and get ready to take a place at the new plant and know how to hold down the cushioned armchair before the engineer's desk.

Radiated Heat

Popular belief regarding the insulating effect of a hollow furnace wall seems to have received a severe jolt as a result of the recent investigations of the Geological Survey, mentioned in the May 23 issue.

Heat may be transferred in three ways: by conduction, by convection and by radiation. The conductivity of air is known to be low, and where convection is eliminated by stopping leaks and preventing the circulation of air currents, an air space between the walls of a boiler setting is generally regarded as affording the greatest protection against the loss of heat to the boiler room. In view of the investigations, however, it appears that notwithstanding the low conductivity of air, its effect upon the transfer of heat is small as compared with that of radiation when high temperatures are considered. This is because the transfer of heat by conduction varies directly as the temperature difference between the two inner surfaces of the walls and the resistance of the intervening air, whereas the radiation varies directly as the difference between the fourth powers of these surfaces.

This may appear somewhat startling at first, but when it is considered that the heat given to the earth by the sun is transmitted by radiation alone, the significance of this factor is at once apparent. Furthermore, when standing in front of an open fire the heat is felt upon the face, yet the temperature of the intervening air may not be materially increased; but if a piece of paper or other shield is placed in front of the face the heat will not be felt. This shows that it is radiated heat. Also, the heat from an incandescent lamp is radiated as the bulb contains very nearly a perfect vacuum.

Some may find it hard to harmonize this with the fact that there are certain vessels on the market for keeping things hot or cold, which have double walls with a partial vacuum between. The fact is, however, that the walls of these vessels are polished and reflect the heat. If it were practicable to do this with furnace walls, one source of heat loss might be greatly minimized. The whole subject is one of unusual interest and should evoke profitable discussion.

Room for Improvement

Ever since Newcomen started his first pumping engine it seems to have been understood that the engineer would stand for more overtime and other undesirable conditions than anyone else around the plant.

It is taken for granted that he will be the first on the job in the morning, the last to leave at night; that he will spend all day Sunday at the plant and work for laborers' wages. This has gone on until after two hundred years' of precedent and practice the bargains that some employers are able to drive with their mechanical help seem almost beyond belief. The following is an example:

This is the case of an "engineer" who runs a machine in a shop. He is an expert on the machine and, although he has some other duties to look after, he turns out nearly as much work as his companions who keep steadily at their tasks. These "other duties" consist of wheeling the coal, firing, and hoisting the ashes for a two-hundred-horsepower heating boiler and attending to a gas engine which runs the shop. The engine runs night and day, shutting down a half hour for the noonday lunch and a half hour in the evening for a change of shifts.

During lunch time the "engineer" tinkers around the plant between mouthfuls and sees to it that the machinery is started for the afternoon run. At night he remains to put the plant in operation for the night run. On Saturday afternoons he works on the engine, getting it in shape for the next week's work, and comes down on Sunday to work around the boiler, lace belts, rebabbitt the line shafting or do any odd jobs of plumbing on the heating system.

For his extra duties he receives twenty-five dollars per month, which helps to pay the rent, and he makes up the rest of his living by hustling on the machine. As an example of industry he is a model; as an example of poor engineering conditions his case could not well be improved upon.

It has often been remarked that this country affords a wonderful field for activities of every description; that there is scarcely a line in which one may enter but what virgin soil may not be encountered.

This is particularly true of all those organizations which have for their object the betterment of the individual. Each is endeavoring in one way or another to better the condition of its members and incidentally the profession in general, and in this work there is no question but that great good is accomplished.

Much time and hard work are necessary to dig down into the depths and reach some individual cases, but with such conditions as cited above existing the possibility of reward is always present; the horizon is limitless; the field has hardly been scratched.

All in the Spirit

One of the arguments frequently advanced in favor of the enactment of engineers' license laws and ordinances is that it will act as an incentive to the engineer to study the fundamental principles of his calling. This may be true of the man who is an engineer because accident led him to the power plant in his search for something to do in order to get a living and who still works for a living and nothing else. It is not true, however, of the engineer who follows his vocation because he loves it. He strives and studies not because of the spur of the license but to fit himself for the highest position possible. His ambition is not alone to hold a license, but to become better educated, a better engineer and a better citizen every day of the year. He does not expect that a law, which unless properly administered will not eliminate the unfit, will place an arbitrary value on his services, for he aims to give value received for every dollar paid by perfecting himself in both the theoretical and practical knowledge of his work.

There were good engineers before the days of license legislation and there are good engineers in those States and cities where there are no license laws. It will be found, however, that it is the progressive and able engineer who is always advocating the passage of license and inspection laws. His knowledge of the dangers attendant on the operation of steam boilers and engines, his appreciation of the possibilities in the loss of life and limb and the damage to and destruction of property and his regard for the safety of others make him the foremost of all advocates for rational license and inspection laws and their administration in the spirit for which they are intended. He does not advocate license laws for the purpose of limiting the supply of competing workers in his field, for none can be found more ready to give effort and time to help another than the real engineer, but because he loves and honors his calling. It is his chosen work and he gives to it the best that is in him and all of it, because to him to be an engineer is to live.

Boiler Horsepower

The new value for the heat of evaporation from and at 212 degrees throws out the American Society of Mechanical Engineers' standard for a boiler horsepower. That standard is 30 pounds of water at 100 degrees evaporated per hour into steam at 70 pounds pressure above the atmosphere.

Or 34½ pounds, evaporated per hour from and at 212 degrees.

Or 33,305 B.t.u. per hour. The first two never did agree and with the corrected heat values the evaporation of 34½ pounds from and at 212 degrees means 33,478.8 B.t.u. instead of 33,305.

Why not leave any consideration of the horsepower of boilers out of the forthcoming (?) report. It is an anachronism and ought to have no further official recognition. Let them be rated in direct terms of the water which they will evaporate from and at 212 degrees per hour. We do not buy condensers by the horsepower.

At the experiment station of the United States Bureau of Mines, Pittsburg, Penn., several trial runs have been made with an experimental gas producer, using coke as fuel, with which limestone has been mixed in varying proportions, the purpose being to flux the ash, and form a liquid slag, thus avoiding clinker and ash troubles and consequent shutdowns. Liquid slag has been readily made which runs freely from the producer. The high temperatures necessary are very efficient in the generation of gas.

It seems that our numerous references to the self-contained outfit which the Europeans call the Locomobile and with which they obtain such wonderful efficiencies have had their effect. It is said that a number of large American companies are considering their manufacture.

The weather has now reached the point where the back door can be kept open, all ready for the speedy exit of the man who tries to sell you one of those gas engines that "require no attention."

Just because warm weather is coming is no reason why you should close your books and let your studies go for another six months.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Flow of Air through an Orifice

A vacuum of 7½ inches of mercury is maintained in a tank while air rushes in from the outside, passing through five ½-inch openings. Required the velocity of the air through the openings and the quantity of air entering per minute.

G. H. W.

The velocity in feet per second is obtained from the equation:

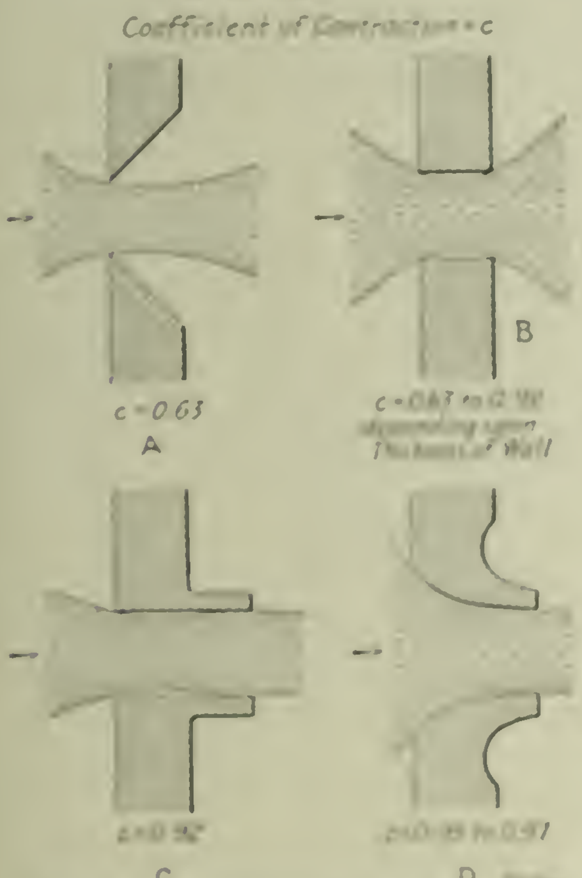
$$\frac{v^2}{2g} = \frac{k}{k-1} p_0 V_a \left[1 - \left(\frac{p}{p_0} \right)^{\frac{k-1}{k}} \right] \quad (1)$$

where,

v = Velocity;

p_0 = Atmospheric pressure in pounds per square foot;

p = Pressure in tank, in pounds per square foot;



JETS WITH DIFFERENT COEFFICIENTS OF CONTRACTION

V_a = Specific volume of air at atmospheric pressure and temperature t_a degrees Fahrenheit;

g = 32.18;

k = Ratio of specific heat at constant pressure to that at constant volume.

With the barometer at 29.92 inches,

p_0 = 14.7 × 144 = 2117 *pounds per square foot*

Corresponding to a vacuum of 7½ inches of mercury,

p = 11.01 × 144 = 1585 *pounds per square foot*

The value of V_a depends on the temperature and the humidity of the air. Leaving aside the effect of humidity, 12.83 cubic feet equals the volume of one pound of dry air at 50 degrees Fahrenheit; then

$$V_a = \frac{12.83 \times (460 + t_a)}{460 + 50}$$

Substituting this value of V_a in equation (1),

$$v^2 = \frac{2 \times 32.18 \times 2117 \times 12.83 \times (460 + t_a)}{510} \times \frac{1.41}{1.41 - 1} \left[1 - \left(\frac{1585}{2117} \right)^{\frac{1.41 - 1}{1.41}} \right]$$

Whence,

$$v = 30.85 \sqrt{460 + t_a} \text{ feet per second}$$

The volume flowing per minute through a ½-inch opening equals

$$60 \times \frac{d^2 \times 0.7854}{144} \times v \times \text{coefficient of contraction}$$

expressed in cubic feet of air at p pounds per square foot pressure or at 7½ inches vacuum.

To obtain the volume of free air at atmospheric pressure and a temperature t_a, let t be the temperature in the tank; then

$$t_a - t = \frac{A \times v^2}{c \times 2g}$$

where,

A = Heat equivalent of work = $\frac{1}{778}$

c = Specific heat of air at constant pressure = 0.2375;

$$t_a - t = \frac{v^2}{0.2375 \times 778 \times 64.36} = \frac{v^2}{11,892}$$

The tank temperature is

$$t = t_a - \frac{v^2}{11,892}$$

The volume V discharged into the tank at the temperature t and pressure p is equivalent to a volume V_a of free air at a pressure p_a and temperature t_a,

$$V_a = \frac{V \times (460 + t_a) \times p}{(460 + t) \times p_a}$$

cubic feet per minute.

Joint Resistance of Parallel Circuits

If a conductor of 20 ohms resistance, one of 22 ohms and one of 25 ohms be connected in parallel and 110 volts applied to the terminals, what current will flow in each one and what will be the joint resistance of the three?

C. H.

The current in each conductor will be exactly the same as though the other two did not exist. By Ohm's law,

$$\frac{\text{Volts}}{\text{Ohms}} = \text{Amperes}$$

therefore, the current in the three branches will be 110 ÷ 20 = 5.5 amperes, 110 ÷ 22 = 5 amperes and 110 ÷ 25 = 4.4 amperes, respectively. The total current in all three branches will be 5.5 + 5 + 4.4 = 14.9 amperes, and the joint resistance, therefore, is 110 ÷ 14.9 = 7.38255 ohms, or practically 7.4 ohms. The joint resistance can also be figured by adding the reciprocals of the three resistances and taking the reciprocal of the sum. Thus, the reciprocal of 20 is 0.05; the reciprocal of 22 is 0.0454545; the reciprocal of 25 is 0.04. The sum of these is 0.1354545, and the reciprocal of that is 7.38255.

Boiler with Little Water

Supposing a 60-inch by 16-foot horizontal-tubular boiler with 58 four-inch tubes was fired up with several inches of water in the boiler. The water at about 100 degrees. Would it be possible for this water to be evaporated into steam and cause the safety valve loaded at 80 pounds to blow off. In other words, would it be possible for the small amount of water in the boiler to be expanded into steam to cause a pressure of 80 pounds, providing the boiler held tightly; also, would this be likely to happen within 20 minutes from the time of starting the fire, coal being used as fuel?

O. C. D.

A boiler 60 inches by 16 feet with 58 four-inch tubes has a capacity of 200 cubic feet. Steam at 80 pounds gage pressure weighs 0.2198 pound per cubic foot. Therefore it will require the evaporation of 0.2198 × 200 = 43.96 pounds of water to fill the boiler with steam at 80 pounds pressure. A depth of water of one inch at the bottom of the boiler would contain 40 pounds or enough to blow the safety valve and then have some water left. It should be an easy matter to boil so little water in much less than 20 minutes with a good coal fire.

Refrigeration Department

Principles and operation of ice making and refrigerating plant and machinery

Charging a Refrigerating System

By F. E. Matthews

How should a refrigerating machine be charged, and how is it possible to tell when it is sufficiently charged; also, when it needs recharging? What are the various systems? What will prevent brine from freezing in the pipes, and how can they be opened after freezing?

Although not specifically stated in the question, the machine is probably of the compression type, and on this assumption proceed as follows: Connect the shipping drums of anhydrous ammonia, one at a time (or more if the plant is of large capacity or the initial charge is being put in and one wishes to save time), to the charging valve usually placed between the master expansion valve on the liquid line, where it leaves the receiver, and the expansion coils or brine cooler. This connection is most easily made by a special fitting built up with two swing joints, one end threaded to fit the valves on the shipping drums and the other provided with a flanged or threaded end to connect to the charging valve. When the connection has been made the air in the pipe may be expelled by slightly opening either the charging or the shipping-drum valve and loosening the flange swing joint nearest the opposite end.

The connection having been carefully made, the main valve on the receiver is closed and the low-pressure side is "pumped down" by allowing the compressor to continue operation after the liquid has been shut off. By the "pumping down" process the ammonia in the expansion side of the system is compressed and discharged into the compression side of the system, where it is condensed and flows to the liquid receiver which it may fill as well as the lower pipes of the condenser.

When the low-pressure gage indicates that the pressure in the expansion coils has been reduced to zero, or atmospheric, pressure, the charging valve may be opened wide and then the valve on the shipping drum may be "cracked," allowing a small stream of the liquid to pour into the system. The valve on the drum virtually becomes the expansion valve of the system and its manipulation should be governed by the same rules that govern the other expansion valves when the machine is in normal operation, except that it is better not to carry the back pressure quite as high as usual. This pressure may be anything above atmospheric, but it is not advisable to go below atmospheric as the vacuum would tend to draw air into the system through the charging connection when the drum is disconnected if the charging valves are not absolutely tight. A considerable inrush of air is not so easily detected as the slightest leak of ammonia outward.

When an open connection is made between the shipping drum and the system, the liquid is forced out of the drum into the system by the pressure of the gas above the liquid just as water is forced out of the blowoff of a boiler by the steam pressure above the water. The only difference is that it requires a higher temperature than that of the atmosphere in the engine room to raise steam pressure, while any temperature above zero will give a pressure above atmospheric in the case of ammonia. The pipe line from the drum valve will frost while there is liquid flowing. The melting and dropping off of this frost is an indication that the drum is empty. Frost may also appear on the bottom of the drum. The end opposite the valve is usually slightly elevated so that the liquid will flow to the outlet pipe which enters the head and turns down within about an inch of the cylinder side. When one drum is emptied, shut both valves and disconnect the pipe connection; then place another drum in circuit if more liquid is needed.

In systems of medium and large capacity it will be found necessary to slow down the compressor during the charging operation to prevent the pumping of a vacuum.

It is easier to form an opinion as to the amount of ammonia that the system needs while it is operating than it is to determine when a sufficient amount has been added. Except in initial charges, in which case the company supplying the machine calculates the amount of ammonia required from the number of feet of pipe on the low- and high-pressure sides, it is better to add a comparatively small amount of ammonia and then operate the system for a sufficient length of time to restore normal conditions. The hight of the liquid in the gage glass of the receiver, or the general performance of the plant when no gage glasses are used, will give the engineer an idea as to whether more ammonia is required. There should always be sufficient liquid ammonia in the receiver to insure a solid stream at the expansion valve. It should be remembered that refrigeration is produced by the absorption of the heat required to change the liquid ammonia to a gas and since it takes only a very small amount of heat to raise the temperature of any gas that passes the expansion valve in company with the liquid, little cooling effect can be expected from the gas. The passage of gas with the liquid can usually be detected by the intermittent whistling sound at the expansion valve, the flow of the liquid being almost noiseless.

Refrigerating systems may be classified first, as to the working fluid, and, second, as to the method of operation. The most common refrigerating fluid is ammonia, the next is carbon dioxide, after which come air, sulphur dioxide, Pictet fluid, sulphuric ether and a few others little used in practical refrigerating systems.

Ammonia systems are operated either according to the compression or to the absorption system, the former being far in the majority. Either of these may be operated on the direct-expansion principle in which the working fluid is conveyed direct to the rooms or tanks to be cooled, or by the brine-circulation system, in which the refrigerant is used in a suitable brine cooler for cooling either salt or calcium-chloride brine which is then circulated through the rooms or tanks to be cooled.

These systems might be further classified as to the type of apparatus employed for converting the refrigerant from the gaseous to the liquid state and the means of utilizing the heat-absorbing power of both the primary (the refrigerant) and the secondary (brine) cooling media. Where brine is employed as a circulating medium, it is usually chosen because it can be more conveniently handled in the compartments to be refrigerated than can the primary refrigerant and because the primary refrigerant can be expanded more efficiently in a single brine cooler especially designed for the purpose than it can in a number of dissimilar expansion coils scattered throughout the various rooms; also, where a brine-storage tank of large capacity is employed, it permits a considerable amount of refrigeration to be stored away during the periods of operation of the system, to be used during periods of rest, as, for instance, where it is desired to operate the principal mechanical equipment of the plant during the daytime only.

Brine is employed instead of water (which would otherwise be used on account of its cheapness) because its density may be so increased by the addition of salts that it will not freeze at the usual temperatures required for cooling. Water will transmit more refrigeration per pound pumped than brine and may be used where cooling at a high temperature only is required and the operating pressure of the primary refrigerant can be carried sufficiently high to insure against the water freezing. This condition could not be realized in the majority of cases, as any pressure of the ammonia below 47 pounds gage will produce a corresponding temperature below 32 degrees Fahrenheit, the freezing point of water. For lower temperatures salt brine is employed, its maximum density being sufficient to insure against freezing at temperatures above zero where tank systems are employed and the brine is kept in circulation. When still lower temperatures are required calcium-chloride brine is employed which at its maximum density is safe against freezing at all temperatures above 25 degrees Fahrenheit. At their maximum densities salt brine and calcium-chloride brine contain by weight respectively 25 per cent. of salt and 33 per cent. of calcium chloride.

To insure against freezing of brine, care must be taken to see that the solution is sufficiently strong to have a freezing temperature above that which will ordinarily be produced by the refrigerating machine. Care must be taken to see that this strength is maintained, as in the case of ice tanks a considerable dilution occurs through the replacing of wet cans and possible overflows due to occasional failure of automatic can fillers to shut off the fresh water at the proper time.

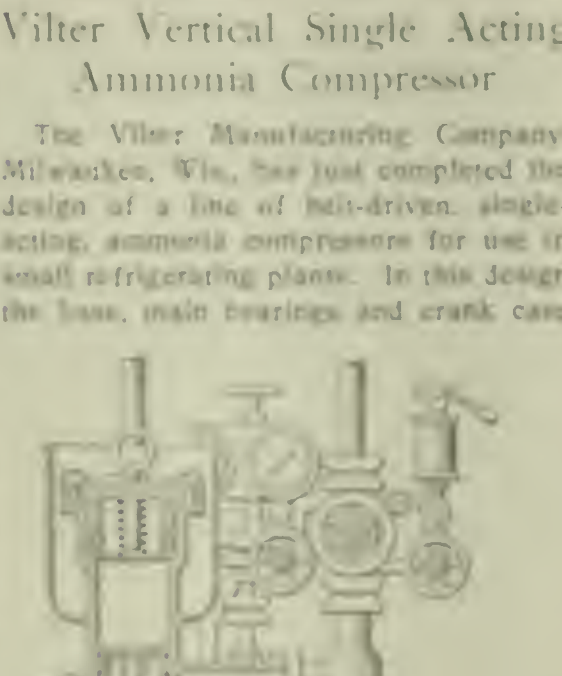
In the case of brine tanks slight freezing of brine on the outside of the expansion coils has no worse effect than that of insulating the pipes, reducing both their efficiency and capacity for cooling until the expansion can be shut off and the brine temperature allowed to rise sufficiently to melt the ice.

In the case of brine coolers a solid freeze may burst the pipes, allowing the refrigerant to escape into the brine and the brine into the refrigerating coils if the system is pumped down while leaks still exist. In both the brine tank and the brine-cooler system care should be taken to insure against abnormally low back pressures being carried when the brine pump is not in full operation. While it is always better to work on a safer margin, it is nevertheless a fact that brine can be circulated at its freezing temperature provided sufficiently brisk circulation is kept up to carry it away from the brine-cooling surfaces before the liquid brine, between any ice crystals that may form, has time to congeal.

When coils have been allowed to freeze up solid the temperature in the cooler should be allowed to rise until the coils are freed, care being taken to see that the brine pressure is kept lower than that of the refrigerant so that the brine will not be forced into the system if leaks have been produced by the freezing. A careful examination of the brine flowing from the coils will show whether or not the higher-pressure refrigerant is escaping.

Vilter Vertical Single Acting Ammonia Compressor

The Vilter Manufacturing Company, Milwaukee, Wis., has just completed the design of a line of belt-driven, single-acting, ammonia compressors for use in small refrigerating plants. In this design the base, main bearings and crank case



Vilter Single-acting Ammonia Compressor

are in a single massive casting, making possible rigid construction and a low center of gravity. These units are built in six different sizes from [illegible] to [illegible] inches of compressor displacement and require a small amount of head room and floor space for their rated capacity.

The compressor water jacket, suction and discharge pipe are cast as a unit, the suction entering the cylinder at a point near the center of the bore and meeting the trunk of the piston.

As will be evident in the sectional drawing, the piston is of the double-trunk design, having long ports between the upper and lower sections, which register with the suction-gas inlet at all points of the stroke, allowing ample gas passage to the compression end of the cylinder but preventing entrance of liquid or gas to the crank case.

The suction valve, contained in the piston as shown, is made of hammered steel, finished and ground to its seat. All superfluous metal is hollowed out from the disk and the valve stem is drilled the full length in order to lighten the valve and render it responsive.

The discharge valve is a light weight cup-shaped, pressed-steel member, housed in a semisteel cage and fitted into the upper counterbore of the cylinder. Both valves are extremely light in proportion to their size, are large with relation to the cylinder bore and give full area of opening from [illegible] to [illegible] inch extreme lift, thus insuring full cylinder charging and noiseless operation.

For lubrication a hand-oil pump is furnished for the upper part of the cylinder. An oil cup or grease box is supplied on the bearing next to the band wheel, while the main bearing, crank pin, wristpin and lower part of the trunk piston are automatically lubricated by oil splashed from the crank case. A gage glass is used to indicate the level of the oil in the crank case.

A strong feature of the design is the accessibility of all parts. By the removal of the large crank-case cover and the cylinder head the entire mechanism may be inspected or the parts disassembled. The same controlling features are used as are furnished with the larger machines of Vilter manufacture.

Repairing Pipe Insulation

How can the sweating of pipe be prevented? In the plant I am operating it has caused the partial disintegration of the 3-inch cork covering. Will wrought-iron pipe painted or galvanized pipe remedy the trouble?

Unless the pipe has actually rusted through, the moisture encountered does not come from the inside. There is no such thing as sweating through a pipe. The so called sweating of cold surfaces is due to the cooling of the surrounding air by contact with the cold surface. Air always contains a certain amount of humidity, or in other words, there is always mixed with air a certain amount of water vapor. The capacity of the air to carry this vapor depends directly on the temperature. The warmer the air the more vapor it will hold; the cooler, the less. When air is saturated with vapor, that is, when it has absorbed all the vapor it can at a given temperature, the slightest drop in temperature will produce precipitation, or a throwing down, of a part of the moisture. If air other hand, the temperature rises, the air will no longer be saturated, and a capacity for absorbing more moisture will have been created.

The temperature at which air becomes saturated to the point of precipitating its moisture is known as the "dew point." When drops of water appear on a cold brine pipe, or, in fact, on a pitcher of ice water, it is because the layer of air immediately surrounding the cold surface has been chilled below the dew point and thus gives up a part of its moisture.

In the case of a cold pipe insulated with cork or other kinds of covering, the liability of the air to be cooled to the dew point is greatly reduced, since the temperature of the outside of the covering is not nearly so low as that of the pipe. Nevertheless, a condition of atmospheric humidity will sooner or later exist when contact with a surface only a degree or two colder than the air will produce precipitation. If there is even the smallest opening through the waterproofing on the outside of the covering, air will enter, and, since the further it passes into the covering the lower the temperature encountered, the more likelihood of precipitation.

When the moisture has once been precipitated in the small openings through the waterproofing, it has limited exposure to the air for reëvaporation and unless there is a rise in temperature to increase the absorptive power of the immediately surrounding atmosphere, it will remain there. If the temperature of the insulation finally falls below 32 degrees, the moisture is frozen and in so doing expands, cracking the insulation still further, and into these minute cracks the moisture flows when another rise in temperature melts the ice. A recurrence of the freezing operation still further tends toward the disintegration of the insulation and the more the moisture penetrates toward the pipe and the more frequent the variations in temperature the more rapid will be the destruction of the insulation.

The place for the waterproofing, or more accurately, air proofing, of all kinds of cold insulation is where it comes in contact with the air and not at the point most remote from the point of attack, as in the case of the application of waterproof paper, paint, etc., next to the surface of cold pipes, where the only possible function of such waterproofing would be to prevent the pipe from rusting after the insulation had been penetrated and rendered useless by moisture.

If the present pipe covering is badly disintegrated and shows signs of being frozen, it should be removed and replaced. If it only shows deterioration in places, it can possibly be dried out. If there is any time of year when the pipes are not in service for a considerable length of time, they may be disconnected and the drying operation accomplished by passing steam through them. When the insulation has been thoroughly dried, the outside should be given a good coat of rubber sealing compound, supplied by the manufacturers, or several coats of quick-drying asphalt paint.

LETTERS

Corrosion in Refrigerating System

In the issue for April 11, comments are invited on the rapid deterioration of a brine-concentrating coil and tank, such as are used in connection with wet-air coolers. The following suggestions are offered for annihilating or at least greatly reducing the difficulty:

The first improvement that can be made is to pass only hot water or at most exhaust steam, not live steam, through the heating coil, so that the temperature of the brine will not exceed, say, 110 degrees Fahrenheit. This will prevent rapid formation of salt crystals on the pipes.

Secondly, the tank should have a large brine surface so that the surrounding atmosphere can absorb the rising water vapor as fast as possible. Let drafts of air pass over the surface, and do the work of concentrating when the humidity of the air is low. If the brine can be kept in motion by means of an agitator or circulating pump it will be an advantage, as it hastens the process of evaporation.

Third, arrange the heating pipes in form of an upright coil in the pan over the brine level, with a V-shaped distributing trough along the top, in the same manner as with an atmospheric type of condenser; and with a small pump keep circulating the warm brine over the coil until the solution has attained the proper strength. It is evident that under this method the atmosphere has a good opportunity of assisting in the work. With steam the heating surface of the coil should not be less than 0.11 square foot per ton of refrigeration; with hot water this surface may have to be doubled.

Fourth, for hygienic reasons it is objectionable to use the same stale brine over and over again; a slight overflow should be permitted to waste and this must be replaced with fresh brine. This can best be prepared by means of a box or barrel fitted with a false bottom, perforated. The water enters the barrel below the false bottom, rises through the salt above it and passes out as strong brine at the overflow pipe near the top of the barrel. This outlet must have a filtering screen to prevent obstructions from getting into the pipe. As it is frequently the impurities which cause rapid corrosion, the fresh brine should next be passed through a filter so as to remove these impurities. As a further precaution, the brine should be allowed to settle for some time in a tank of large area, where more impurities will precipitate to the bottom. At this opportunity it would be well to neutralize the corrosive properties of the solution by adding, in the case of salt brine, one to two pounds of carbonate of soda per 100 pounds of salt used, or one-half pound hydrate of soda per 100 pounds of calcium used in the case of chloride of calcium brine.

Fifth, as the expense for heating the brine and evaporating the water is considerable in a large plant, an economy can be effected by letting the hot discharge gas from the compressor pass direct through the concentrating coil. The coil should be made of extra-heavy pipe, galvanized on the outside only, and of sufficient cross-sectional area so as not to impose undue resistance on the gas. This plan will require very little attention and saves heat and condenser water.

Sixth, if this arrangement is not convenient the efficiency of the plant can be improved by means of a heat exchanger, in which the cold brine coming from the air cooler exchanges heat with the warm brine leaving the concentrator, in the same way as is done with the liquors of an absorption-refrigerating plant. In order to be able to advise as to the surfaces needed for a heat exchanger, one must know the temperatures and quantities of each medium available per hour, also the relative densities. In this connection it is well to bear in mind that it is important to work with brine just dense enough to prevent formation of ice on the ammonia coils. In order to see that this is the case, one must test the specific gravity of the solution every day by means of a hydrometer, and be guided by a table which gives the correct relations between specific gravity, freezing points and working temperatures of the salt or calcium brine used in the system.

CHARLES H. HERTER.

New York City.

With reference to the article, "Trouble with Refrigerating System," in the issue of April 11, the author has had trouble with brine rusting the boiling tanks and coils. Most of the trouble is caused from the fact that the brine does not let the tank dry when empty and the air rusts the moist iron. If the tubes fail at the fittings, it is due to electrolysis in the brine solution, which does not leave the tubes when they are apparently dry. If the tank is covered and copper coils used or perhaps a jacket, the trouble from corrosion of the tanks or from electrolysis will disappear.

F. G. WHEELER.

Trenton, Mich.

The Ohio Society of Mechanical Electrical and Steam Engineers

The twenty-third meeting of the above society was held at Youngstown on May 18 and 19, in the auditorium of the Elks Club, the privileges of which were extended to the visitors during their stay in the city. Six excellent papers were presented and discussed, of which those of interest to POWER readers will be treated in the columns following and in a later issue.

Inspection trips were made to the works of the Youngstown Sheet and Tube Company and to the Ohio works of the United States Steel Corporation, and outside of the formal program visits were arranged to the power station of the Youngstown Consolidated Gas and Electric Company of which Vice-President H. L. Patterson is mechanical engineer, the works of the William Tod Company and other local industries.

The next meeting will mark the tenth anniversary of the organization of the society, and will be held in November at Canton, where the first meeting took place.

Hydroelectric Developments in Ohio

BY PAUL M. LINCOLN

Reliability and continuity of supply is the first requisite for any power development. In former years the grist mill or sawmill was more or less common on many of the streams in Ohio. These operations required a comparatively small amount of power, and the continuity of supply was, under the conditions then existing, not absolutely necessary for success. However, most of these small developments of power have fallen into disuse.

A study of the rainfall and runoff conditions that apply to the Middle West is essential in arriving at a proper valuation of water powers. Table 1 shows the mean rainfall and runoff as recorded for the Muskingum River basin at Zanesville, O. This record covers the eight years of 1888 to 1895 and also shows the average of the same quantities for the three dry years of 1889, 1894 and 1895.

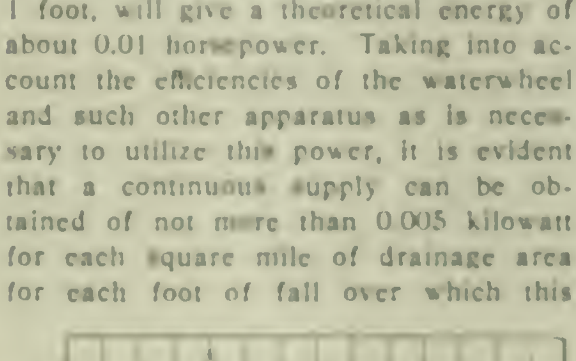
For the three months of August, September and October, the runoff reaches a comparatively low figure. A better idea of the conditions will be obtained by referring to the curves in Fig. 1, which show in dotted lines the average for the three dry years and in solid lines the average for the eight years. Referring to the months of August, September and October of the three dry years, it will be noted that the average monthly runoff amounts to 0.131 inch. Considering that this is the average for nine months (three consecutive months of three different years) it is certainly not too radical to assume that one cannot depend upon a continuous amount of water at the minimum flow of the stream of more than 0.1 inch per month. As a matter of fact, it is quite probable that this estimate is higher, rather than lower, than what would actually be obtained.

The table shows that the average rainfall, if distributed equally throughout the whole year, would amount to about 3.3 inches per month and that the average runoff for the same conditions would be about 1.1 inch per month.

One square mile with a runoff of 0.1 inch per month, falling through a head of 1 foot, will give a theoretical energy of about 0.01 horsepower. Taking into account the efficiencies of the waterwheel and such other apparatus as is necessary to utilize this power, it is evident that a continuous supply can be obtained of not more than 0.005 kilowatt for each square mile of drainage area for each foot of fall over which this water can be used. For instance, if it were possible to obtain a point at which the runoff from the entire State of Ohio (41,000 square miles) could be utilized over a 10-foot fall, it would be possible to obtain a continuous power supply of only about 2000 kilowatts at the minimum flow point. This seems an astonishingly small result but is nevertheless true when it is conceded that a runoff of 0.10 foot per second per square mile is all that is available.

TABLE 1

Month	Mean for 8 Years 1888 to 1895 Inclusive: Rainfall, Inches	Mean for 8 Years: Runoff, Inches	Mean for 3 Dry Years, 1889, 1894, 1895: Rainfall, Inches	Mean for 3 Dry Years: Runoff, Inches
December	2.31	0.821	2.37	0.810
January	[illegible]	[illegible]	[illegible]	1.221
February	[illegible]	[illegible]	1.80	1.241
March	[illegible]	[illegible]	[illegible]	[illegible]
April	[illegible]	[illegible]	[illegible]	[illegible]
May	[illegible]	[illegible]	[illegible]	[illegible]
June	[illegible]	[illegible]	[illegible]	[illegible]
July	[illegible]	[illegible]	3.21	[illegible]
August	[illegible]	[illegible]	[illegible]	0.118
September	[illegible]	0.418	[illegible]	0.110
October	[illegible]	[illegible]	1.87	0.106
November	[illegible]	[illegible]	4.11	[illegible]
Totals	[illegible]	[illegible]	[illegible]	[illegible]



CURVES SHOWING RUNOFF OF MUSKINGUM RIVER

The foregoing figure is for a continuous power supply. As a matter of fact, actual conditions do not demand a continuous supply throughout all hours of the day. Considerably more power is demanded at certain hours than at other hours, and for an ordinary lighting load a 30 to 40 per cent. load factor might be expected. Only a relatively small amount of pondage is necessary for equalizing a continuous supply of water so as to take care of the variations in daily load demanded by a daily load factor of 30 to 40 per cent. This would increase the maximum power which would be available at certain hours of the day by conserving the water for the remainder of the day. A 30 per cent. load factor would mean that 3⅓ times the continuous supply can be depended upon at the maximum demand.

There are two plans which may be adopted for the utilization of such water power as is available in relatively flat and variable rainfall localities. The first is to build reservoirs for the purpose of impounding the water during flood periods and releasing it during the low-water periods; the second, to use water-power plants as auxiliaries for steam operation, depending upon each kind of plant as a relay for the other.

Referring to the first of these remedies, suppose, for instance, that it is desired to increase the runoff available from 0.1 inch per month, which represents about 45 per cent. of the average runoff. The curves in the figure indicate in a general way what is necessary. The line *C* shows the low-flow period of the stream, namely, 0.1 inch per month. The line *D* is drawn at the average flow point of 0.5 inch per month, and the area *e f g e* represents the amount of water which would have to be released during the summer months of the average dry year to raise the flow from what records show really does exist during such years to the 0.5 inch per month. In order to release this amount of water, it would be necessary to impound an amount of water indicated by the area *e h i f e*. On account of the losses which necessarily take place by evaporation and seepage, it would be necessary that the amount of water stored exceed that released by about 20 per cent.

If the water-power plant be considered simply as an auxiliary to a steam-power plant, it at once becomes necessary to install duplicate machinery for a considerable part of the load. Steam-driven machinery must be provided to carry the load during the periods of insufficient water. The question at once arises, will the installation of a water-power plant pay? In order to get a basis for answering this, assume first that the duplication of machinery is complete, that is, that there is an available water power during a part of the year and that it is therefore necessary to have a steam plant that can carry the entire load during such period. A brief consideration will show that practically the only saving that can be obtained by the operation of a water-power plant as an auxiliary to a steam plant is the saving of the fuel which would be burned if the water plant were not operated. The item of labor for attendance will certainly not be reduced. In fact, the attendant expense is apt to be increased, since during a considerable part of the year both plants would have to be operated, necessitating practically a double crew. Supplies, such as oil, waste, etc., would not be reduced by the operation of the double system, nor would maintenance and repairs be reduced as the upkeep on the steam plant is apt to be even higher if run intermittently than if run continuously.

Another feature which plays an important part is the load factor. The lower the load factor, the smaller will be the number of kilowatt-hours turned out per kilowatt capacity of machinery installed; also the smaller will be the fuel bill per kilowatt of machinery installed. Table 2 indicates, in the first column, the load factor, and in the second column, the total number of kilowatt-hours which a plant will put out for each kilowatt-hour of maximum load; the third column shows the cost of the fuel for each kilowatt of maximum load at 0.5 cent per kilowatt-hour, and the fourth column, the maximum amount of money per kilowatt that should be put into a water-power plant for the conditions assumed. The figures in this column are arrived at by considering that the annual fixed charges on the water-power plant must not exceed the annual fuel bill, if the steam plant produced all the power. The fixed charges on the water-power plant are taken at 13 per cent. per annum, which is obtained by assuming 5 per cent. for interest, 6 per cent. for depreciation and 2 per cent. for insurance and taxes.

TABLE 2

Load Factor in Per Cent.	Kilowatt-hour per Year for Each Kilowatt of Capacity	Yearly Cost of Fuel per Kilowatt of Capacity at 0.5 Cent per Kilowatt-hour	Limiting Cost per Kilowatt of Auxiliary Water-power Plant
20	1750	$ 8.75	$ 67
30	2630	13.10	100
40	3500	17.50	135
50	4380	21.90	169

In arriving at the cost of a water-power plant, one should take into consideration not only the hydraulic development and the cost of the machinery but also the cost of transmitting the power from the plant to the market. This last item is very often an important one, since it is usually necessary to make the hydro-electric development at a considerable distance from the market, therefore making the cost of transmission high.

The figures in Table 2 were based upon the assumption that the water-driven plant will save all the coal. Reference to the curves in the figure will show, however, that this is much more than can actually be saved unless the stream be developed for the minimum flow only. If more than the minimum flow is developed, all the coal that would have been used by the equivalent steam plant could not, of course, be saved. To correct for this, the figures in the fourth column of Table 2 would have to be increased, the amount of this increase running as high as 33 per cent. for the conditions indicated by the cross-hatching on the curve.

In conclusion, it would seem that where load factors are low, the question of developing a water-power plant in a region such as Ohio is one that demands a very close scrutiny. The cost per kilowatt of a water-power development is a variable quantity, but it seldom runs below $100 per kilowatt, and sometimes runs to four or more times this figure. The amount spent in a water-power plant can therefore easily exceed the economic limit.

The Coming Chicago Convention of American Institute of Electrical Engineers

The annual convention of the American Institute of Electrical Engineers will be held in Chicago on June 26 to 30, inclusive, in the new Hotel Sherman, the most recently completed of Chicago's group of modern hotels. While the list of papers to be presented at the convention is not complete, the following partial list of papers that will probably be presented shows the diversity of subjects to be considered: "Economical Design of Direct Current Magnets," by R. Wikander; "Catenary Span Calculations," by W. L. R. Robertson; "Currents in Inductors of Induction Motors," by H. Weichsel; "Multiplex Telephony and Telegraphy by Means of Electric Waves Guided by Wires," by Major G. O. Squier; "Electrolysis in Reinforced Concrete," by C. E. Magnusson; "Induction Motor Design," by T. Hoock; "The High Efficiency Suspension Insulators," by A. O. Austin; "The Electric Strength of Air," by J. B. Whitehead; "Electrification Analyzed, and Its Application to Trunk Line Roads," by W. S. Murray; "Telegraph Transmission," by F. F. Fowle; "The Cost of Transformer Losses," by R. W. Atkinson and C. E. Stone; "The Costs of Railway Electrification," by B. F. Wood; "Induction Motor for Single-Phase Traction," by E. F. W. Alexanderson; "Magnetic Properties of Iron at 200,000 Cycles," by E. F. W. Alexanderson; "Electric Storage Batteries," by Bruce Ford; "The Characteristics of Isolated Plants," by P. R. Moses; "Elevator Control," by T. E. Barnum.

New Coal Region Being Developed

To those who are looking forward with so much apprehension to the time when the coal supply shall have been exhausted, the announcement that a large tract of land in Kentucky is about to be developed will prove welcome news.

The Consolidation Coal Company has recently purchased a tract of 100,000 acres of virgin coal land known as the Elkhorn district in Kentucky, and is building a railroad of its own from Shelby to the mine. The Louisville & Nashville railroad is also building a branch to this district, and when these two are completed there will be adequate facilities for working the mines to their limit; which, it is estimated, will occur in less than two years.

Extensive borings have been made throughout the entire region, and the coal has been found to run in almost continuous veins of about 9 feet in thickness. It is a high-grade bituminous coal with about 37 per cent. volatile and possesses excellent coking qualities, making the byproduct gas available for gas-engine purposes.

Bill for Ventilation of New York Factories

A bill has been introduced into the assembly of the New York legislature by Mr. Boylan to regulate the ventilation of factories and workrooms in the State of New York. This is a measure for which a committee of the American Society of Heating and Ventilating Engineers, D. D. Kimball, chairman, has been working on for over a year.

The bill provides that a workroom must be ventilated so that the air within does not contain more than nine parts of carbon dioxide in 10,000 volumes of the air in excess of the number of parts of carbon dioxide in 10,000 volumes of the outside air, or so that there is constantly supplied throughout the interior of the room at least 1200 cubic feet of air per hour per person and in addition 1000 cubic feet of air for each cubic foot of gas burned per hour, the air to be taken from an uncontaminated source. The temperature must never be less than 55 degrees and, except in boiler rooms, never more than 72 degrees wet-bulb temperature, unless the wet-bulb temperature outside exceeds 70 degrees, when the wet-bulb temperature inside must not exceed the wet-bulb temperature outside by more than 5 degrees.

The means for ventilation must be provided for by the owner unless a written agreement can be shown that the occupier is to furnish the means.

Illinois N. A. S. E. State Convention

The seventh annual convention of the Illinois State association of the National Association of Stationary Engineers was held at Ottawa, Ill., May 19 and 20. After opening with prayer by Rev. W. G. Irish, Mayor Bradford spoke briefly to the delegates and W. H. Miller, also of Ottawa, delivered a cordial address of welcome. Response was made by F. W. Raven, national secretary.

John W. Lane, in speaking of the National Association of Stationary Engineers, made the suggestion that the State educational committee make an effort to get into closer touch with the University of Illinois at Urbana, and possibly hold, during the coming fall and winter, a session at the university, devoted to the practical problems which the operating engineer is meeting in his everyday practice.

E. P. Gould, secretary of the Central States Exhibitors Association, read a paper at the opening exercises in which he outlined methods by which the exhibitors and engineers could cooperate to the benefit of all.

At the Friday afternoon session Prof. K. G. Smith, of the University of Wisconsin, gave a talk on "Smoke and Smoke Prevention," in which he explained the fundamental laws of combustion and illustrated, by means of a kerosene lamp, how such laws must be observed to get good results. The proportions of oxygen and nitrogen in the air were taken up with reference to their effect on the carbon, hydrogen and sulphur in the fuel, the chemical problem involved being treated in an unusually clear and simple manner.

In speaking of developments in the burning of coal under boilers, Professor Smith told of a new practice in Europe, where a chain-grate stoker is being used under a marine-type Babcock & Wilcox boiler, with a stationary hand-fired grate located at the back end of the boiler in such a manner that on heavy loads the unburned fuel from the stoker will fall onto the stationary grate and burn; meanwhile the auxiliary grate can be stoked by hand if it becomes necessary, to carry the load.

Another subject of interest touched on by the speaker, was the problem of burning low-grade fuel in pulverized form. In an improved form, as introduced in Europe, the process consists of blowing the fuel upward into the furnace from the center of the grate, under a brick arch. It is claimed that by this method better combustion has been obtained and that boiler and furnace efficiencies from 76 to 82 per cent. are being realized.

W. F. Mozler, principal of the Ottawa high school, addressed the convention at the Saturday afternoon meeting, his subject being "A Practical Education." The professor spoke from experience in educating the young in the practical things of life and offered many suggestions as to how they could be guided in making a proper choice of their life work. Following Professor Mozler, W. A. Converse, of the Dearborn Drug and Chemical Company, gave an interesting talk on "The Purification of Boiler Feed Water," illustrating the important points with actual demonstrations, using chemical apparatus specially set up for the occasion.

Ex-Mayor J. T. Farrell wound up the exercises with a spirited talk entitled "What I Know about Engineering," which was well received.

One of the pleasing events of the program was the presentation to No. 6, of Peoria, of a handsome blackboard, for the highest honors in the State educational contest, the winning grade being 94.3 per cent. The convention indorsed John F. McGrath, of Chicago, for national vice-president.

Officers for the following year were elected as follows:

John F. Alt, of Ottawa No. 10, president; John R. Moore, of Chicago No. 1, vice-president, and W. E. Hill, of Moline No. 17, reëlected secretary-treasurer. Place and date of the next convention were left subject to the call of the incoming officers.

The following firms exhibited: American Steam Pump Company, Battle Creek, Mich.; V. D. Anderson Company, Cleveland, O.; George B. Carpenter Company, Chicago, Ill.; Centralene Oil Company, Chicago Heights, Ill.; Crandall Packing Company, Palmyra, N. Y.; G. M. Davis Regulator Company, Chicago, Ill.; Dearborn Drug and Chemical Company, Chicago, Ill.; Garlock Packing Company, Palmyra, N. Y.; General Specialty Company, Buffalo, N. Y.; Greene, Tweed & Co., New York; Harrisburg Foundry and Machine Works, Harrisburg, Penn.; Hawkeye Boiler Compound Company, Chicago, Ill.; Hills-McCanna Pump Company, Chicago, Ill.; Jenkins Brothers, New York; H. W. Johns-Manville Company, New York; Keystone Lubricating Company, Philadelphia, Penn.; George W. Lord Boiler Compound Company, Philadelphia, Penn.; Lunkenheimer Company, Cincinnati, O.; Lyons Boiler Works, De Pere, Wis.; McMaster-Carr Supply Company, Chicago, Ill.; *National Engineer*, Chicago, Ill.; Osborne High Pressure Joint and Valve Company, Chicago, Ill.; Peerless Rubber Manufacturing Company, New York; POWER, New York; *Practical Engineer*, Chicago, Ill.; John Roebling Sons' Company, New York and Sullivan Oil Company, Chicago, Ill.

VISITORS AND DELEGATES TO THE ILLINOIS STATE CONVENTION, N. A. S. E.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

Have you ever noticed that in the famous Greek statue of the Discus Thrower the athlete stands with his right foot forward, ready to hurl the discus?

For centuries the Greeks had thrown it this way—it was a custom, a tradition of their favorite national sport.

No one had ever stopped to think whether or not there was a better way of doing it.

But, in the 20th century—when discus throwing was more than 2000 years old—Martin Sheridan, the American athlete, went to Greece for the Olympian Games and entered the discus event for about the first time in his life.

He grasped the missile and threw it in the *natural* way, with his *left* foot forward, and in one throw smashed not only the ancient Greek custom but also the world's record.

In this little tale there are several morals.

The men who have accomplished things and gotten ahead of their fellows are nearly always the ones who have had the nerve and the brains to break with old traditions and customs.

In these modern times there have arisen newer, better methods of doing things—in the power plant as elsewhere.

And the man who puts his *best* foot forward, no matter what *custom* has decreed, is the man who will make new records and get farther ahead in his profession.

That most engineers realize this is proved by the fact that most engineers nowadays read the ads. in their technical paper.

They know that the *newer*, *better* ways to do the old things are *advertised* —and they follow those ads. conscientiously, and profit thereby.

The engineer who reads the Selling Section of POWER these days is the man who is putting his best foot forward in the double-quick march of Progress.

Are you one of them?

POWER

NEW YORK, JUNE 6, 1911

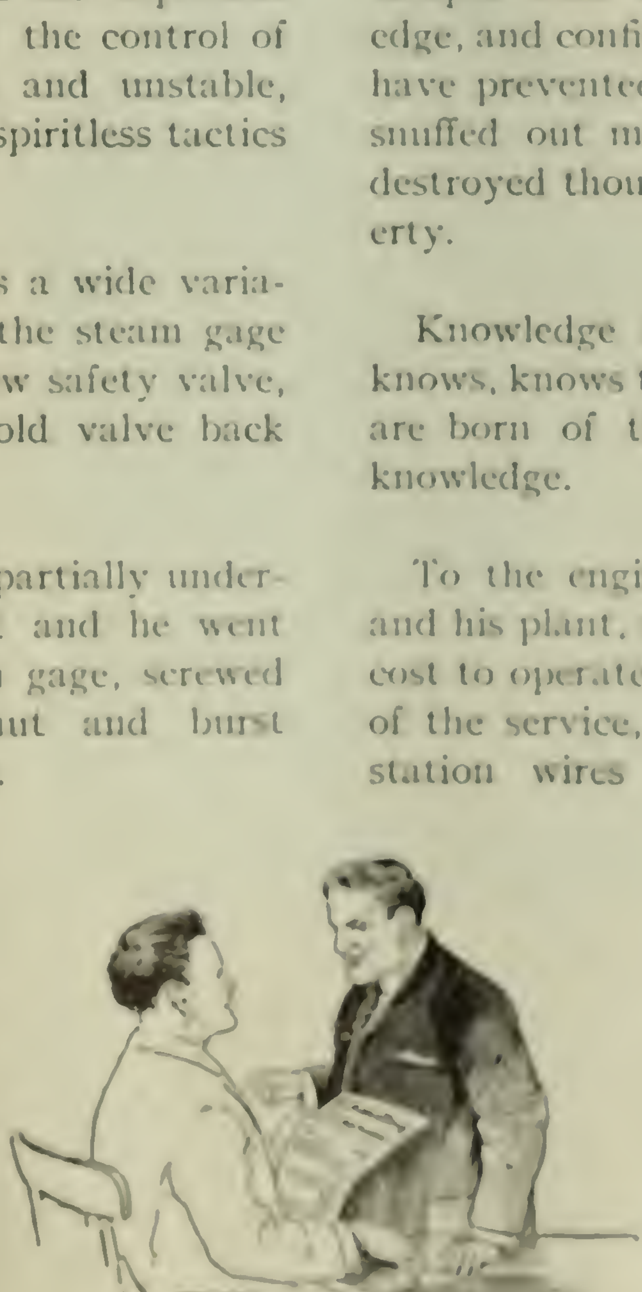
PROBABLY few engineers realize the influence that the mental attitude has upon their conditions and surroundings. It is said that shortly before Jeffries met Johnson in the ring he remarked that he wished it was over.

He went into the contest with a fear in his heart that dimmed his eye and depressed his spirit. His body, under the control of an unsound mind, was infirm and unstable, and his ineffective blows and spiritless tactics brought on certain defeat.

After seeing that there was a wide variation between the reading of the steam gage and the blowing point of a new safety valve, an engineer wished for the old valve back on the boiler.

Fear of something he only partially understood impaired his judgment and he went wrong. He trusted the steam gage, screwed down on the valve-spring nut and burst the boiler with over pressure.

While it matters little which of two pugilists has the heavier punch or can stand the more severe punishment, the lesson, by the result of the mental attitude of men at critical moments, is rich in the possibilities of its teachings.



Johnson knew and had the confidence that knowledge begets. Jeffries did not know. To him the result was a matter of doubt and he failed; not because of inferior physique and agility, but because doubt and fear lodged where only knowledge and confidence should rest.

Doubt and ignorance led the engineer to tamper with the safety valve when knowledge, and confidence in that knowledge, would have prevented a disastrous explosion which snuffed out more than a score of lives and destroyed thousands of dollars worth of property.

Knowledge is power, and the man who knows, knows that he knows, and his decisions are born of the confidence based on that knowledge.

To the engineer who knows his vocation and his plant, what it will do and what it will cost to operate it under the varying demands of the service, has no fear that the central-station wires will furnish the energy that makes the wheels go around in his plant.

It is the man who does not know who fears this competition and the one who will get the "wallop" in the first round, while he who knows and shows that he knows, will win "hands down" both as an engineer and as a man.

A Really Low-Pressure Turbine

By Henry F. Schmidt

A turbine designed to operate between an admission pressure of 2 1-2 pounds absolute and an exhaust pressure of 1 pound absolute. On a test this machine showed a Rankine efficiency of 52 per cent.

Much has been written about low-pressure turbines, that is, turbines taking steam at a pressure equal to or lower than that of the atmosphere, and also of the great increase in economy gained by the use of a high vacuum on high-pressure condensing turbines. Attempts have been made to show by diagrams that the amount of energy available in a pound of steam expanded from atmospheric pressure to a 29-inch vacuum is approximately equal to the energy available by expanding from a pressure

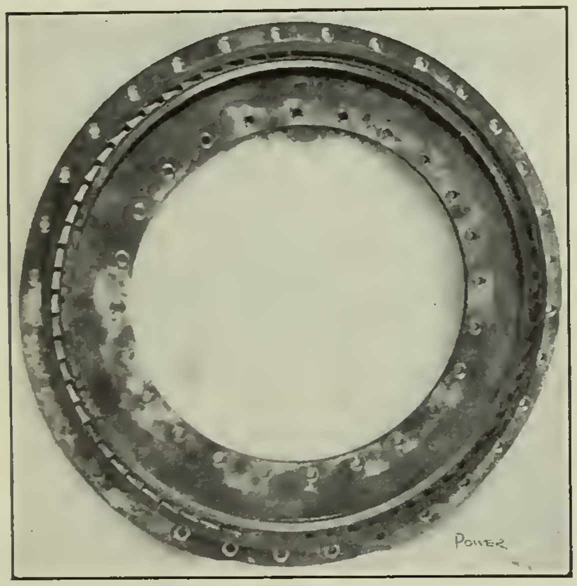


Fig. 1. Nozzle Block

of 150 pounds absolute to atmospheric pressure. Likewise, the statement has been made repeatedly that a large proportion of this available energy is lost in the low-pressure cylinder of a reciprocating engine because release occurs before complete expansion has taken place.

So far, however, it has been necessary to trust almost wholly to theory, and for the benefit of those who are not yet convinced of the soundness of the theory, some tests and details are presented of a turbine designed to develop 20 brake horsepower when supplied with steam at 2½ pounds absolute pressure and exhausting into a condenser maintaining a pressure of one pound absolute.

This turbine is of the impulse type, having all the energy available in the steam converted into kinetic form in the nozzles. There are two "velocity drops"; that is, the steam first traverses one row of moving blades and then enters reversing chambers where it is redirected into a second row of moving blades without a drop of pressure.

As shown in the view of the nozzle block, Fig. 1, the turbine is of the total-admission type; that is, it takes steam around the entire circumference. The steam after leaving the nozzles enters the inner row of blades of the rotating wheel, shown in Fig. 2, and after having passed through the inner row enters the inner row of passages of the reversing chamber shown in Fig. 3. The steam passes through the reversing chamber and leaves it at the outer openings, reëntering the rotor and passing through the outer row

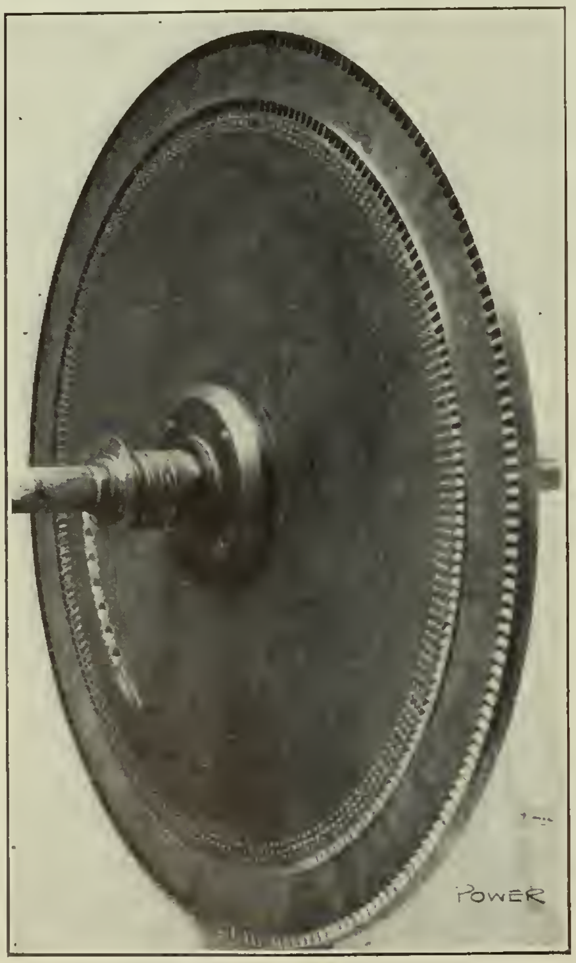


Fig. 2. Wheel Disk

of blades, after which it passes to the condenser. This path of the steam can be understood better by reference to the cross-section in Fig. 4, in which *A* is the steam inlet; *B* is the steam chest extending completely around the turbine; *C* is one of the nozzles; *D* the inner row of blades; *E* the reversing passage; *F* the outer row of blades and *G* the exhaust ports. Two exhaust ports were provided, as this was an experimental machine, and it was desired to note the effect of taking steam away at different points. The nozzle block, shown in Fig. 1, is represented by *H* in Fig. 4, and *I* is the reversing chamber, shown in Fig. 3.

Construction

The bearings are of the standard babbitted type with ring oilers, and the glands, to prevent the leakage of air into the cylinder, are of the snap-ring type and water sealed. Water guards *J J* are fitted to prevent any water escaping from the glands and getting into the oil.

Fig. 2 shows clearly the way in which the blades are attached to the disk. A groove is turned in the disk and the shank of the blades inserted, the latter being secured in place by three Stubb's steel pins driven in and riveted over. This has proved a very satisfactory fastening, and is easily made and very strong, as is shown by the fact that this turbine was run at blade speeds in excess of 600 feet per second without any ill effects, in spite of the fact that the blades are unusually heavy. Furthermore, the construction readily permits the replacement of blades which may become damaged, only a few minutes being required to replace a blade.

A point in design which may be criticized is the fact that the turbine is not split horizontally, which fact makes assembling difficult, as it requires uncoupling and drawing off the turbine half of the coupling before the rotor can be removed. The reason for employing this rather undesirable type of construction was because splitting the turbine along the horizontal joint would have involved a rather complicated construction to in-

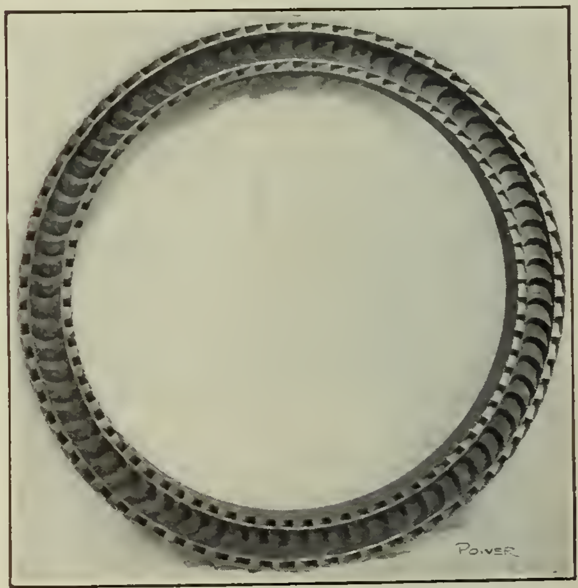


Fig. 3. Reversing Chamber

sure steam and air tightness—which, in this case, is of the utmost importance. It will be noted that there is but one joint which can leak air into the exhaust chamber, and as these surfaces are bored and turned, a tight joint was easily obtained.

The side clearances are approximately 1/16 inch and the radial clearances are very large. As a matter of fact, the longitudinal clearances are far greater than they should have been, as 10/1000 is ample clearance in a turbine of this capacity, and smaller clearances would have shown better economies than were obtained.

As there was no governor designed for this turbine, an automatic stop valve was fitted, which consisted of the usual overspeed tripping device and a 2-inch vacuum breaker, which, as the inlet pressure to the turbine was always below atmospheric pressure, would shut down the turbine before it could reach a dangerous speed.

The turbine glands were supplied with water from a barrel by the pump *G*, which delivered it to the pipe *E*. In order to maintain a constant water pressure in the glands, an overflow pipe *I* was fitted and drained any excess water back into the supply barrel.

As the glands were not perfectly tight, all the leakage to the outside was caught and returned to the barrel by the pipe *F*. By this arrangement no gland water was lost outside of the turbine, as all the water which was necessary to maintain the original level in the supply barrel must have passed into the condenser where it was weighed with the condensed steam and was, therefore, subtracted from the condensation. The supply barrel was fed from another barrel above it mounted on platform scales.

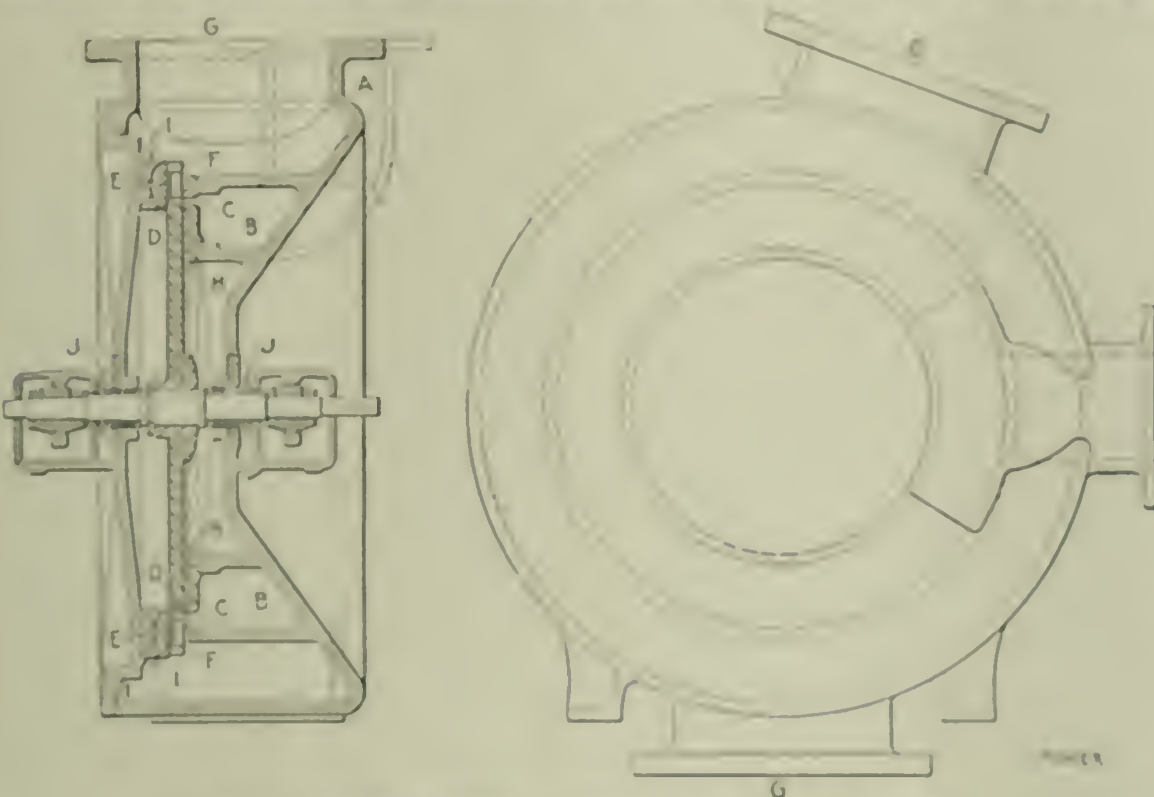


Fig. 4. Section through Turbine and End Elevation

Test Arrangements

As shown in Fig. 5, which represents the turbine ready for testing, the power developed was absorbed by a small water brake *D*. The load on the brake was measured on calibrated platform scales and water was supplied through the pipes *H H*, fitted with valves to control the brake resistance.

The inlet pressure was measured by the mercury column *B* and the steam temperature by means of the thermometer *C*, which was graduated to read to one-half a degree. The vacuum in the turbine exhaust was measured by the mercury column *A*, and the variation of speed between observations with a speed counter was observed by means of a tachometer. As it was necessary to throttle the steam supply from 150 pounds to a 25-inch vacuum, a water jet was fed into the steam line in front of the throttle to keep the steam saturated and prevent the superheating which the wiredrawing would otherwise have caused.

The steam was condensed in a surface condenser and the water weighed in tanks on platform scales, the weight being checked every five minutes.

Fig. 5. Turbine Ready for Testing

Results of Test

Although the turbine was designed to operate between 2½ pounds absolute and one pound absolute, the tests were carried over a considerable range, and the power developed varied from friction load to nearly 500 horsepower. One of the most astonishing results was the operation at friction load, 2250 revolutions per minute being attained with a pressure difference of ½ inch of mercury between the steam inlet and the exhaust, and 1400 revolutions per minute with a difference in pressure less than 1/10 inch of mercury, measured by a U-tube connected between the inlet and exhaust chambers. The latter was with nearly a 29-inch vacuum in the exhaust, but even at that low pressure 1/10 inch of mercury pressure difference theoretically gives up only about 4 B.t.u. per pound of steam, corresponding to a steam velocity of about 448 feet per second.

In Figs. 6 and 7 the horsepower, total water per hour and water rates have been plotted against the absolute inlet pressure. If all the test observations are correct, the curves of horsepower and total water per hour should be straight lines, as each varies as a straight-line function of the absolute inlet pressure. The closeness with which the actual test points fall upon a straight line shows the accuracy of these tests, as all the points shown are taken from the actual tests without any corrections of any sort whatever.

In Fig. 8 are shown the results with various inlet pressures up to 13 pounds absolute and with a vacuum of approximately 28½ inches referred to a 30-inch barometer. As will be noted from the water-rate curve, at 2½ pounds absolute the turbine consumed but 69 pounds of steam per brake horsepower, or 56 pounds less than the guarantee of 125 pounds per brake horsepower.

The curve marked "efficiency" is for the Rankine cycle, or the ratio of the brake horsepower developed to that theoretically available for the given inlet and exhaust pressures. Also the B.t.u. theoretically available has been plotted against the absolute inlet pressures.

The efficiency curve first rises and reaches a maximum at about the inlet pressure for which the turbine was designed, and then gradually decreases. The reason for the increase in efficiency at first is due to the friction load becoming a smaller proportion of the total power developed, and the decrease in efficiency beyond 3 pounds absolute is due to the fact that the nozzles were designed only for the pressure range of 2½ to 1 pound absolute, and have not sufficient divergence to efficiently handle the higher pressure ranges. This will be further observed from the tests shown in Fig. 7 with 26- and 27-inch vacuums. In these tests the point of maximum efficiency has shifted to higher inlet pressures, but occurs at approximately the same B.t.u. range as during the tests at 28¼-inch vacuum.

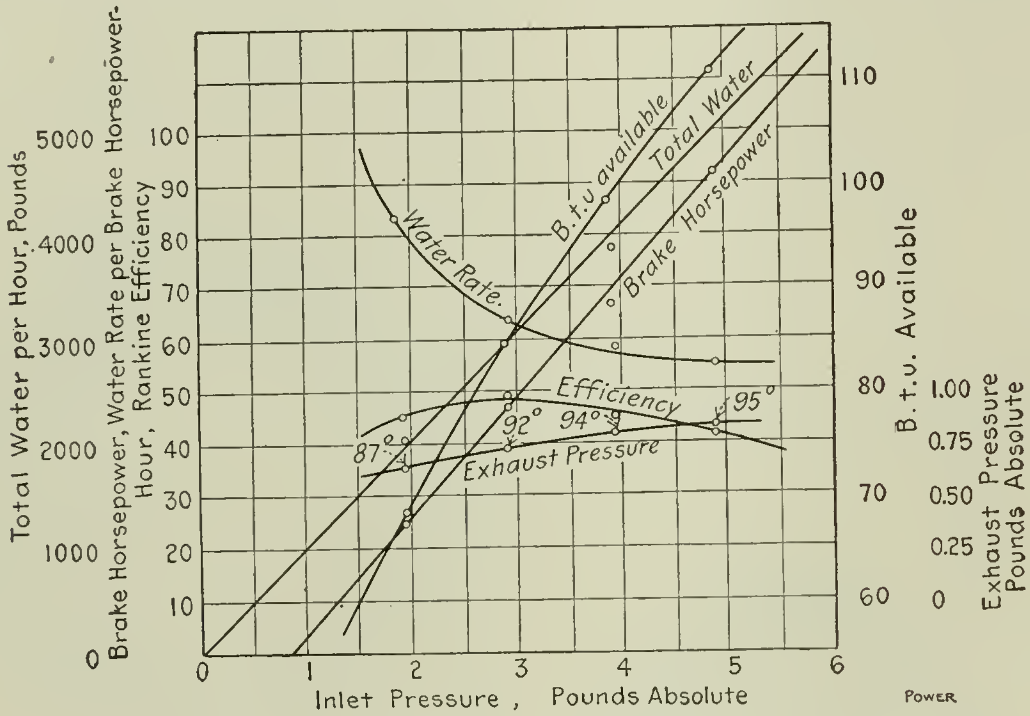


Fig. 6. Performance with High Vacuum

Conclusions

There are several points of interest shown by these tests which, though they have been known in a general way, have never before, to the writer's knowledge, been proved in the same conclusive manner as by the tests on this small turbine.

Looking at the test results the reader should not confine himself to the water rates per brake horsepower-hour, but should observe rather the Rankine efficiency, which, after all, is the only true criterion. Low water rates can easily be obtained even with a poor machine, if the operating conditions are made favorable. The actual measure of the value of a machine, however, is not its output but the proportion of the output to the maximum obtainable.

The maximum Rankine efficiency obtained was 52 per cent., and varied from this figure down to as low as 42 per cent. under extreme operating conditions. In tests on a number of high-pressure noncondensing turbines of exactly similar design and under varying conditions, the highest Rankine cycle efficiency ever obtained was 48 per cent. This shows that steam expanded at even the lowest pressures can be utilized in a steam turbine not only as efficiently but more efficiently than high-pressure steam.

However, the writer does not wish to be understood to have made the statement that in every case low-pressure steam is as efficient or nearly as efficient as steam at a moderate pressure, for there are conditions which arise where for practical purposes it is impossible to establish those necessary points in design to accomplish the best results. The tests do prove, however, that any degree of efficiency which can be obtained with high-pressure steam cannot only be duplicated with low-pressure steam but can be exceeded. Hence, it is only fair to say that while the turbine tested was not of a high efficiency, turbines of the Parsons or reaction type can be built, which over the same range would develop a Rankine efficiency of 75 per cent., or better.

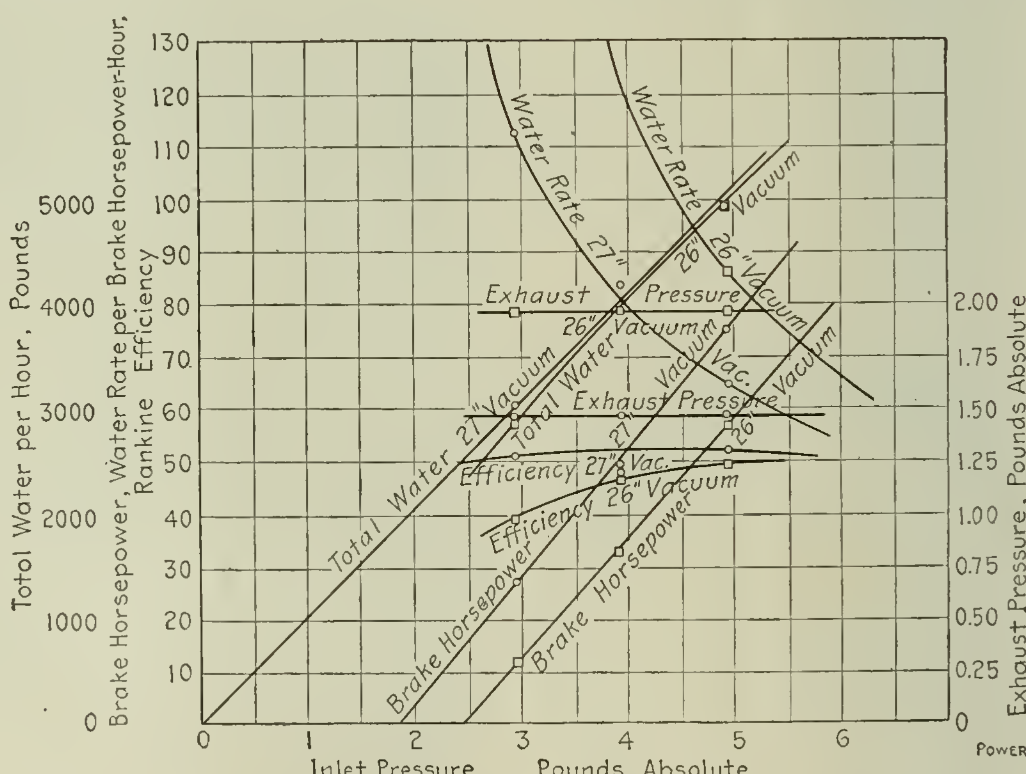


Fig. 7. Performance with 26- and 27-inch Vacuum

A Lentz Engine on the Pacific Coast

Due to the construction of an annex for the Hotel Alexandria, the leading hotel of Los Angeles, Cal., extensive additions are being made to the power plant thereof. The plant will contain six Stirling boilers of 1100 horsepower total rated capacity. Provision will be made for 700 additional boiler horsepower.

The present electrical generating equipment consists of one 150- and one 250-kilowatt Bullock dynamos, each driven by a Skinner compound automatic engine. To this will be added one 300-kilowatt Fort Wayne dynamo to be driven by a Lentz type poppet-valve engine built by the Erie City Iron Works. This is the first engine of its type to be installed in this country west of Chicago.

The refrigerating plant will remain unaltered. There are a Stevens compressor of 20 tons capacity, driven by an electric motor, and a Vulcan Iron Works compressor of 55 tons capacity, driven by a steam engine.

The hotel is equipped with hydraulic elevators which are operated by a 5,000,000-gallon Monarch pumping engine built by the H. N. Strait Company.

A complete description of this interesting plant will be published as soon as possible after the finishing touches have been made.

The Value of Flue Gas Analysis*

By Joseph W. Hays

How the fireman can be interested in the subject of combustion and flue-gas analysis without resorting to any chemical terms, whatever. The disadvantage of too much air is shown and hints are given as to taking samples.

Fuel is the largest single item of expense in almost every steam-power plant. The fuel is often purchased without reference to or a check upon its potential heat value, and is burned, almost invariably, with an utter disregard for economy. The fireman is provided with a shovel and allowed to have his own way with the coal pile. If he can throw coal straight enough for it to pass through the door and keep up steam, he is a good fellow. No attempt is made to instruct him. No check is kept upon him. He shovels coal in the same way that he is permitted to worship in this country, "according to the dictates of his conscience," and as a result wastes from 20 to 60 cents every time he puts a dollar's worth of coal in the furnace.

In order to insure the highest possible furnace efficiency it is necessary that the engineer or some other responsible person should first ascertain the correct method of furnace operation. No rules can be laid down that will apply to all plants except in a general way. Every plant and, to a certain extent, every boiler, is a problem in itself. The engineer, before he undertakes to instruct the fireman, must see to it that the boiler settings are tight and the dampers in order. He must learn what draft should be employed for the best results, how thick the fires should be carried and various other things of importance.

When the engineer knows his boiler furnaces and exactly how they should be managed to secure the best economy, the next step is to make sure that the fireman will follow instructions. This is where the real difficulty comes in, but the problem is an easy one if it is approached from the right direction.

The fireman should have explained to him what the engineer is striving to accomplish; he must be shown how the furnaces should be operated and what arrangements have been made to keep a check upon him. Say to him: "Do this and do that and you will get all of the steam possible out of every pound of fuel. If you do not operate the furnaces according to these instructions, we shall know it, and we intend to find out who the best firemen are in this boiler house."

The fireman will exert himself to secure results when he knows there is a continuous and reliable check upon him. His efforts will be redoubled when he discovers that he is in competition with every other operative in the furnace room; that it is a free-for-all race to discover who is the best man. This is only natural, and the man who says that he cannot handle firemen admits that he does not understand human nature. Place the thing upon the basis of a sporting proposition and the firemen will do the rest.

*From a paper read before the Ohio Society of Mechanical, Electrical and Steam Engineers, at Youngstown, Ohio, May 18, 1911.

The average engineer is frightened when the subject of engineering chemistry is suggested. He has never studied the science. He is too old and perhaps lacks the education necessary to tackle it. Chemistry is impossible so far as he is concerned; therefore, how can he expect to apply the science in his boiler house and reap some of the economics he has been reading about? The chemistry that the engineer ought to know, however, involves very little special knowledge. The most ordinary fireman can understand all that any practical man need know about it.

Suppose "Mike" is just an ordinary, everyday fireman; CO_2 could not be beaten into him in a thousand years, but he can be filled with chemistry without reference to a chemical formula. He is discovered in the act of throwing coal into the boiler furnace, and it will be noticed that he is careful to close the furnace door when he is through firing. Say to him: "'Mike,' why do you close the door when you are through throwing in the fuel? Why not leave it open? Why not take the door off and throw it on the scrap pile? Every time you close the door you have to open it again. This takes time and means work and might burn your fingers."

"Mike" is astonished and proceeds to deliver a lecture on economical furnace operation. He says: "Do you see that steam gage up there? Well, it is my business to keep the arrow pointing at 100 pounds. How long do you think I could hold steam if I left the fire door open? The cold air would rush in and cool off the boiler." Thus he gives, offhand, the greatest of all causes of fuel waste—excess air. When asked if it makes any difference where the excess air enters, he cannot see that it does, and his attention is called to a bare spot a foot and a half square over in the southwest corner. He is shown cracks in the fuel bed where the coal has coked and broken open in fissures. These bare places and cracks are letting fully as much air into the furnace as could possibly pass through the open fire door. Then the engineer in charge is called. He is asked if the boiler settings are tight and free from leaks. He is quite sure that they are. A candle is procured and it is found that the setting is leaking like a sieve; that there are a hundred openings big and little where the flame is drawn in. The suction at some of these holes is strong enough to snuff out the candle. The plates about the blowholes and clean-out doors are loose. In many places it is possible to insert the fingers. If it be a return-tubular boiler, a hole of several inches area may be found around the blowoff pipe, if it be a water-tube boiler, air leaks about the headers.

How much attention do the dampers get in the average plant? Is there any pretense whatever to any kind of damper regulation? There are steam boilers that are not equipped with dampers at all. Not one steam plant in five will shift its dampers a hair's breadth during the entire day's run. Not one steam plant in fifty is supplied with a proper draft gage. Not one plant in a hundred that has such a gage makes a proper use of it. Managers and owners are always complaining about the coal consumption. It is too high. They wonder where the trouble is located.

The boiler damper stands in the same relation to the furnace that the cutoff valve occupies to the engine. The one is intended to adjust the rate of coal consumption to the steam demands upon the boiler, the other to suit the rate of steam consumption to the power demands upon the engine. If steam is wasted at the engine, the money loss is not measured by the wasted steam but by the coal that was burned to generate this steam. It is a question of fuel loss, first, last and always.

In every properly designed power plant an excess of draft is provided for, in order that there may be sufficient coal-burning capacity to take care of all future loads and all probable increase in the power demands.

Excess air will do more to lower efficiency than any other known agent. Such excess should not exceed 40 per cent., but as the average plant is operated it is found in the neighborhood of 200 per cent. Enough air flows through the furnace of the average boiler to keep nearly three such boilers going under the conditions of good furnace practice. The preventable waste occasioned by such excess air is about 15 per cent. of the fuel.

When the air supply is insufficient, combustion will be incomplete and the waste due to this cause may run as high as 15 per cent. of the fuel. Most steam plants suffer from both excess air and incomplete combustion. The losses due to the first mentioned cause, however, are usually about 10 times those due to the latter.

When the draft pressure is increased the time allowed the air to work its way through the fuel bed and act upon the coal is decreased. Excess air accordingly finds its way into the furnace chamber. If the fuel bed is thin, the volume of such air excess is multiplied, and if there are cracks or "rat holes" in the fire there is another multiplication. When the draft is increased the suction is multiplied at every crack and fissure leading into the furnace and the gas passages of the boiler.

Increased draft usually means an increase in the temperature of the escaping gases. It also means an increase in the volume of the gases flowing up the chimney in a unit interval of time. When the gases are diluted and the dilution is followed by raising the temperature of the escaping mixture, there is employed the most effective method that has ever been discovered to increase the coal bills.

If coal is to be burned economically, the draft must be maintained in proper relation to the load and to the fuel in the furnace. If the dampers are manually operated, only an approximation can be expected of correct draft conditions, because, to have correct draft continuously, the damper must be kept continuously on the move in order to compensate for the several variables referred to.

There are a number of good damper regulators on the market, but there are also a great many poor ones, and a poor regulator may be worse than no machine at all. Automatic damper regulators may be divided into two classes for the purposes of this discussion: First, the machines that swing the damper from the wide-open position to the closed one when the pressure rises, and back again from the closed position to the wide-open one when the pressure falls; second, the machines that maintain the damper in such intermediate positions as the varying conditions of load may call for.

Machines of the first class may produce a perfect steam line on the gage chart, but they may and often do obtain uniform pressure at the expense of economy; whereas, machines of the second class will secure economy, and uniform pressure will follow in the wake of economy.

Regulators of the first class operate the dampers as follows: Assume the machine to be adjusted to hold the pressure at an even 100 pounds. The pressure rises slightly above this point and the machine immediately closes the damper and shuts off the draft. Combustion is interfered with because the furnace is now receiving insufficient air, and the pressure falls. This would be well enough were it not for the fact that insufficient air means incomplete combustion and a loss of 10,000 B.t.u. for every pound of carbon converted to CO. If, on the other hand, the pressure should fall below 100 pounds, the damper is thrown wide open. The furnace gets practically no air at all when the damper is closed and all the air that the chimney can pull through it when the damper is open. The machine provides the furnace one minute with a feast of air and the next minute with a famine.

Regulators of the second class keep the damper continuously on the move, shifting its position in one direction or the other with every little variation of steam pressure.

There is one particular in which practically all damper regulators fail, by reason of the fact that the machines, whether they come under the first or the second classification, are governed by the steam pressure. When the fireman opens the fire door, cold air enters, chilling the furnace and the boiler, and causing the pressure to fall. This blast of cold air reduces the furnace temperature, and the temperature drops all along the line between the furnace door and the top of the chimney. When the door is closed the temperature rises again rapidly. This means expansion and contraction, which is bad for both the boiler and the setting, causing cracks in the brickwork and leaks in the boiler. It also means a loss of fuel, because coal must be burned to restore the furnace again to its normal temperature.

When the furnace doors are opened the damper should be closed. Damper regulators usually do the wrong thing under such circumstances; they throw the damper wide open. They do this because they are governed by the steam pressure.

There are four ways in which the furnace and the fireman can waste coal:

1. A large portion of the heat energy generated may be nullified by excess air. Combustion may be complete to the last atom of the combustible, and yet, if the gases are cooled off as fast as manufactured they will be of little use to the boiler.

2. Combustion may be incomplete. In such cases a portion of the fuel passes up the furnace in an unconverted condition. Smoke usually accompanies incomplete combustion, but not necessarily and not always. There may be a great deal of smoke and very little combustible matter in the gases or there may be no smoke at all and a great deal of combustible.

3. Much fuel may be, and some fuel always is, lost with the ash and clinker. These losses are often the fault of the grate.

4. More or less heat will be radiated from the furnace and some loss of this kind is unavoidable. The only remedy is insulation so far as it can be applied to the furnace and boiler setting.

No one can look at a furnace and say exactly how near to or how far from the highest attainable economy it may be performing. With a flue-gas analysis instrument the efficiency of the furnace can at once be determined, and if coal is being wasted the cause of the loss is ascertained and steps may be taken to correct it. No other apparatus can be substituted for the gas-analysis instrument in this sort of an investigation, because nothing can be said about furnace efficiency until all is known about the quality of the escaping gases; it is these gases alone that can tell the percentage of excess air being heated and the proportion of combustible matter discarded to the chimney.

The gas-analysis instrument tells exactly what is taking place in the boiler furnace and with all of the certainty that the steam-engine indicator reports upon conditions inside the engine cylinder.

Anybody can understand and operate an engineer's gas-analysis instrument. Ordinary firemen can work it. No knowledge of chemistry, whatever, is required. Any man with sense enough to read a scale can make a perfectly correct analysis of the flue gases.

It may be explained to the fireman that the matter of cold air should be further investigated, and that here is a machine that tells all about it. It has a tube with a scale etched on it like a thermometer glass. The tube is filled with chimney gas until the water goes down to the zero mark. Then the gas is passed over into this other compartment which is filled with lye. The lye soaks up all of the coal gas and leaves nothing but air. When the soaking operation has been accomplished, the scale is read. It ought to register 14 or 15 per cent. coal gas and about 85 per cent. air. The more gas found, the less air heated, and *vice versa*. The fireman is interested; this is something he can understand, and in 15 minutes he is actually working the gas-analysis instrument like an expert. If any permanent and substantial benefit is to be derived from flue-gas analysis it is necessary that all of the firemen in the plant should be interested. Place a bonus on efficiency. This will bring the men into line if nothing else will. The results are most gratifying when the men know what the work means. It is important that the business of checking up the furnaces and the firemen should be made a part of the daily routine.

If the flue gases show around 14 per cent. CO_2 and no CO, the furnace and the firemen are doing all that can be expected of them. The percentage of CO_2 can be determined in one minute and the percentage of CO in five minutes. The percentage of CO_2 is a recognized measure of the volume of excess air.

The difference in economy between 14 and 10 per cent. CO_2 is around 5 per cent. of the fuel; between 14 and 5 per cent. CO_2, 23 per cent. of the fuel; and between 14 and 2 per cent. CO_2, 75 per cent. of the fuel. Furnaces have been worked with less than 2 per cent. CO_2.

The benefits that come from the use of gas-analysis apparatus in the boiler room are twofold:

1. The apparatus, as already stated, diagnoses the case of the boiler furnace for the engineer.

2. The apparatus keeps a check on the firemen and turns in a report at the end of the day on each one of them. If the CO_2 results are posted daily where the men can see them and a summary of the results at the end of the month, the firemen will do the rest and the fuel bills will go down as the percentages of CO_2 come up. The bonus system has been tried with good results in a number of large power plants. Pay the firemen a premium for high CO_2 averages. The company can afford to give the fireman an extra dollar when he is saving ten. It is in the nature of every man to be more attentive to business when he is under inspection.

There are hundreds of CO_2 recorders standing unused in the dark corners of power plants. The trouble was not with the machines but with the people who bought them and the others who sold them. It is one thing to possess a recorder; it is another thing to make proper use of the apparatus after its purchase.

In a large power plant equipped with four CO_2 recorders, the machines were registering from 4 to 6 per cent. of CO_2. The manager complained that there was nothing to be gained from using flue-gas analyzers; that his coal bills were just as heavy as they were before the recorders were installed. He produced a pile of charts and there was not a decent one among them. It was then pointed out to him that the business of a CO_2 recorder is to report conditions as they are and not as they ought to be. Every one of the charts was a protest against a preventable waste of nearly 25 per cent. of the fuel. Upon investigating the conditions it was discovered that the hoppers of some of the chain-grate stokers were running half empty. The fires were running short under all of the boilers. The settings were all in need of repairs. The cracks were so large in some places that the flames could be seen playing in the first passes of the boilers. The load could have easily been carried on two-thirds of the boilers and two-thirds of the coal.

It is one thing to attain high efficiency; it is another thing to maintain it. There is no apparatus that can compete with a good hand analysis set in searching out trouble and building up furnace efficiency. There is no instrument more efficient than a CO_2 recorder in maintaining efficiency after it has been attained.

In order to measure air leakage, gas must be simultaneously sampled from two places, the first pass of the boiler and the breeching. The leakage may be computed from the difference of the CO_2 content of the gases at these two places. The recording apparatus can only work at one place at a time. It is not practical, furthermore, to connect the recorder at any place but the uptake or breeching. Questions of temperature and mixture enter the problem when a permanent sampling tube is inserted into the gas passages of the boiler.

In checking up a boiler furnace it is necessary to identify each gas sample analyzed with observed furnace conditions. If the CO_2 is low there is a reason for it and the cause must be found. For example, a crack or a "rat hole" is noted in the fuel. To what extent is the air leak responsible? The engineer wants to know, and he wishes to give the fireman an object lesson. It takes one minute to get a sample of gas into the hand instrument and determine the percentage of CO_2. The volume of excess air flowing through this leak is measured. It is surprising to note the quantity of nullifying cold air for which the leak is responsible. The effect of covering the air leak is shown by the analysis. The fireman will be impressed and he will watch for these leaks in the future.

A patent has just been issued to Rosendo Ladron de Guevara, of Vera Cruz, Mex., for a boiler disincrustating compound consisting of 100 parts calcium oxide, 20 parts of pulverized baked clay, 15 parts of refined petroleum, 35 parts of the juice of agave leaves, one part of carbolic acid, two parts hydrochloric acid.

A Pair of Old Engines

By A. Heaton

The installation of a central power plant with electric transmission of power to the different buildings of the old plant of the Wheeler & Wilson Manufacturing Company at Bridgeport, Conn. (now the Singer Manufacturing Company's plant No. 10), has put a number of engines out of commission which have done good service in the past. The illustration shows the pair which drove the main machine shop, and which have just completed a run of 44 years and 3 months without being shut down during working hours to exceed a total of one and a half hours during the whole period.

They were built by the Pacific Iron Works, and had a fixed cutoff and throttling governor, but in 1882 the right-hand one was fitted with the Heaton automatic cutoff, which was illustrated in the September, 1880, issue of Power.

Engines after 44 Years of Service

The series of comparative cards shown in Houghtaling's book on "The Indicator and Its Appliances," which illustrates the difference in water consumption between automatic and throttling engines at the same load, was taken from this pair.

Both the speed of the engines and the boiler pressure have been increased twice during their term of service in order to meet the increasing demands for power, and, although laid off for the summer, they are still rated A 1 and are ready to be put into service in an emergency.

It is estimated that 250,000 electric flat irons were sold in the United States and Canada last year. There are more than 10,000,000 homes within central-station territory, of which fewer than 2,000,000 have electric service; consequently the estimated sales last year approximated one iron to every eight houses.

Flow of Water in Clean Iron Pipes

By Albert E. Guy

Concluding article of a series upon the development and use of the "alinement chart" as applied to the flow of water in pipes. The present chart gives the horsepowers equivalent to various quantities of water at different heads.

In the preceding articles of this series an attempt was made to show the resemblance between operations on a slide rule and those performed on a three-line diagram. The problems used as examples were rather crudely worked out, and the reader may conclude, after perusing the present article, that the order has been unduly reversed; that is, the theory should have been expounded first and followed by the examples. However, as the practical man is inclined to make light of "so called theory," it was deemed best to adopt the method used. With this as a basis the formulas may now be put into a more concise form, and their derivations explained.

In its simplest form the slide rule consists of two duplicate scales capable of being slid past one another. On each a given number is represented by its logarithmic length measured from the origin of the scale, marked "1," to the division representing the number. To multiply a number A by a number B, to the length $1 - A$ on one scale is added the length $1 - B$ on the other scale; the sum is read directly on the first scale, but the graduation of this scale is such that the reading recorded is exactly $A \times B$. Division is accomplished by subtracting one length from another.

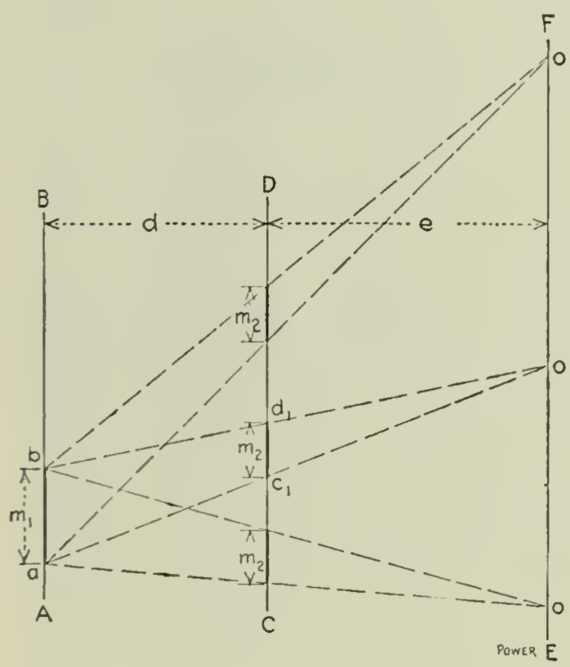


Fig. 7

Likewise, with three-line diagrams, multiplication or division is effected by the addition or subtraction of logarithmic lengths of numbers, but with these differences:

The number A is read on one scale, B on another, and the result C on a third scale. On the slide rule the logarithmic length of one number is the same on each scale, whereas on the diagram this length may be different on each of the scales. In short, a three-line diagram may be considered as composed of three specially constructed "slide-rule scales" properly spaced and set so that, by means of a straight-line index, an equation of the form

$$A x B y = C^z$$

may be solved at one reading.

In addition and subtraction, the quantities added or subtracted must be of the same kind. To satisfy this requirement, the scales of the diagram must be so located that the index, placed in any given position, will automatically reduce the large scale and increase the smaller, so that, as measured on the third scale, the logarithmic length spaced off on each will be that of the same number.

The scales $A B$, $C D$ and $E F$, Fig. 7, are parallel and fixed, and no matter how the triangle $a b o$ is placed, provided its base ($a b = m_1$) remains on the scale $A B$, and its vertex o on $E F$, the intercept ($c_1 d_1 = m_2$) will always be on scale $C D$ and its length will remain constant. The ratio $\frac{m_1}{m_2}$ is a constant and

$$\frac{m_1}{m_2} = \frac{d + e}{e}$$

In Fig. 8, the logarithmic length of the number 10 is m_1 for scale $A B$, m_2 for $C D$, and m_3 for $E F$. This length is called the *modulus*. It takes one modulus for the number 10, two moduli for 100, three for 1000, four for 10,000, and so on.

By joining point A to the point representing 10 on $E F$, and E to that representing 10 on $A B$, the two lines intersect precisely on the point representing 10 on $C D$. From this the relation between the three moduli can be obtained.

As in Fig. 7,

$$\frac{m_1}{m_2} = \frac{d + e}{e}, \text{ and } \frac{m_3}{m_2} = \frac{d + e}{d}, \frac{m_1}{m_3} = \frac{d}{e}$$

Whence,

$$d = e \frac{m_1}{m_3}$$

and

$$e = (d + e) \frac{m_2}{m_1} = \left(e \frac{m_1}{m_3} + e\right) \frac{m_2}{m_1} = e\, m_2 \left(\frac{1}{m_3} + \frac{1}{m_1}\right)$$

and

$$\frac{1}{m_1} + \frac{1}{m_3} = \frac{1}{m_2} \qquad (16)$$

From this

$$m_1 = \frac{m_2 m_3}{m_3 - m_2}$$

$$m_2 = \frac{m_1 m_3}{m_1 + m_3} \qquad (17)$$

$$m_3 = \frac{m_1 m_2}{m_1 - m_2}$$

The position of the scale is determined by equation

$$\frac{d}{e} = \frac{m_1}{m_3}$$

With these formulas the problem is entirely solved.

To test the correctness of the diagram thus established, join point 100 on $A B$ to point 10 on $E F$; also, 10 on $A B$ to 1000 on $E F$; the corresponding readings on $C D$ will be respectively

$1000 = 100 \times 10$ and $10{,}000 = 10 \times 1000$

From this it may be inferred that the product of any number on $A B$ by any number on $E F$ will be read on $C D$ with the degree of accuracy aimed at when the diagram was established.

As explained in the preceding articles, the products just obtained are the logarithmic sums as read on $C D$ of the parts spaced off on the other scales. Thus,

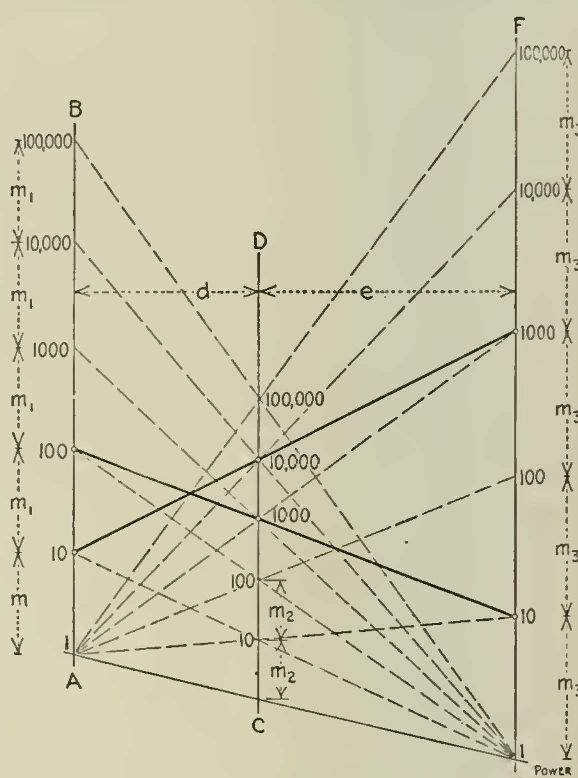


Fig. 8

$1000 = 2\, m_1$ (on $A B$) $+ m_3$ (on $E F$) $= 2\, m_2 + m_2$ (on $C D$)

and

$10{,}000 = m_1$ (on $A B$) $+ 3\, m_3$ (on $E F$) $= m_2 + 3\, m_2$ (on $C D$)

Usually the datum line $A E$ does not appear in a finished diagram.

The graduations of the scales will depend upon the equation represented and may be different from those of Fig. 8; for example, let the equation be

$$G = P^2 R^3$$

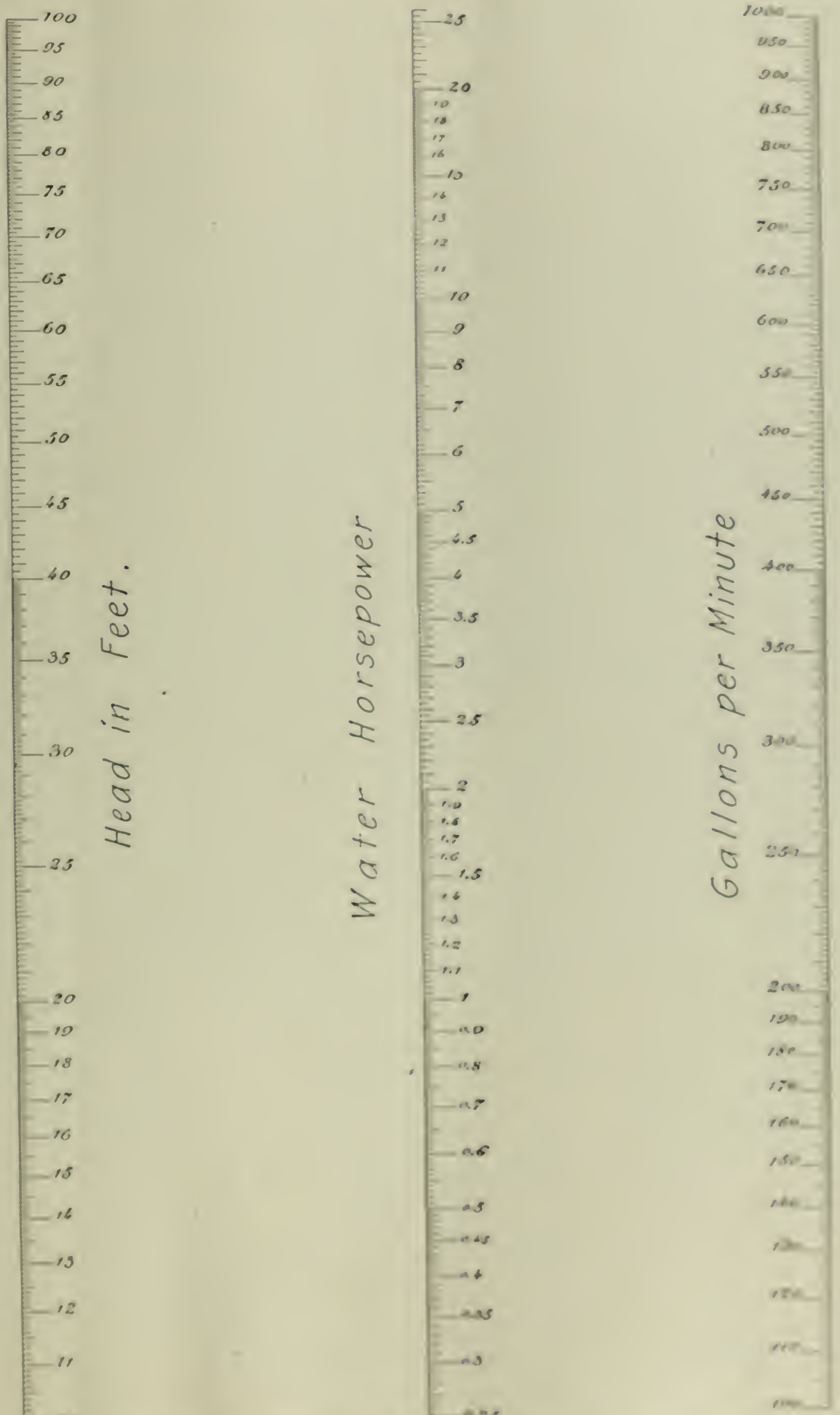


CHART NO. 3

If any two of the factors represented by the scales are known, the third may be found by drawing a straight line through their positions on their respective scales. The line will intersect the third scale at the number representing the desired factor.

the value P being read on $A B$, R on $E F$ and G on $C D$. Selecting, for example, a value of the equation where P equals 12 and R equals 8,

$$G = \overline{12}^2 \times \overline{8}^3 = 144 \times 512$$

In order to find the value of G it would be necessary to join point 144 on $A B$ to point 512 on $E F$ by a straight line cutting $C D$ precisely at G. But these numbers, 144 and 512, are not at hand, and it is precisely for the purpose of saving the trouble of figuring them and the more difficult task of reading them accurately on the scale that the whole diagram is established. Hence, the scale of R should be made with a modulus M_3, such that when a number as R (= 10) is used, although this point on the scale would read only 10, it would correspond to a value of $\overline{10}^3$ or 1000. And, although it might be stated that the modulus of R is M_3, this being equivalent to the logarithmic length of the number 10, at the same time it would be well understood to equal three times the length of m_3, because on scale $E F$, 1000 equals $3\,m_3$. Likewise, the modulus of P, on $A B$, would be M_1 (equal to $2\,m_1$) because on $A B$ when P equals 10 or M_1; in reality it represents

$$P^2 = \overline{10}^2 = 2\,m_1$$

The general form of the equation solved with a three-line diagram being

$$A^x \quad B^y \quad = \quad C^z$$

and adopting m as the modulus or logarithmic length of the number 10, this equation, treated by logarithms, becomes:

$$x \text{ log. } A + y \text{ log. } B = z \text{ log. } C$$

and

$$x\,A\,m_1 + y\,B\,m_3 = z\,C\,m_2$$

If the scales are to express the true value of each function, such as A^x, although simply marked A, the moduli adopted for the three functions may be M_1 for A^x, M_2 for C^z, M_3 for B^y, and the general equation will be:

$$[A^x B^y = C^z] = [x A\,m_1 + y B\,m_3 = z C\,m_2] = [A\,M_1 + B\,M_3 = C\,M_2]$$

If this reasoning be applied to the calculation of Chart No. 2, shown in the preceding article, the ease with which the necessary elements can be established, as compared with the somewhat laborious process followed before, will be at once apparent.

Neglecting the constant, the equation in connection with this chart was

$$Q = D^2\,V$$

Q being on the first scale, V on the third, and D^2 on the second. The equation may be written

$$Q\,M_1 = D\,M_2 + V\,M_3$$

It was found convenient to use the moduli $M_1 = 83\frac{1}{3}$ millimeters, and $M_3 = 125$ millimeters, with $d + e = 170$ millimeters.

Applying equation (17)

$$\left(m_2 = \frac{m_1\,m_3}{m_1 + m_3}\right)$$

$$\frac{M_2}{2} = m_2 = \frac{M_1\,M_3}{M_1 + M_3} = \frac{83\frac{1}{3} \times 125}{83\frac{1}{3} + 125} = 50$$

whence,

$$M_2 = 50 \times 2 = 100 \textit{ millimeters}$$

Then,

$$\frac{d}{e} = \frac{M_1}{M_3} = \frac{83\frac{1}{3}}{125} = \frac{2}{3}$$

$$d = \tfrac{2}{3}\,e,\quad d + e = \tfrac{2}{3}\,e + e = \tfrac{5}{3}\,e = 170$$

$$e = \frac{170 \times 3}{5} = 102 \textit{ millimeters}$$

$$d = 170 - 102 = 68 \textit{ millimeters}$$

The location of the constant depends upon the conditions of the problem, and also upon the most preferred arrangement of the scales on the diagram. When, as in Chart No. 2, the constant is introduced on the second scale, either of two ways may be followed. At the intersection D^2 on $C D$ of a straight line joining two points Q and V, selected on $A B$ and $E F$, the value of the constant, expressed with a logarithmic length of modulus m_2, is spaced off on $C D$, either above or below D^2, as the case may be, and the scale is then laid out with D^2 located at the point just found. Or, the equation may be solved with the constant, as has been done, for a given value of Q and D^2, thus obtaining the corresponding true value of V. A straight line joining these Q and V intersects $C D$ at the exact location of D^2, and the scale of the diameters (D) is laid out as in the first instance.

Horsepower Chart

When a quantity of water Q weighing W pounds is raised through a hight H feet, the power expended, independent of frictional losses, is

$$W \times H \textit{ foot-pounds}$$

The quantity is expressed in cubic feet or in gallons. In matters concerning waterworks or pumping installations, Q is expressed in gallons per minute (g.p.m.), in million gallons per 24 hours or in cubic feet per second. The engineer usually deals with gallons per minute; hence, when estimating, the other values are transposed into gallons per minute.

One United States gallon is equal to 231 cubic inches or 7.4805 cubic feet. One cubic foot per second equals

$$7.48 \times 60 = 448.8 \textit{ g.p.m.}$$

or, with sufficiently close approximation, 450 gallons per minute may be used. One million gallons per 24 hours equals

$$\frac{1{,}000{,}000}{24 \times 60} = 694.445$$

approximately 700 gallons per minute.

It is usual in calculations to assume the weight of one cubic foot of clear water at 62 degrees Fahrenheit to be 62.355 pounds.

The water horsepower (w.hp.) corresponding to $Q \times H$ foot-pounds of work done is:

$$\frac{G.p.m. \times H \times 231 \times 62.355}{1728 \times 33{,}000} = \frac{G.p.m. \times H}{3958.9}$$

With the constant in round figures, this becomes:

$$\textit{Water horsepower} = \frac{G.p.m. \times head}{3960} \qquad (18)$$

The hight H is usually termed the head. When the water is discharged against a pressure of P pounds per square inch, the corresponding head is

$$P \times 2.309$$

Equation (18) transformed, becomes:

$$\text{log. } (w.hp.) = \text{log. } (G.p.m.) + \text{log. } (Head) - \text{log. } 3960$$

After a few trials it is found most convenient to put the head on scale $A B$ with M_1 equal to 250 millimeters, $G.p.m.$ on $E F$ with the modulus M_3 equal to 250 millimeters, and the $w.h.p.$ on $C D$ with a modulus M_2.

Equation (17) gives

$$M_2 = \frac{M_1\,M_3}{M_1 + M_3} = \frac{250 \times 250}{250 + 250} = 125 \textit{ millimeters}$$

$d + e$ is selected equal to 143 millimeters; hence, since

$$\frac{d}{e} = \frac{M_1}{M_3} = 1$$

$$d = e = \frac{143}{2} = 71.5 \textit{ millimeters}$$

The first and third scales are each laid out with a 10-inch slide-rule scale 250 millimeters long; then, after solving equation (18) for one set of values of $G.p.m.$ and of H, a line is drawn joining these two points on the $A B$ and $E F$ scales, and intersecting $C D$ at the precise corresponding value of the horsepower. The $w.hp.$ scale is then drawn with a 10-inch slide-rule scale of squares, 125 millimeters long, the number on the scale coinciding exactly with the number at the point just determined on $C D$.

This chart is made to read directly on $C D$ the water horsepower corresponding to a head ranging from 10 to 100 feet, with a quantity varying from 100 to 1000 gallons per minute. Should the head dealt with be greater than 100 feet, say 265 feet, for example, while the gallons per minute are between 100 and 1000, then the water horsepower corresponding to 26.5 feet should be read on the middle scale, and this reading multiplied by 10 would be the required horsepower.

For a quantity greater than 1000 gallons per minute, say 7550, the water horsepower corresponding to 755 gallons per minute would be read on the middle scale, and the reading multiplied by 10 would again give the water horsepower required.

The process would be the same for heads and quantities simultaneously greater than the scale limits; thus for 265 feet and 7550 gallons per minute, the reading obtained would be that corresponding to

$$\frac{26.5 \times 755}{3960}$$

and that, multiplied by

$$(10 \times 10) = 100$$

would be the required water horsepower.

How Mat Made Good and Then Lost

By Luke Marier

By hard work and diligent application to his studies Mat worked himself up from fireman to chief engineer with a first-class license. With his ambition satisfied Mat became careless and drifted back to a miserable failure more rapidly than he had risen.

Let me assert that if I ever read an interesting bit of literature it certainly was the editorial which appeared on the first page of POWER for March 28. It is real, true and practical—and the admonitions it contains should unquestionably actuate the average engineer who, through long years of trudging in the same old habits, has forgotten himself and laid his studies aside long ago; that is, if he studied at all.

It would be well for all of us to read that same editorial again and thoroughly absorb its wholesome advice.

Health is quoted as being a valuable asset, for an engineer. The following is the story of two engineers; it illustrates what an important part health plays in a man's career.

Matthew Ella was the son of a very poor couple, totally ignorant of the English language and just emigrated from Canada. He was full of ambition and energy; and possessed a bulldog determination to succeed.

Shortly after he arrived in a certain New England city, he secured a small job as carpenter's helper. Soon after this he made the acquaintance of the night fireman of the F. R. B. Company, and came regularly to spend his evenings in the plant with his friend, cleaning out furnaces, etc.

The steam-engineering field seemed alluring to this young man, and he got all the pointers he could on boilers and auxiliaries from his new friend. He also got well posted on questions which might be encountered during an examination. Invariably he would remain and work strenuously until midnight, in spite of the fact that his regular work during the day was most tiring.

After a couple of months—worn and pale as a ghost—he applied for a first-class fireman's license and got it. Immediately he took charge of a fireroom in a large cotton mill where there were 10 horizontal tubular boilers. But after a week he was compelled to descend to coal wheeling because of his inability to "make good." This did not discourage him, but instead, made him realize he needed experience.

Three months elapsed before he made any headway. This time, he accepted the "dignified" position of oiler in the L—— L—— mills, and "made good." He remained in this position for about 18 months. During this time he got somewhat entangled in things matrimonial and presently "tied the fatal knot."

About this time he was offered another position for more money and he accepted without a question. All the while, Mat studied incessantly on a well known correspondence-school course and acquired an ever-increasing degree of proficiency in the English tongue. He also studied with a private instructor who gave him many "good pointers" or "jewels" as they were called. These "jewels" played a mighty important part when at length he was examined for a first-class engineer's license, which he secured.

Next, Mat became assistant engineer in the M—— mills, where he made himself valuable in many ways. He operated one plant while the chief made his headquarters at the other plant across the road, perhaps five minutes' walk away.

It was on a Thursday morning that the chief came to see Mat's "big license." Mat, anxious to show the chief his beloved "ticket," pulled it from his pocket with alacrity and handed it over with a smile. The chief examined it with a frown and a look of displeasure. "What is this good for anyway?" demanded the chief. "Will this help to run the plant any better or any more economically?"

"Well, this surely will mean, at the very least, $2 more in my pay envelop," replied Mat, whose smile had instantly changed into a frown like the chief's. "And if I can't get the increase here I can get it somewhere else," he added.

This sort of talk naturally aroused the chief and enmity was created. Mat began to keep an eye open for a vacancy somewhere.

Presently the job at the L—— L—— mills was open and as Mat was familiar with the plant there, he immediately applied for the position and was fortunate enough to get it. He was placed in full charge at a salary of $22 a week, the largest sum he had ever seen in his envelop up to this time.

This plant was located some two miles from his home, which distance he cheerfully plodded morning and night. This was indeed healthful for him, he was pale no longer, but instead, had the color in his cheeks which he had totally lost during the five years of hardship. He steadily increased in weight and eventually this plodding got to be commonplace. He began to feel considerable dignity and soon required a larger-sized hat and perhaps the removal of a few buttons from the upper part of his vest to allow for chest expansion.

All this led him to the purchase of a horse and buggy. He had reached the goal of his ambition and was in a mood now "to take things easy." He grew indifferent from doing so little and let things about run themselves.

His mind became centered on "money making." Most every night would see him make the rounds of his acquaintances in an endeavor to sell them jewelry, in which there was a handsome profit, some 50 per cent. to be realized on every sale. This formed a sort of side business, which proved to be quite remunerative. He once told me that he never sent less than $30 to the bank every week. Shrewd and saving he certainly was.

However, this business did not adjust his engines nor repair his boilers, which soon got in need a general overhauling. The fires of ambition and interest were dying out. He said to me one day that he was not paid for what he did but, rather, for what he knew. This was simply idiotic!

Everything had been very well adjusted and as "clean as a whistle" when the plant was turned over to him and this had enabled him to "take it easy." And, so he did—but his stomach did not, especially from the time he purchased the horse and buggy. It became mighty difficult to digest, say, a good heavy bit of fried steak or a generous portion of clam chowder, especially if it was half cooked and prepared in a hackneyed fashion. After a feast on such things he would doze for the rest of the afternoon in his arm chair. Imagine what beautiful unprintable language his stomach would have uttered had it been able to speak!

Johnny B—— often advised him to exercise but such advice was simply futile—he was too arrogant ever to take heed. He often told me that he had worked and studied so extremely hard to obtain his license that now he intended to rest, as he did. He was [illegible] since he took charge of this plant studying was simply repugnant to him, and he read but one steam technical magazine.

Months slipped away, and so did the pink in poor Mat's cheeks. He got to be indifferent from doing so little and repairs were utterly neglected. A deplorable condition of affairs must come to exist.

One afternoon while visiting his plant, my attention was attracted by the unusual thudding of the eccentric on the tandem-compound Corliss engine. I observed that the eccentric strap held by merely the top bolts, the bottom bolts had fallen into the oil tray below. Further observation showed that cylinders were cutting; boilers were in need of resetting; the other engines needed as thorough an overhauling as did the Corliss; the condensing system was in very poor condition; in a word, everything was on the verge of complete dilapidation.

Finally, after being in charge for 22 months, Mat took sick and two weeks after died. Poor fellow, but perhaps this was as fortunate for him as to be suddenly destroyed by a bursting cylinder head. His headquarters were directly abreast of the high-pressure cylinder of the tandem-compound Corliss engine, one of the eccentric straps of which held only by the top bolts.

Mat had often boasted that it would be quite a difficult matter for the company to find a stranger to run his plant successfully should he ever leave, since this plant was so differently constructed than any other he had seen.

"My dear friend," I said, smilingly, "should you leave this job this very minute, there would be a dozen capable applicants ready to fill it in half an hour."

He smiled and could not believe it.

At any rate, this is just the condition of affairs which existed when he died. Some ten or fifteen good, capable men applied. The one who was selected was a brilliant sort of fellow, level-headed, well read—a gentleman, one you may meet in every hundred engineers, one who attends strictly to business. This man was an engineer worthy of the name; always on the alert, always attending to even the most trivial things with care and precision; he was a master. He remained in charge for some 18 months, during which time he overhauled everything from sump pit to chimney top. The finest thing about this *gentleman* was that his head always remained at its normal size.

When finally he moved up another rung, he accepted a job as chief engineer in New Bedford, Mass., for some $15 a week more than he was receiving at this place.

Vapor Heating Systems*

By Thomas G. Mouat

About twenty-six years ago a journeyman steamfitter remarked to the writer that vapor was the coming heat. Upon being asked what he meant by the term "vapor," he replied that it was steam slightly above atmospheric pressure. In those days it was deemed necessary to carry from 1 to 10 pounds of steam pressure in order to heat a building successfully with the ordinary gravity low-pressure system without the means of producing a partial vacuum; and most boiler manufacturers still set the pop valves to blow at 15 pounds.

This steamfitter's prophesy has been realized, and, although it is a long step from 10 pounds to 2 ounces pressure, it has been practically demonstrated that a building can be heated in the coldest weather with from 2 to 3 ounces pressure, and the term "vapor heat" is now applied to a steam-heating system which operates under this very low pressure.

The main object of vapor heating is to provide for a system that will operate with just a little heat turned on each radiator, enough heat to be comfortable without overheating in moderate weather and plenty of heat for the coldest days, by simply opening the supply valves a little further. Several attempts were made from time to time to perfect a system, which would permit the partial heating of the radiators, but in each case they met with failure, due to the inability to control the pressure with the ordinary diaphragm damper regulator and devices of this character, where the steam pressure was directly applied to do the work. It was not until the direct application of steam in connection with a diaphragm was dropped, and the agency of water plus the steam pressure was employed that a system permitting positive and practical graduation was perfected. The graduated admission of steam to each radiator may now be accomplished in a properly constructed vapor system by the use of a sensitive pressure and damper regulator attached to the boiler with fractional valves and special return fittings on the radiators, and an opening in the return pipe near the boiler to permit the escape of air. No air vents are used on the radiators.

The regulator must be so constructed that it will open or close with the variation of an ounce of pressure. This result has been obtained by a regulator operated according to the principle of a hydraulic balance, water being forced out of a stationary tank into a movable tank placed at the end of a lever which causes the movable tank to tilt downward and close the dampers. When the pressure has dropped an ounce, part of the water leaves the movable tank and returns to the stationary tank; the former is then tilted upward by the aid of a counterweight and the reverse operation occurs.

There is also a regulator on the market operated by a float in a tank placed alongside of the boiler. When the water is forced out of the boiler the float is raised and the drafts are closed. When the water in the tank drops back into the boiler again, the float descends and the dampers are opened.

The graduating valves are constructed so as to permit a small amount of steam to enter the radiator, so little that it will be condensed in heating a small portion of the radiator; or, on the other hand, they may be opened still farther and heat the entire radiator. The valves are furnished with stop screws so that they may be set to heat the entire radiator without permitting any steam to pass through the radiator into the return pipe.

Water radiators are used, which heat horizontally along the top first and thence downward according to the amount of steam turned on. The return fitting is placed at the opposite end and is connected to the bottom connection of the radiator. This return fitting is constructed with a small water seal which presents a full opening for the flow of condensation into the return pipe, and a restricted opening for the escape of air into the same pipe. This restricted opening and water seal retard the flow of steam into the return pipe. The air and water travel together to a point near the boiler where an opening for the escape of the air is provided in the top of the return pipe. From this a pipe leads to the chimney flue, where a slight reduction in pressure is produced, tending to help the removal of the air. The water separated from the air falls to the boiler.

The ordinary steam-heating system with its variable pressure, uncertain regulation and the tendency toward a vacuum will not permit of any graduation A sufficient reduction of pressure in the radiator would immediately fill the radiator with water through the return pipe; or in a one-pipe system the radiator would gradually fill with water if the supply-valve area was materially decreased. No vacuum can be produced in a vapor-heating system of this type because, as has been already stated, it is open to the atmosphere. With the ordinary steam-heating system the supply valves must be either turned on full or shut off tight, which frequently makes the rooms either too hot or too cold, causing waste of fuel and discomfort.

With the vapor-heating system, however, the pressure is generally much higher in the supply pipes than in the radiators. It may be 2 ounces in the pipes and only a small fraction of an ounce in the radiators, due to graduation and condensation. The water of condensation returns to the boiler at a very low temperature, averaging about 85 degrees Fahrenheit, and with some vapor systems the return water may be reheated by means of the waste gases.

There are many other reasons which recommend the vapor system to the public. The very low pressure at which the system operates reduces the cost of maintenance to a minimum. It is noiseless in operation, and is economical due to the sensitive regulation, the very low pressure and the graduation. Furthermore, it is capable of keeping up a steady heat from 10 to 12 hours

*From a paper delivered before the Ohio Society of Mechanical, Electrical and Steam Engineers, at Youngstown, Ohio, May 18, 1911.

with hard coal without attention. There are no air vents to leak, sputter, or emit odors into the rooms, and it is much quicker to act than hot-water heat, and the danger from leakage or freezing is reduced to the minimum. The radiators are smaller than those used for hot water, and about 15 per cent. larger than those required for the ordinary steam systems. When natural gas is used for fuel, the regulator is attached to a butterfly valve on the gas-supply pipe, which prevents overpressure and makes the system almost automatic, with the exception of turning the valves on and off at the radiators.

Boiler and Flywheel Explosions in America

It may be of interest to read what our British contemporary, the *Mechanical Engineer*, has to say in regard to boiler and flywheel explosions in the United States, and incidentally a few side remarks on American recklessness.

The United States maintains its unenviable position as record breaker in respect to accidents from the working of power plants. According to *The Locomotive*, a little publication issued by the Hartford Boiler Inspection and Insurance Company, there occurred last year no less than 533 explosions of boilers, killing 280 persons and injuring 506 others. As compared with the rate of fatality in this country the figures are astounding, and, moreover, are in no ways exceptional. There were 550 explosions in 1909, while the average for the previous four years was 455, with a similar proportion of killed and injured. It is difficult to compare these figures exactly with similar ones in this country, because the exact number of boilers in the States is not known, while the above figures only refer to the results of explosions of boiler shells and do not include the multitude of minor fatalities and scalding cases arising from the failure of steam pipes and subordinate details of steam apparatus, which, however minute, and whether on land or afloat in any vessel flying the British flag, come under the purview of the Boiler Explosions Act, and hence are included in the annual returns. Taking this sweeping inclusion, the average number of failures for the past ten years only works out at 69 per annum, with a fatality of 23 and a list of injured of 52. Were such minor failures as are embodied in these returns included in the statistics given by our contemporary, they would, of course, be greatly increased. But if we neglect them, it will be seen that, roughly speaking, the comparison is about ten to one. There are, no doubt, a larger number of boilers in the States than here; exactly how many it is impossible to say, though if we assume twice as many, a very liberal estimate, the figures imply a recklessness and absence of supervision in the States which is serious.

Similar recklessness appears to characterize the working of engines as of boilers, judging from a list of flywheel bursts recorded by our contemporary during 1910, which is admittedly incomplete since it rests mainly on the reports of such accidents as were sufficiently important to secure notice in the press. The list gives details of 67 accidents of this kind, causing the deaths of 16 persons, and more or less serious injury to 28 others. A perusal of the details, where these could be obtained, show that in a great many cases the accidents were due to the failure of the governing mechanism, though we cannot help feeling that the structural weakness of flywheels usually fitted to prime movers in the States, and the correspondingly small margin between safe and bursting speed, is responsible in considerable measure for the frequency of failure.

Duffy Wants a "Picture"

By Danny Hogan

"An' how's the laundry?" asked Doolin.

"Fine," replied Duffy, "the boss wants me to take out a license an' be the engineer as Cogan is drinkin' again."

"An why not?" asked Doolin, "you've been there seven years doin' this and that an' by rights you should know enough to get a picture for the frame."

"I know," says Duffy, "but I dunno if I could answer the questions about bilers. I'm told one must know all about riveting an' I'm no biler maker at all."

"True for ye," said Doolin, "an' biler makin' is one of the grandest studies we have. There ain't, Duffy, within reason, annything made by man that equals for profound interest an' deep research, a steam biler. An' the older it is, the more interesting it becomes. Ye would need years to learn the line. But there's no call, Duffy, for you to learn biler makin' to be an engineer. The City Hall gang ain't biler makers either. They will ask you some questions from a book and look at the answers an' find out if you are right.

"They will ask you, no doubt, to lay out a lap-joint seam for 5/16-inch plate at 60,000 pounds tensile strength and how to find the thickness of plate for a 60-inch biler, 100 pounds pressure, with a double-riveted seam."

"I couldn't do it," said Duffy.

"In two hours," replied Doolin, "ye can learn it all an' can get a job as a layer out."

Mr. Doolin filled his pipe and on some manila paper proceeded to lay out as follows:

P = Pitch of rivets;
WP = Working pressure allowed;
F = Factor of safety, 5;
R = Radius or ½ diameter;
T = Thickness of plate;
TS = Tensile strength of plate;
D = Diameter of rivet hole;
A = Area of rivet hole;
N = Number of rivets in a pitch;
S = Shearing strength in single shear;
RE = Rivet efficiency;
PE = Plate efficiency;
E = Lowest efficiency.

$$WP = \frac{TS \times T \times E}{R \times F} \quad (1)$$

$$RE = \frac{A \times N \times S}{T \times TS \times P} \quad (2)$$

$$PE = \frac{P - D}{P} \quad (3)$$

$$T = \frac{WP \times R \times F}{TS \times E} \quad (4)$$

$$E = \text{Lowest of } (2) - (3) \quad (5)$$

$$P = \frac{A \times N \times S}{T \times TS} + D \quad (6)$$

$$F = \frac{TS \times T \times E}{R \times WP} \quad (7)$$

$$R = \frac{TS \times TE}{F \times WP} \quad (8)$$

"There, Duffy, ye have," said Doolin, "the data, so as to speak, of lap seams either single, double or triple riveted. An' with that ye can use some short cuts. For instance, firebox steel may be taken at 56,000 TS and the shearing strength of steel rivets is 42,000 pounds. Now, 56,000 is to 42,000 as 3 is to 4.

"In finding P you can drop the large figures and with 5/16-inch plate and ¾-inch rivet hole make it

$$P = \frac{0.4417 \times 2 \times 3}{0.3125 \times 4} + 0.75$$

an' P will be 2.87 inches, or 2⅞ inches. Now, what is the efficiency of this, ye will ask. Well,

$$PE = \frac{2.875 - 0.75}{2.875} \text{ or } 73 + \text{ per cent.}$$

$$RE = \frac{0.4417 \times 2 \times 3}{0.3125 \times 4 \times 2.875} \text{ or } 0.73 + \text{ per cent.}$$

Ye will note, Duffy, that PE and RE are equal. Some prefer to favor the plate over the rivet, having in view that with the "bull" the rivet will surely fill the hole an' the plate may be hurt in the bending rolls. But, if you increase the pitch by as much you reduce the calculated E of the joint. Now, ye can work over these matters until your head is full and ye will get the picture in frame."

"But," says Duffy, "how will I know what size rivet to use for a given thickness of plate?"

"That's right," replied Doolin. "Well, 'tis this way. With plate of from ¼ to 5/8 inch ye can use

Thickness × 2

to find the diameter of rivet hole. From this [illegible]. Some use

$T \times 2 - \frac{1}{16}$ inch

and some

$T \times \frac{3}{2} + \frac{1}{16}$ inch

but $T \times 2$ gives [illegible] practice an' [illegible] a light job. Another thing, Duffy, is important. Suppose we lay out a straight line to be the pitch line, we must now find the distance from this line to the edge of the plate for the joint might fail by crushing out in front of the rivet. Ye should allow $1\frac{1}{2}$ diameters of rivet for this distance an' if you use $T \times 2$ for the diameter the matter of the plate crushing out will be properly taken care of."

"What is the allowance for steel plate crushing in this way?" inquired Duffy.

"The rule to find this," said Doolin, "is

$$D \times T \times 95{,}000$$

With the 5/16-inch plate and ¾-inch rivet hole, this equals 22,266 pounds, showing it is stronger than the shear of the rivet. In designing one must look after this crushing detail the same as the rivet shear and the net plate efficiency; so bear that in mind. The City Hall bunch may spring this on ye so it's well ye go over it and absorb it in your system."

"I will," says Duffy, "but there is one thing else I never understood. How do you find the distance between pitch lines on double and triple rows? Tell me that."

"Well," said Doolin, "the authorities vary on this point also. For instance, many rules ignore the matter, important as it is. In this country we use zigzag riveting exclusively and each shop is a law to itself on this subject. A safe rule to use for common plates is,

$$Pitch \times 0.7$$

for double and

$$P \times 0.65$$

for triple riveted. In the joint we have discussed this would give the distance as 2 inches and it represents good practice.

"The lap of these joints, ye will remember, will equal the distance from center of rivet hole to edge of plate times 2 plus the distance between the rows. Here is a table of rivet values that covers all sizes an' will save your pencil an' temper. Ye will need to work out various sizes, etc., to be able to answer anny question they may spring on ye."

"I know," replied Duffy; "I'll do it, too, for I want the picture in the frame and the extra money the job will pay. But what does this double shear mean in the rivet table?"

"When ye understand," said Doolin, "the lap joints which are the single shear I'll put ye wise to the butt-strap joints. It will be another story."

RIVET VALUES IN POUNDS PER SQUARE INCH

42,000 LB. SINGLE—78,000 DOUBLE SHEAR

Diameter of Rivet Hole	Area	Shear	
		Single	Double
$\frac{9}{16}''=0.5625''$	0.2485″	10,437 lb.	19,383 lb.
$\frac{5}{8}''=0.625''$	0.3068″	12,885 lb.	23,930 lb.
$\frac{11}{16}''=0.6875''$	0.3712″	15,590 lb.	28,954 lb.
$\frac{3}{4}''=0.75''$	0.4417″	18,551 lb.	34,460 lb.
$\frac{13}{16}''=0.8125''$	0.5185″	21,777 lb.	40,443 lb.
$\frac{7}{8}''=0.875''$	0.6013″	25,254 lb.	46,901 lb.
$\frac{15}{16}''=0.9375''$	0.6902″	28,988 lb.	53,843 lb.
$1''=1.000''$	0.7854″	32,986 lb.	61,261 lb.
$1\frac{1}{16}''=1.0625''$	0.8866″	37,237 lb.	69,155 lb.
$1\frac{1}{8}''=1.125''$	0.9940″	41,748 lb.	77,532 lb.
$1\frac{3}{16}''=1.1875''$	1.1075″	46,515 lb.	86,385 lb.
$1\frac{1}{4}''=1.25''$	1.2271″	51,538 lb.	95,722 lb.
$1\frac{5}{16}''=1.3125''$	1.3530″	56,826 lb.	105,534 lb.
$1\frac{3}{8}''=1.375''$	1.4849″	60,365 lb.	115,822 lb.
$1\frac{7}{16}''=1.4375''$	1.6230″	68,166 lb.	126,594 lb.
$1\frac{1}{2}''=1.5''$	1.7671″	74,218 lb.	137,833 lb.

Air Required per Pound of Coal

By Charles M. Rogers

Some reasons tending to show that, as a rule, a high percentage of CO_2 indicates a good furnace efficiency. From the results of actual observations the amount of air per pound of coal is calculated in detail.

Some experts are of the opinion that a high percentage of CO_2 is always accompanied by a correspondingly high loss due to incomplete combustion, that is, the formation of CO. In the writer's opinion this is usually not the case, although in some instances while forcing the fires for the purpose of obtaining a high percentage of CO_2, this holds true. Under ordinary conditions, however, with the stokers running normal, a high percentage of CO_2 is indicative of a high furnace efficiency.

With the usual boiler setting it is difficult to obtain an average CO_2 above 12 or 13 per cent., without considerable loss, due to the formation of CO, unconsumed carbon in the ash, increased weight and temperature of the escaping gases, and the potential energy contained in the unconsumed combustible constituents in the smoke.

Recently, in a certain plant, while the CO_2 recorder was showing good results and the stokers were running normal, a complete analysis of the gases was made and the pounds of air per pound of coal and the loss due to the formation of CO, were calculated. Observations of the flue-gas temperatures in the breeching showed them to be 10.43 per cent. lower with an average of 14 per cent. CO_2 than with an average of 12 per cent., which represents a saving. Further observations showed that the gain due to the reduced weight of the flue gases and likewise increased percentage of CO_2 was balanced by the loss due to incomplete combustion. The accompanying chart shows an autographic record of the percentage of CO_2, and the corresponding draft.

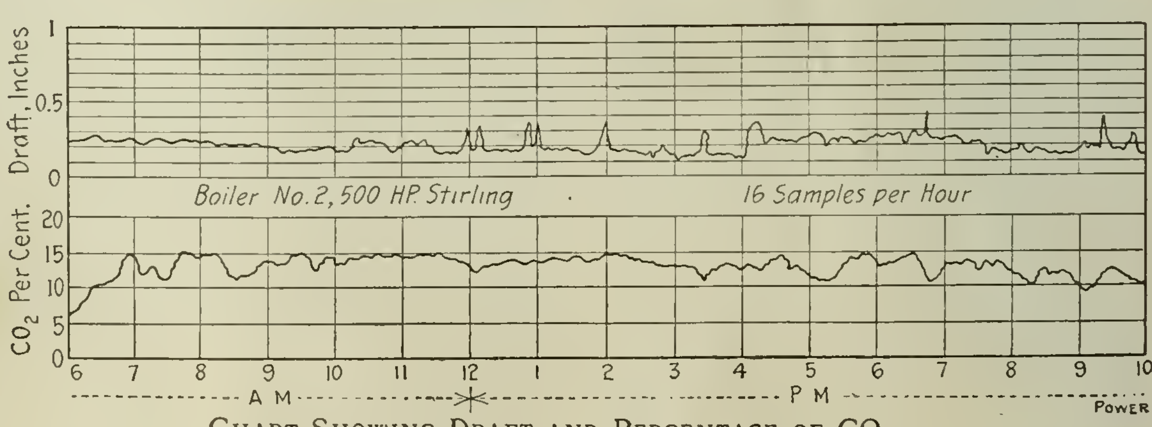


CHART SHOWING DRAFT AND PERCENTAGE OF CO_2

In order to determine the number of cubic feet of air supplied per pound of carbon, it is necessary to determine the total weight of oxygen from the following analysis, and knowing that air contains 23.1 per cent. by weight of oxygen, the air supplied per pound of coal can be readily calculated. In the particular case referred to, an analysis of the gases for four hours showed 14 per cent. of CO_2, 0.68 per cent. of CO and 6.02 per cent. of O. For convenience in figuring, 100 cubic feet of flue gas will be assumed. The respective weights per cubic foot of the component gases are: 0.1234, 0.0781 and 0.0893 pound. Then the total weight of each gas in 100 cubic feet of flue gas are:

CO_2.... 14 $\times$ 0.1234 = 1.7276 pounds

CO..... 0.68 $\times$ 0.0781 = 0.0531 pound

O..... 6.02 $\times$ 0.0893 = 0.5376 pound

The atomic weight of carbon is 12 and of oxygen 16; then a unit of CO_2 contains $\frac{32}{44}$ $\left(\text{equal to } \frac{2 \times 16}{12 + (2 \times 16)}\right)$ part by weight of oxygen and $\frac{12}{44}$ of carbon. Then in 1.7276 pounds of CO_2 there are

$$1.7276 \times \frac{32}{44} = 1.2564 \textit{ pounds}$$

of oxygen and

$$1.7276 - 1.2564 = 0.4712 \textit{ pound}$$

of carbon.

In one unit of CO there are $\frac{16}{28}$ $\left(\text{equal to } \frac{16}{12 + 16}\right)$ part by weight of oxygen and $\frac{12}{28}$ of carbon. Then in 0.0531 pound of CO there are

$$0.0531 \times \frac{16}{28} = 0.0303 \textit{ pound}$$

of oxygen and

$$0.0531 - 0.0303 = 0.0228 \textit{ pound}$$

of carbon. In 100 cubic feet of the flue gases there are

$$1.2654 + 0.0303 + 0.5376 = 1.8243 \textit{ pounds}$$

of oxygen and

$$0.4712 + 0.0228 = 0.4940 \textit{ pound}$$

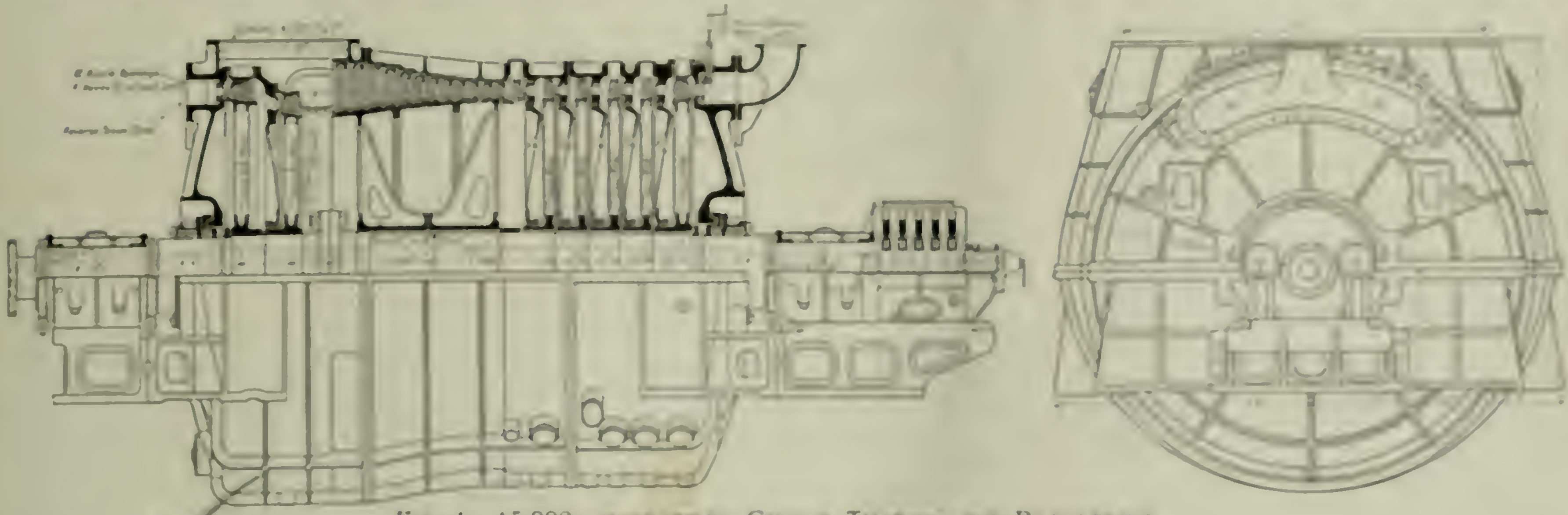


FIG. 1. 15,000-HORSEPOWER CURTIS TURBINE FOR BATTLESHIP

of carbon. There are then 0.4940 pound of carbon for every 1.8243 pounds of oxygen or, for every pound of carbon, there are 3.693 pounds of oxygen. As air contains by weight 23.1 parts of oxygen, this analysis would show that

$$3.693 : 23.1 = X : 100$$

where X represents the weight of air supplied per pound of carbon. This is found to be 15.98 pounds. As the coal contained only 70 per cent. carbon, the

mula 36 $(H - O/8)$. This, however, would amount to less than one, and is negligible for practical work. Without knowing the ultimate analysis of the coal it would be somewhat difficult to calculate the heat lost in the escaping gases.

When carbon burns to CO_2 there are 14,650 B.t.u. produced; consequently, when it burns to CO, producing only 4460 B.t.u., there is a loss of 10,190 B.t.u. Then the loss due to the formation of CO is found by multiplying the number of pounds of carbon burned to CO by 10,190 and dividing the product by the calorific value of the coal; that is,

$$\frac{10,190 \times 0.0228 \times 100}{12,450} = 1.87 \textit{ per cent.}$$

loss, due to the formation of CO.

Then about 16 pounds of air were supplied per pound of carbon, which is an excess of 40 per cent. over the theoretical requirement of 11.54 pounds; and as 40 per cent. excess air is considered good practice, no mistake should be made by

Curtis Marine Turbines

In this country great progress has been made in the impulse turbine, especially by the Fore River Shipbuilding Company, of Quincy, Mass., which has devoted itself very largely to the manufacture of the Curtis turbine for war vessels. *The Engineer* in a supplement illustrated two of the latest turbines built by this firm, the smaller turbine being the type employed for a scout cruiser, and the larger that for two new battleships. The accompanying illustrations are reproductions, and the following data are particulars of these vessels:

	Scout Cruiser	Battleship
Number of shafts	2	2
Number of turbines	2	2
Brake horsepower of each turbine	7500	[illegible]
Revolutions per minute	[illegible]	[illegible]
Steam pressure, pounds per square inch	[illegible]	[illegible]
Superheat, deg. Fah.	[illegible]	[illegible]
Pitch diameter of turbine wheels	85	120
Number of stages	16	18

In general design these turbines do not differ from each other to any consider-

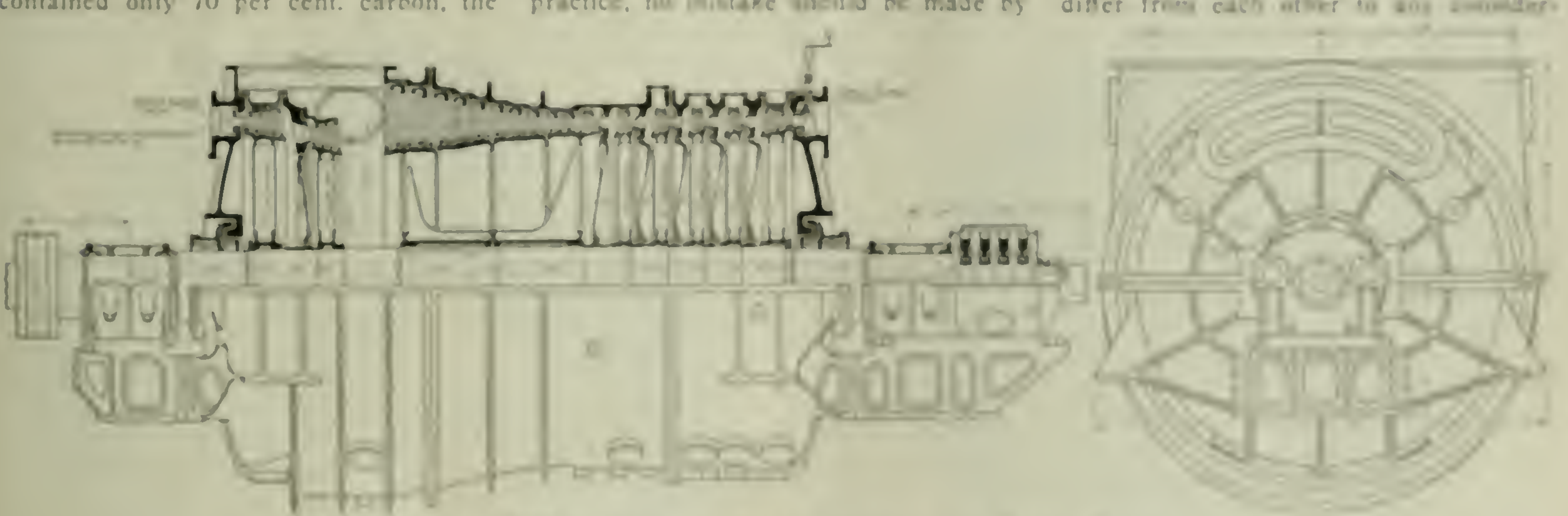


FIG. 2. 7500-HORSEPOWER CURTIS TURBINE FOR SCOUT CRUISER

weight of air per pound of coal used would be

$$15.98 \times 0.70 = 11.19 \textit{ pounds}$$

The hydrogen and oxygen contents in the coal were not known; hence, a slight error is introduced as the oxygen combines with $\frac{1}{8}$ its own weight of hydrogen and forms water. Each remaining pound of hydrogen requires 36 pounds of air for combustion, and is calculated by the for-

firing so as to obtain a CO_2 reading of about 11 per cent., providing the coal is somewhat near the same grade and the furnace equipment is similar to the particular installation considered.

In Munich, peat sells for 280 marks (about $66) for a carload of ten metric tonnes (about eleven short tons).

able degree. In both turbines there are five moving wheels, the total number of stages being sixteen and eighteen, and the diameters 85 inches and 120 inches respectively, while in each case there are two reverse stages with twelve nozzle openings and four valves. For the ahead turbines there are twenty nozzles, each provided with a valve, these being of the usual sliding type.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Types and Connections of Alternating Current Generators

By Norman G. Meade

Classification of Generators

Alternating-current generators may be divided mechanically into three classes:

Belt-driven machines, entirely self-contained, with two or three bearings, a shaft and a pulley; direct-driven machines, having one or two bearings and a shaft arranged for direct coupling to the prime mover; engine-type alternators, consisting of the field magnet and armature without bearings or shaft, the field magnet being the revolving member and arranged to be mounted on the extended shaft of the steam engine or other prime mover. These three types are illustrated in Figs. 1, 2 and 3, respectively.

Alternators of small capacity are built in two forms, one with a revolving armature and a stationary field magnet and the other with a revolving field magnet and stationary armature. The latter has come into general favor with manufacturers because of its more simple mechanical construction and the greater facility with which the extra insulation necessary for a high-tension armature winding may be provided when the armature is stationary.

Fig. 4 shows the elementary connections of a single-phase revolving-armature alternator and its exciter. The connections of a revolving-field alternator are exactly the same in all essentials, the only distinction being that the low-tension current for the field winding passes through collector rings and brushes, because the magnet revolves, and the high-tension armature current does not, because the armature is stationary. The exciting current for the field winding of any standard alternator may be supplied from any constant-potential direct-current circuit of about 125 volts.

Electrically, alternators may be also divided into three types: Single-phase,

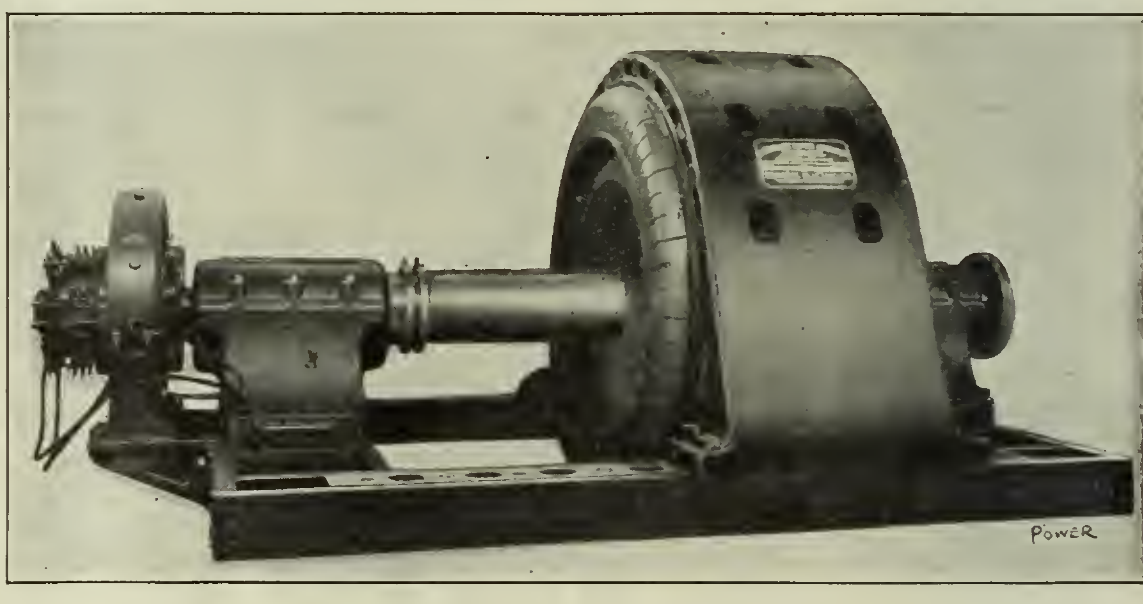


Fig. 2. Alternator for Direct Coupling

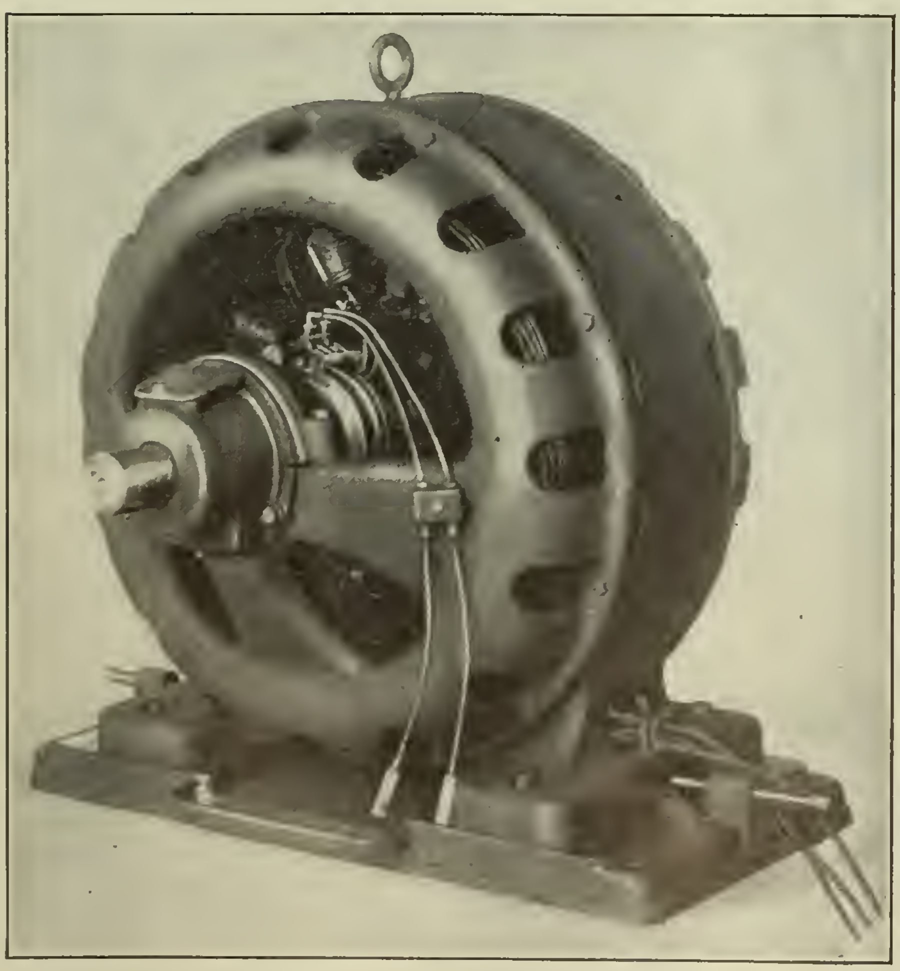


Fig. 1. Alternator for Belt Drive

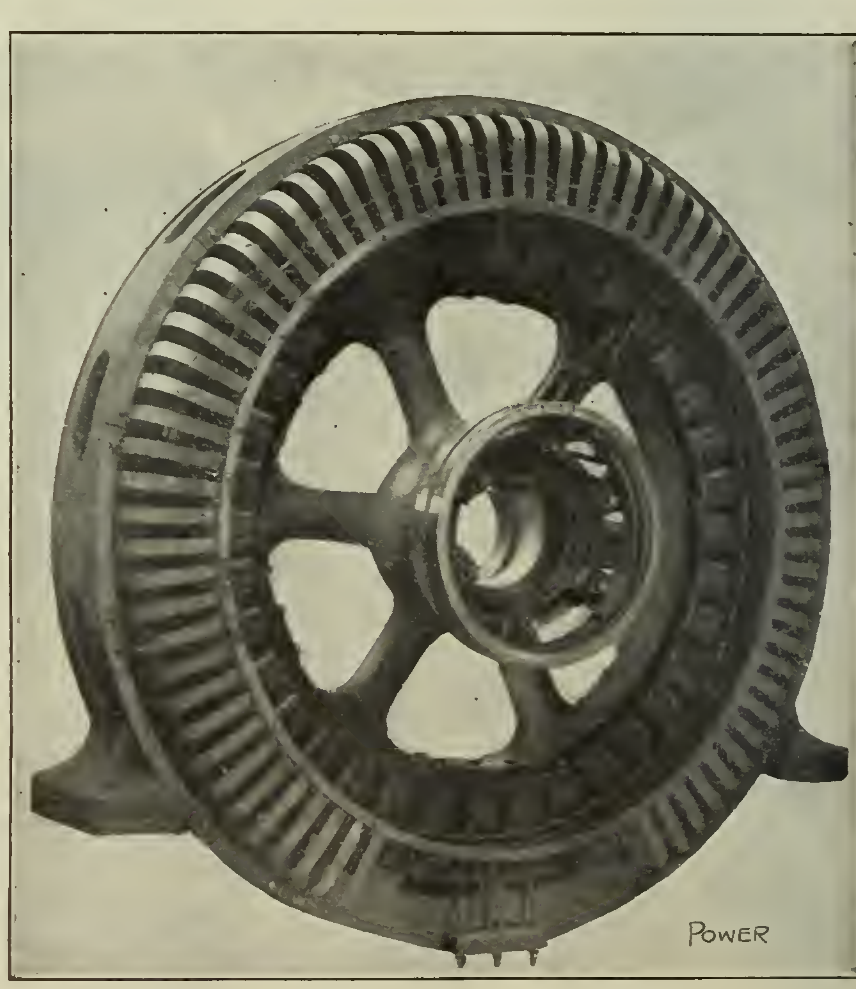


Fig. 3. Alternator for Direct Mounting

two-phase and three-phase. There was formerly a fourth type designated the "monocyclic," but that is no longer manufactured. Fig. 5 is a schematic diagram of a single-phase armature winding for

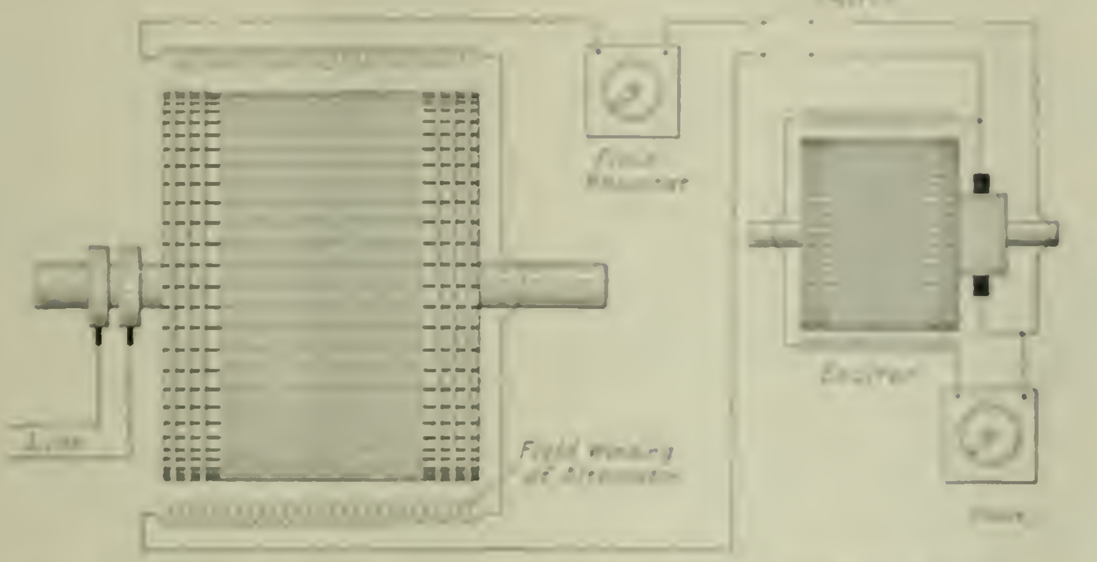


Fig. 4 Connections of Single-phase Alternator and Its Exciter

an alternator having six field-magnet poles. As alternators are generally designed to deliver a high voltage the coils are connected all in series and the two ends are connected to two collector rings

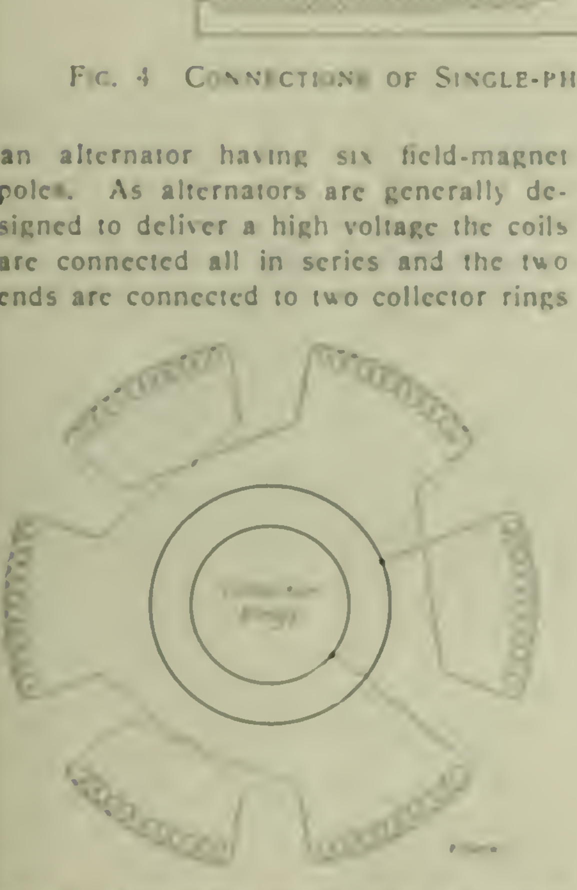


Fig. 5. Single-phase Six-coil Armature Winding

on the revolving-armature type of machine, as here shown, or to terminal blocks or leads on the revolving-field type of machine.

Fig. 6 is a diagram of the most common type of two-phase winding, which com-

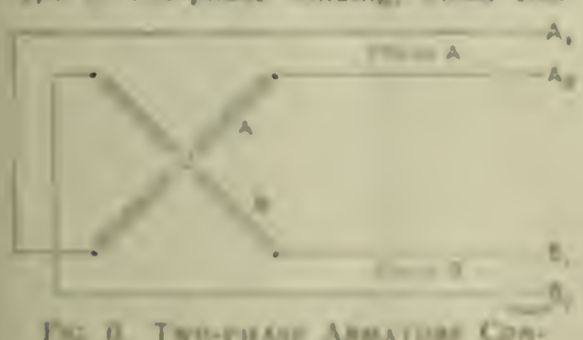


Fig. 6. Two-phase Armature Connections

prises two distinct circuits. The windings, indicated by A and B, are connected respectively to the external circuit-wires A_1, A_2 and B_1, B_2. The windings have no electrical connection with each other and the circuits are also distinct. The circuit A_1, A_2 constitutes one "phase" or division of the general system and the circuit B_1, B_2 the other. In some instances, instead of using two separate circuits with four terminal connections, as shown in Fig. 6, a common return wire is employed as shown at C in Fig. 7. This arrangement is seldom used in modern plants.

The three-phase alternator furnishes three electromotive forces differing in phase by 120 degrees or one-third of a complete cycle. This is accomplished by providing the armature with three

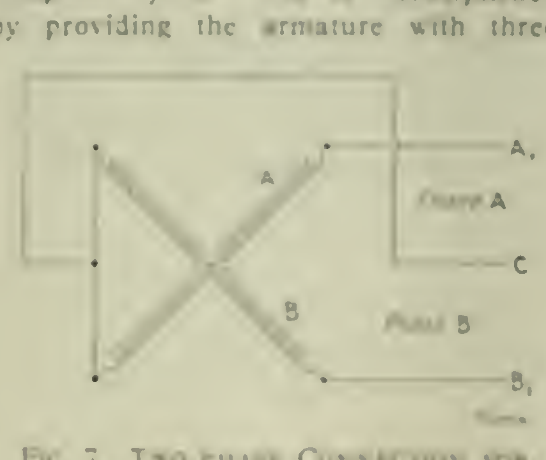


Fig. 7. Two-phase Connection for Common Return

windings displaced 120 degrees from each other. There are two general types of windings, designated as the "star" or "Y" and the "mesh" or "delta", these are represented diagrammatically in Figs.

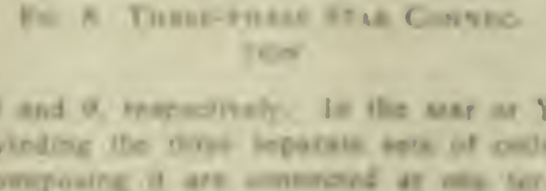


Fig. 8. Three-phase Star Connection

8 and 9, respectively. In the star or Y winding the three separate sets of coils composing it are connected at one terminal each to a common junction which forms the neutral point of the winding and the three free ends are connected to the line wires. The connections of the delta winding are evident in Fig. 9.

The monocyclic alternator was built for use in stations where the greater part of the load consists of electric lights but where it is desired to supply current also to a number of induction motors. It is really a single-phase machine with an auxiliary armature winding which is used only to supply current for starting motors.

Fig. 10 shows the connections of a

Fig. 9. Three-phase Delta Connection

monocyclic generator and Fig. 11 shows the arrangement of the coils on the armature core. The larger coil indicates the main winding and the smaller one the auxiliary winding, which is commonly called the "teaser" winding. In the diagram, Fig. 10, the electromotive force of

Fig. 10. Monocyclic Generator Connections

the generator has been put at 2080 volts and the various voltages indicated correspond to this potential. If the machine were wound for the more modern voltage of 2300, the teaser winding would give 575 volts.

As there are two main terminals and the teaser terminal, three collector rings

Fig. 11. Monocyclic Armature Winding

are provided, as shown. Between each end of the main winding and the end of the teaser winding there is a resultant electromotive force which is nearly 12 per cent. larger than one-half of the main electromotive force, as indicated by the voltage figures. This e.m.f. also differs in phase from the main e.m.f. and it is this feature which enables an induction motor to start automatically when supplied from a monocyclic alternator.

Small single-phase generators are usually provided with compensating field windings by means of which the field excitation is made to vary automatically in proportion to the load and thereby compensate for the voltage drop in the armature winding. The field magnet is equipped with two windings similar to those used on compound-wound direct-current generators. The main winding is supplied with direct current from the exciter and the other winding is supplied with rectified current from the armature of the alternator, causing the excitation of the field magnet to increase when the load increases. The current flowing through the compensating winding is rectified by a commutator and is reduced to the proper voltage by means of a series transformer.

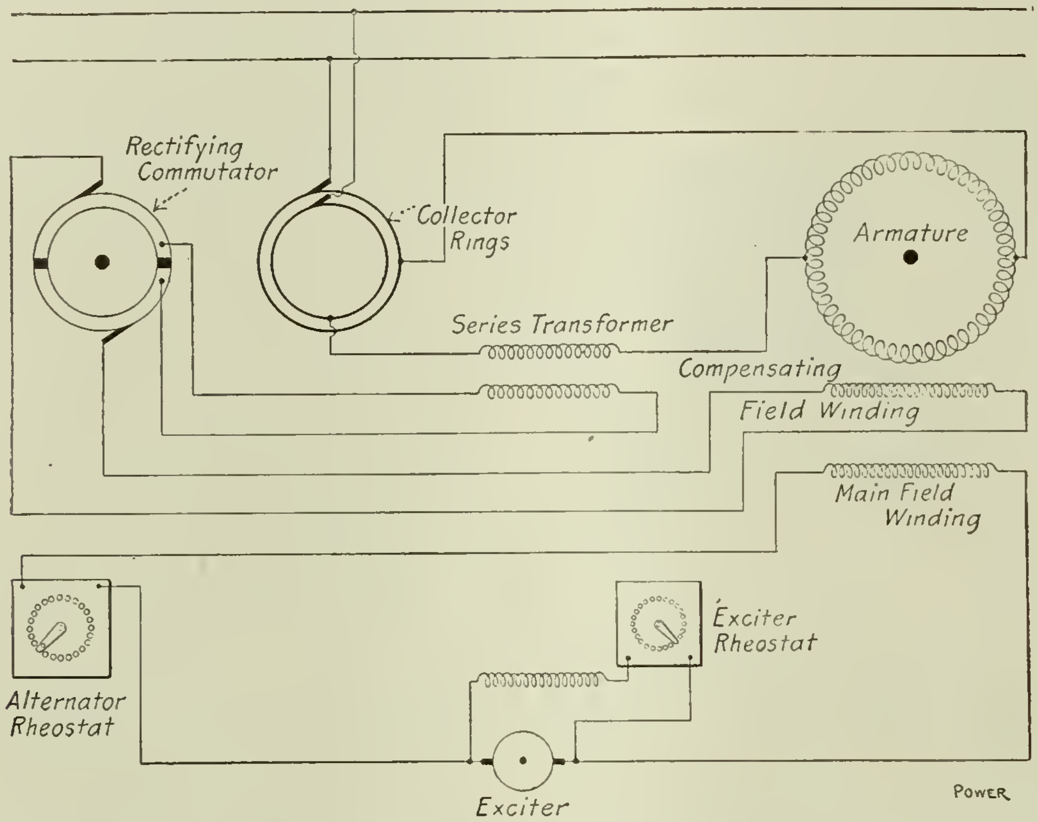


Fig. 12. Complete Circuits of Single-phase Compensated Alternator and Its Exciter

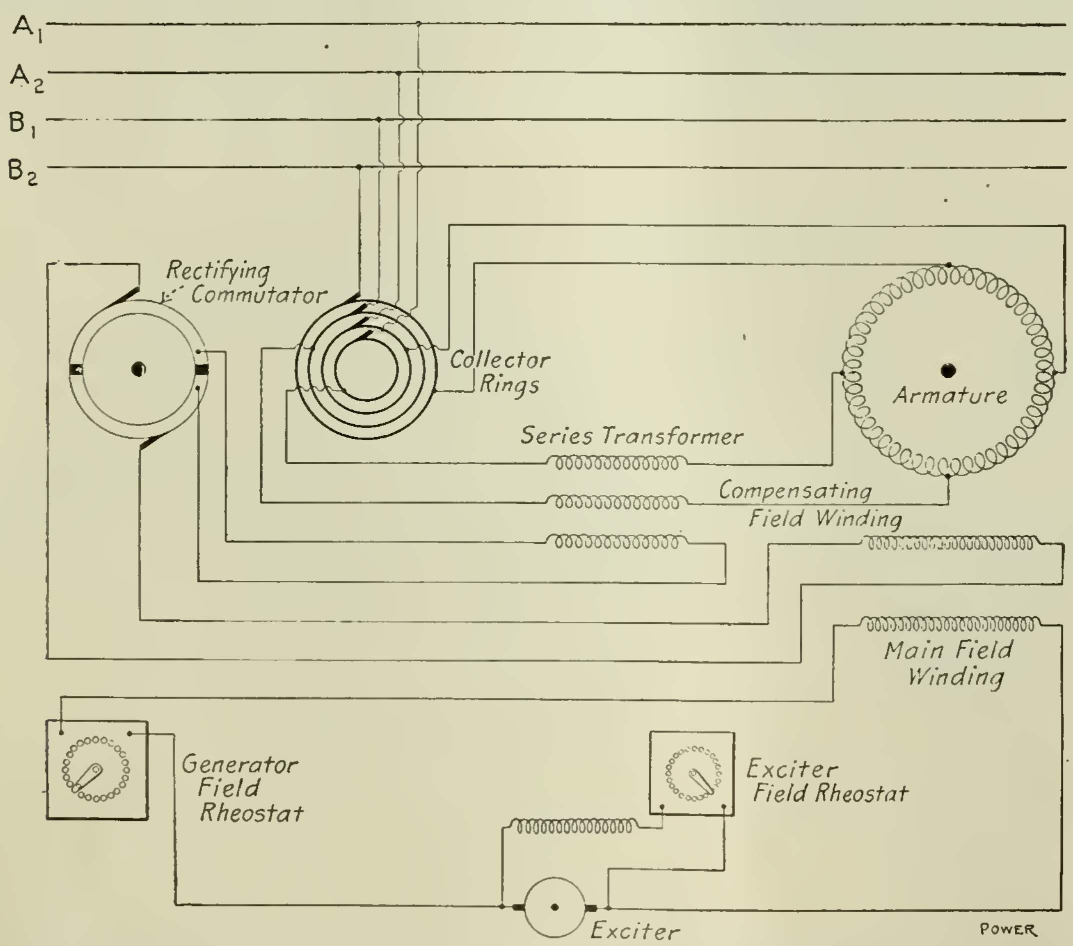


Fig. 13. Complete Circuits of Two-phase Compensated Alternator and Its Exciter

Fig. 12 shows the connections of a single-phase alternator with a compensating winding, and Figs. 13 and 14 show respectively the corresponding connections of a two-phase and a three-phase alternator.

Switchboard Connections of a Single Generator

Figs. 15, 16 and 17 are diagrams of the connections of single-phase, two-phase and three-phase alternators, respectively. The usual switchboard accessories of a single-phase machine, as indicated in Fig. 15, consist of a pair of fuses or a circuit-breaker, an ammeter, a voltmeter, a ground detector and its plug receptacle, a field rheostat and field-connecting plugs and sockets; the exciter is connected to the generator field winding by means of these plugs and sockets.

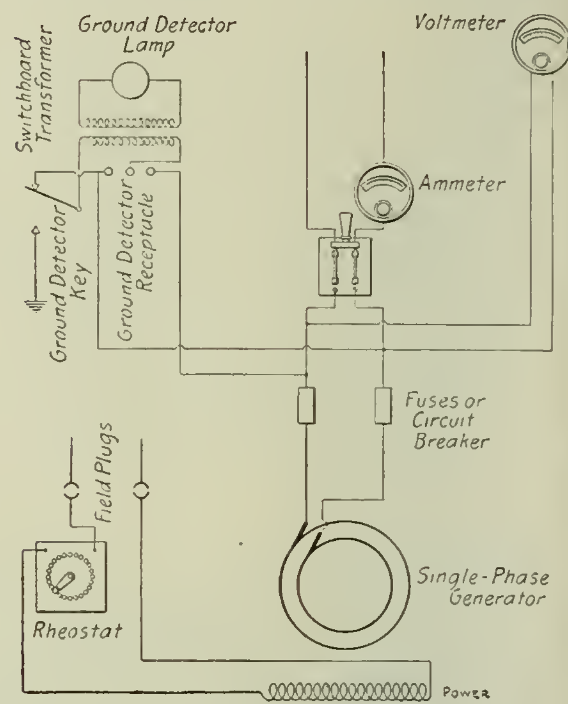


Fig. 15. Circuits and Switchboard Connections of Single-phase Alternator

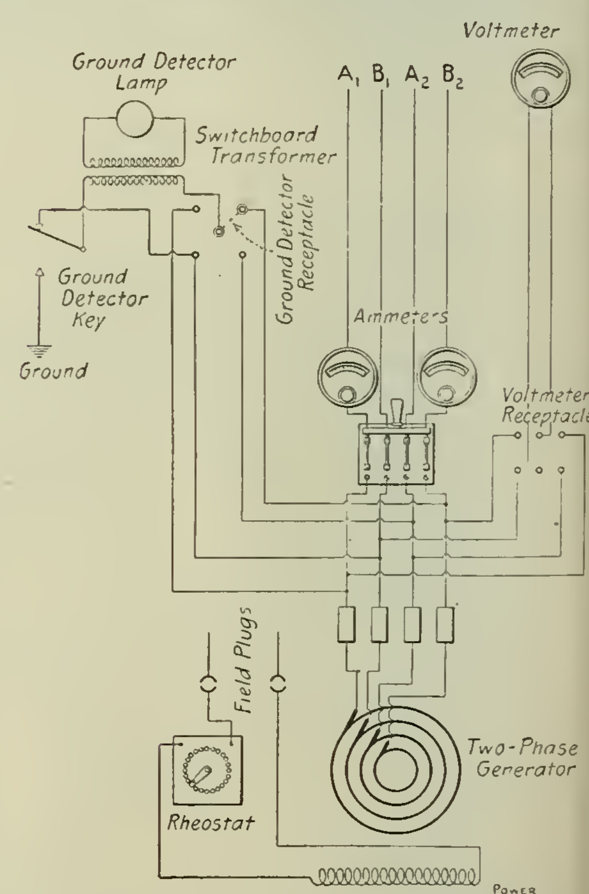


Fig. 16. Circuits and Switchboard Connections of Two-phase Alternator

For low-tension generators of about 600 volts and under, a lamp supplied through a transformer is used to indicate grounds. The ground-detector receptacle is provided with three holes and by means of

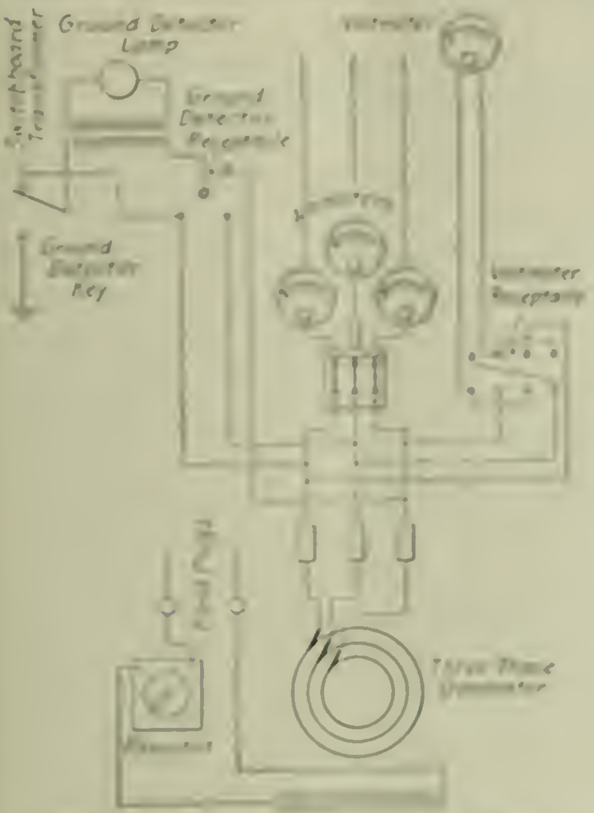


FIG. 17. CIRCUITS AND SWITCHBOARD CONNECTIONS OF THREE-PHASE ALTERNATOR

a double plug the lamp can be connected to either side of the circuit by inserting it in the left-hand and center holes or in the right-hand and center holes. The detector key is depressed when the plug is in one of the two positions and if there be a ground it is then indicated by the burning of the lamp.

Fig. 10 shows the switchboard connections of a two-phase low-voltage alternator. With this type of machine two ammeters are necessary, one for each phase. By means of the voltmeter receptacle a single voltmeter may be connected to either phase; with the plug in the center and right-hand holes it is con-

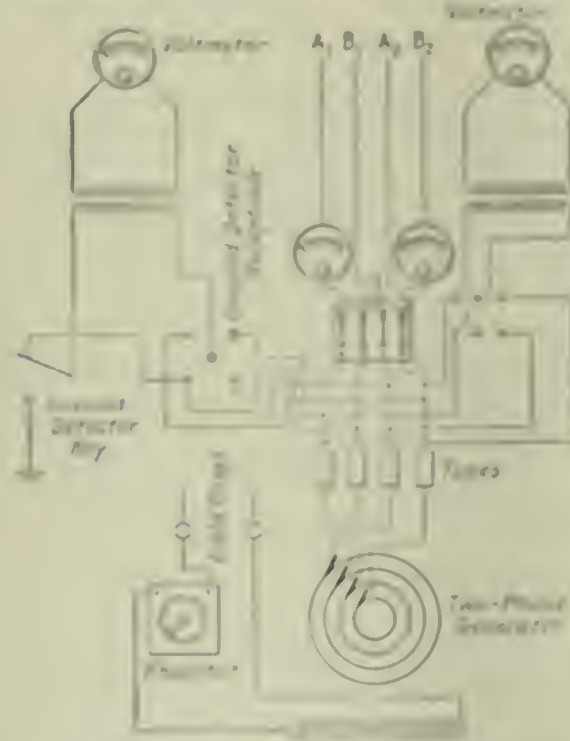


FIG. 18. CIRCUITS AND CONNECTIONS OF HIGH-TENSION TWO-PHASE ALTERNATOR

nected to phase A. The ground-detector receptacle is constructed so that the ground-detector lamp can be connected to either wire of either phase.

The connections of a low-voltage three-phase alternator are shown in Fig. 17. The connections are similar to those of the two-phase generator with the exception that three ammeters are necessary, one for each phase, and the voltmeter and ground-detector receptacles are arranged a little differently to allow connection to either one of three phases instead of either one of two only.

Fig. 18 shows the switchboard connections of a high-voltage two-phase alternator, which differ from those in Fig. 10 only in that a voltmeter is used instead of a lamp for indicating grounds and the main voltmeter is connected to the alternator leads through a transformer instead of by a direct metallic circuit.

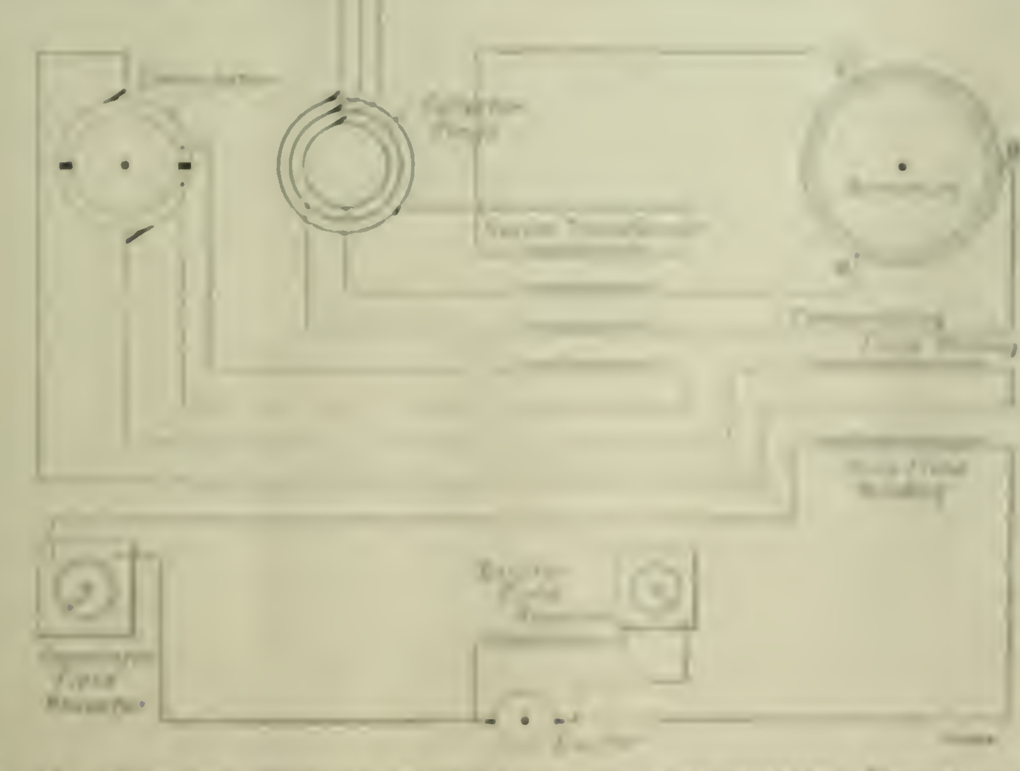
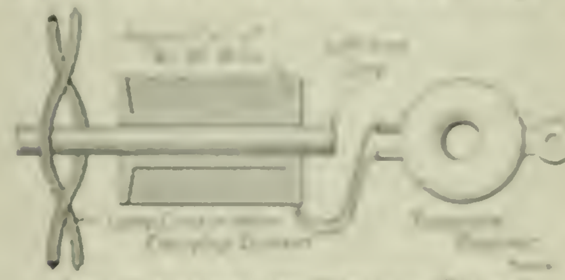


FIG. 14. COMPLETE CIRCUITS OF THREE-PHASE COMPENSATED ALTERNATOR AND ITS EXCITER

LETTERS

Identification of Alternating and Direct Current

The device shown in the accompanying drawing is of much convenience, not only in testing house wiring but in conduit and line work. One of the many uses to



ARRANGEMENT OF TESTING DEVICE

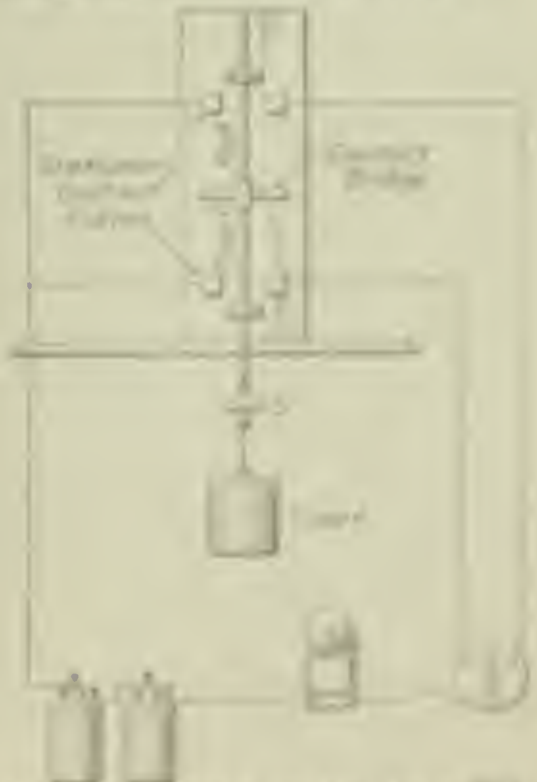
which it can be put is the distinction of alternating and direct currents, which has been the subject of considerable discussion in this department. If the soft-iron core be brought near a wire in which an alternating current is flowing, a loud hum will be heard in the telephone receiver; in the case of a direct-current circuit, the only indication will be a click when the circuit is closed or broken.

R. S. STEEL.

Urbana, Ill.

Mr. Dolphin's Signal System

In Mr. Dolphin's description of a water-tank signal system, which appeared on page 733 of the May 9 issue, the diagram of connections contained an error. The two wires leading up from the two-way switch to the float contacts were shown connected by a "jumper." The correct diagram is shown herewith.



CORRECT DIAGRAM OF MR. DOLPHIN'S CIRCUIT

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Peat Gas Power in Germany

By F. E. Junge

Scarcity of resources and density of population force the German engineer to reduce to the utmost the cost of power in industrial production. In most German industries the power cost is an important item in the total cost of manufacture and, unlike wages and interest rates, it can be lowered by scientific endeavor without harming the income of either capitalists or workmen.

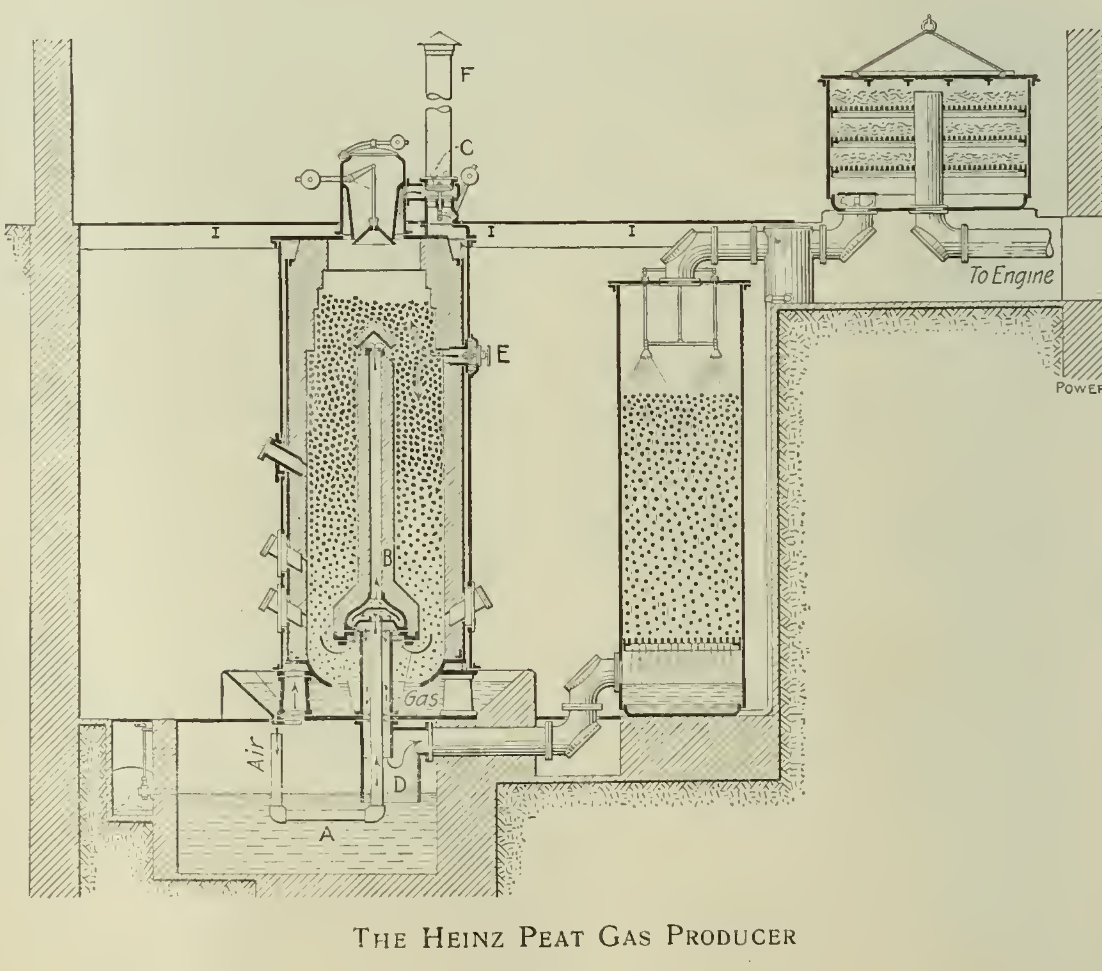
Fuel Supply

While there is a sufficiency of high-grade coals, like anthracite, bituminous and lignite, in the country, it has been found more profitable to use these fuels wherever possible at the mouth of the pit than to transport them by rail or canal to the power houses. In combined iron- and steel-smelting plants and coal mines, for instance, gasification in coke ovens and producers is most practicable, the coke and gas produced being utilized in the furnaces of the plant, the valuable byproducts, tar, benzol and ammonium, being marketed while the surplus available energy is distributed by high-tension electrical systems to neighboring industries, cities and agricultural districts.

Unfortunately, the German coalfields are not distributed symmetrically over the whole country; they are located partly in the extreme east and partly in the extreme west. Consequently, industries which are located in the middle or northern regions suffer from the natural discrimination by lack of cheap sources of power. This disadvantage is being gradually overcome, at least in some sections of the country, by utilizing the peat bogs, which are abundant, for the generation of power.

These bogs have an average depth of 3 meters (9.8 feet). Assuming that one cubic meter of raw peat yields about 150 kilograms (330 pounds) of dry peat, the quantity of dry peat available in Prussia for purposes of power production can be estimated at some eleven billion tons. In Germany, labor is comparatively cheap and reliable. Hence, when installing a power plant we can figure on fetching the raw peat by hand from the field and transporting it by rail or cableway to the power house, which is built in the immediate vicinity of the bog and located below the surface level so that the peat can be dumped from the cart or bucket right into the producer.

One laborer with an average pay of 75 cents a day supplies about 1800 kilograms (3960 pounds) of dry peat per day, 1 kilogram (2.2 pounds) costing about one-twenty-fifth of one cent. For purposes of large-scale power generation, automatic dredges are employed. Such a machine weighs about 3000 kilograms (6600 pounds), is run by one attendant and produces 6 tons of dry peat per hour. The detail cost of operation is 3.5 cents for fuel (benzol), 0.25 of a cent for lubricant, 1 cent for wages, making the total 5 cents per ton of peat turned out. This obviously does not include interest, amortization and repairs to the dredging machine. The capital invested in peat bogs need not be amortized because in most cases good fertile soil is laid open to the plow, whereby the value of the land increases.



The Heinz Peat Gas Producer

Utilization of Peat

There are various processes which enable one to utilize not only the peat gas but a number of valuable byproducts besides. Thus the Woltereck process provides for the utilization of ammonium, which is produced in considerable quantities when a mixture of air and steam is passed above a stratum of carbon. Frank and Caro, having adopted an improved Mond process, utilize not only the byproducts but also part (15.5 per cent.) of the potential heat energy of the peat. Ziegler makes coke, gas and byproducts in special peat-coke ovens. But it is obvious that all these processes, interesting though they are, are rather complicated, requiring both mechanical and chemical skill and making the enterprise often unprofitable, especially when markets for the disposal of byproducts are not at hand. The direct combustion of peat on special grates under steam boilers has also not proved a complete success, because, in most cases, ordinary steam coal must be mixed with the peat in order to evolve the necessary heat.

By far the greatest practical success has been attained with the direct gasification of raw, air-dried peat in producers, the gas being used for the development of power in gas engines and no utilization of byproducts being attempted. Being both porous and light, peat is by nature well suited for gasification in producers. These qualities permit a deep bed of fuel to be used which, in turn, offers a large surface to the air, whereby the oxygen finds ample opportunity to unite with the carbon of the peat. The chief difficulty is, of course, to dispose of the tar-forming constituents and of the high moisture contained in the peat and the only practical way so far developed is to eliminate both within the generator itself. To attain this some producer designers employ two zones of combustion, the same as when using lignite, the gas produced being usually withdrawn from the middle, between the two zones. Some of them draw the gas which is produced in the upper zone through a bypass into the lower zone, the gas being cooled on its way down and the water vapor condensed. Naturally there is some heat lost by this cooling and, furthermore, it is difficult to maintain combustion in the upper zone when the fuel is very wet, because the heat liberated by the combustion below does not materially assist the combustion above.

Peat, being a very poor conductor of heat, does not yield its moisture contents easily by mere warming up. It has been observed in practice that frozen lumps of peat after being for three hours in the combustion zone of the generator, where they were subject to a temperature of some 3000 degrees Centigrade, when taken out were incandescent on the outside but still frozen within, there being a zone of moisture between the outer layers and the kernel.

Another mistake which was made in the construction of peat producers consisted in arranging so that the gas was taken out from the side of the generator wall. There the fuel is generally looser than in the center of the bed; hence, the resistance offered by the fuel to the passage of air is less and combustion livelier, whereby hollow spaces burn out near the wall, through which the air entering below may escape into the delivery pipe without doing any useful service. This leads to operative difficulties.

Finally, there is the difficulty with double-zone peat gas generators that the amount of air admitted to the two zones at various loads cannot be balanced. It is obvious that there must be a fixed ratio between the air entering above and the air entering below, if the composition of the gas during operation is to remain the same. But the flow of air depends on the resistance offered to its passage by the fuel column, and this resistance changes constantly and not proportionally in the two zones; consequently, at one time relatively more air enters from above than below and at another time more from below. If the load on the engine should drop from full to quarter load, the suction effect of the engine in the gas generator will be very low and the air will enter through the path of least resistance, which may be either above or below, depending on the momentary composition of the fuel beds. There is no certainty of operation and the output of the producer remains in practice often far below its rated capacity.

The Heinz Producer

All of the difficulties mentioned appear to have been overcome in a peat producer designed by Carl Heinz for the Görlitzer Maschinenfabrik in Görlitz, Silesia, which seems to afford the most satisfactory method of utilizing peat for the purpose of power development. Unlike the double-zone type, the air enters above and the gas is withdrawn from the center of the combustion chamber below. Gasification of the fuel takes place in one direction only, and the air, instead of traveling along the walls of the generator, is forced to enter the inner strata of the fuel bed. The heavy gases produced in the upper layers of the fuel bed are forced to pass through the incandescent zone below, where they are split up and converted into light and permanent gases.

Another feature of the Heinz producer consists in the complete utilization of the heat generated in the processes of gasification. The accompanying illustration is a vertical section of the complete producer. All of the air for the generator is taken from the pit beneath it, which also contains the scrubber water and the gas-delivery pipe *D*. Part of the air is drawn through the pipe *A* and the superheater *B* into the upper part of the fuel column, whence it must travel down through the fuel bed in order to reach the gas outlet below. The remainder of the air ascends through the space between the outer and the inner shells of the generator, absorbing radiant heat, and under normal conditions it enters, through the valve *C* at the base of the purge pipe *F*, the combustion chamber above the fuel bed. The outer shell usually does not become warmer than the surrounding atmosphere, and the delivery pipe entering the scrubber is only moderately heated, indicating unmistakably that almost all of the heat which is usually lost through convection and radiation is utilized in the generating process.

If the water content of the peat exceeds certain limits, somewhere around 60 per cent., an auxiliary process is employed temporarily by starting a second combustion zone near the top of the fuel bed. This is done by opening the pipe *F* and the auxiliary air-inlet valve *E*, as soon as the attendant notes that the fire on top of the fuel column is disappearing. The valve *C* then closes automatically and the air which is preheated in the space between the shells enters the fuel bed directly through the valve *E*. Thus combustion is started at the level of *E* both ways, the up-draft being provided by the pipe *F* serving as a chimney and the down-draft by the suction of the engine. As soon as incandescence is reestablished on top of the fuel bed the purge pipe *F* is closed off and the valve *E* also, the normal process is thereby resumed. By the temporary employment of this expedient, fuels of very high water content can be gasified. Of course, there is a moisture limit, for in peat containing 80 per cent. of water the 20 per cent. of combustible would be only sufficient to vaporize the water and no combustible gas could be produced. With the auxiliary process the consumption of fuel per horsepower-hour becomes somewhat greater than normal, but the operation is very simple and free from troubles.

In this producer all the gases emanating from the scrubber water are drawn up with the air into the combustion chamber and destroyed. The gas produced is very clean. With continuous day and night operation cleaning of the engine is necessary only once every three months, there being only a slight coating of sediment on the interior surfaces. The removal of slag and ashes can be done at any time during operation.

Air-dried peat, under conditions as they are in Germany, can be had for an average price of 25 cents on the bog. The consumption of peat containing 40 per cent. of moisture varies between 1.9 and 2.7 pounds and that of air-dried peat between 1.20 and 1.62 pounds per brake horsepower-hour, according to the composition of the fuel and the load on the engine. The efficiency of the generator alone is about 92 per cent. and that of the complete plant about 80.5 per cent.

CORRESPONDENCE

Make and Break Ignition Troubles

Under this heading in the April 18 issue of Power, Mr. Kiehn refers to igniter troubles and gives particulars of tests for locating them. Operating engineers will find scant need for these tests if they will remove their make-and-break igniters, say, twice a week, not necessarily for filing up or adjustment but just to see that conditions are all right, that the points are not badly worn and pitted and that serious corrosion has not taken place. Waiting until trouble comes and then applying Mr. Kiehn's tests would savor rather of laziness. It is no great trouble to occasionally remove the two nuts which usually hold the igniter in place; the wiring need not be disconnected at all if the igniter is all right. The foregoing applies to high-tension jump-spark plugs as well as to make-and-break igniters.

Prevention is better than cure in the engine room just as truly as in the conservation of personal health.

[illegible]

Manchester, Eng.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Filing Clippings

Although most of the articles appearing in POWER will be found to be interesting, few will be of such a nature that the average man will want to keep them, for what interests one man, another already knows.

If the card index of the articles kept for reference is used, a good plan is to give not only the title of the article but also information regarding the text.

I have been clipping articles and filing them for the last ten years and, after trying out all other ways, I believe this to be the best.

In order to keep the articles upon different subjects separate from each other they should be placed in heavy manila-paper folders, which should not be folded exactly in the middle, but so that one side will project ½ inch above the other side. This will furnish space upon which to write the title or number of the file. The best way is to use numbers and to have one number placed in each corner of the folder. By means of an alphabetical index written on a sheet or sheets of paper and kept in the file it will be easy to find the proper folder at any time, as this index will give the number of the folder as well as the type of the articles to be found in it.

Instead of filing the folders alphabetically a better plan is to place all of those referring to closely related subjects together. As an example, all of the articles referring to engines, although they might be in several folders, would be so placed that the folders containing them would follow each other. Then there should be several numbers left vacant so that if other folders containing matter on engines, but not contained in any of the first folders, are added later there will be space for them at the proper place. After the space left for added folders there should be several folders covering boilers and their various parts. The file should be made up in this way until all of the subjects have been covered.

In order to be able to turn quickly to the right folder without having to turn over a number of them before reaching the right one it is well to have what are known as guide cards. These are made of stiff paper and are placed between each ten folders. They should project about ⅜ inch above the folders and this ⅜ inch should be cut away for four-fifths of the distance across the tops. The projecting tabs, after the rest has been cut away, should be staggered so that they will not be directly behind each other but each will be one-fifth of the distance across the top to the side of the one in front. Then the guide cards numbered 10 and 60 will be directly behind each other, as will 20 and 70, and so on.

G. H. McKELWAY.

Brooklyn, N. Y.

Making Smokestacks in Manila

The accompanying photograph shows how two smokestacks were rolled on three rollers made out of old pipe. One was a 58-inch stack for a crematory and the other was an 11-inch stack for a road roller. One of the pipe rollers is not shown in the photograph. Any old pipe and timber which happens to be on hand answers. The rolls are adjusted by turning the nuts on the bolts that pass up through the four corners of the frame with monkey wrenches in the hands of the two natives.

HOW SMOKE STACKS ARE MADE IN MANILA

A part of the 58-inch stack is shown, but the 11-inch stack was sent out before the photograph was taken. The rollers are easily turned by means of a chain pipe wrench. A piece of strap iron is placed between the pipe and timbers.

J. M. G. TONEY.

Manila, P. I.

Air Compressor Lubrication

Having noted that considerable interest is being taken in the subject of lubrication by readers of POWER, I am giving the accompanying data which may be of interest. It is a report of the use of lubricating oils in the three air-compressor plants of the Isthmian Canal Commission for the month of February, 1911. It shows the number of revolutions, square feet covered per pint of oil, output in cubic feet of air and the cost per million square feet covered.

Oils Used:	Empire Air Compressor	Las Cascadas Air Compressor	Rio Grande Air Compressor
Valve oil . . .	87¾ gal.	22 gal.	38 gal.
Stationary-engine oil .	157¾ gal.	35 gal.	60 gal.
Air-compressor cylinder oil. . . .	87¾ gal.	23 gal.	45 gal.
Revolutions per gallon of valve oil:			
	236,458	295,655	217,650
Revolutions per gallon of stationary-engine oil:			
	131,532	185,840	137,845
Revolutions per gallon of air-compressor cylinder oil:			
	236,458	282,800	183,682
Square feet covered per pint of valve oil:			
	1,041,107	1,392,597	1,025,122
Square feet covered per pint of air-compressor cylinder oil:			
	1,354,971	1,837,513	1,028,152
Cost per million square feet covered (surface):			
Valve oil. . .	$0.0234	$0.0175	$0.0237
Air-compressor cylinder.	$0.0134	$0.0098	$0.0176
Output of free air, cubic feet:			
	378,879,661	118,770,526	151,205,582

In the air-compressor plants at Empire, Las Cascadas and Rio Grande, there are 14 compressors, each of 425 horsepower and all operating at a steam pressure of 125 pounds. The engines are simple twin cylinder. The compressors are of the double-cylinder cross-compound type. The area of the two steam cylinders is 9.42 square feet; the area of the low-pressure air cylinders is 15.17; the area of the high-pressure cylinders is 9.42 square feet. The speed of these compressors is from 127 to 137 revolutions per minute.

D. E. IRWIN.

Empire, Panama.

Adjusting Cutoff of Corliss Engine

When about to adjust the cutoff of a Corliss engine, of the short-range cutoff gear, start the engine running very slowly and loosen the check nuts on the reach rod, and see that the governor is down on the stops. Then lengthen the rod until the knockoff cam starts to disengage the valve stem; screw the rod out until the knockoff cam will not disengage the hook; or, in other words, until the engine carries the valve. After setting the first cutoff cam set the head-end cam in the same way.

In the case of a long-range cutoff gear, shorten the reach rod until it carries the valve and then lengthen the rod until it will just disengage the hook. Then adjust the knockoff on the second valve or one on the head-end in the same manner.

All Corliss engines with short-range cutoff gears should carry the valves without disengaging when running slowly. A Corliss engine with a long-range cutoff should disengage the hooks at all times; if not, the steam will blow through the engine.

W. R. BOWERS.

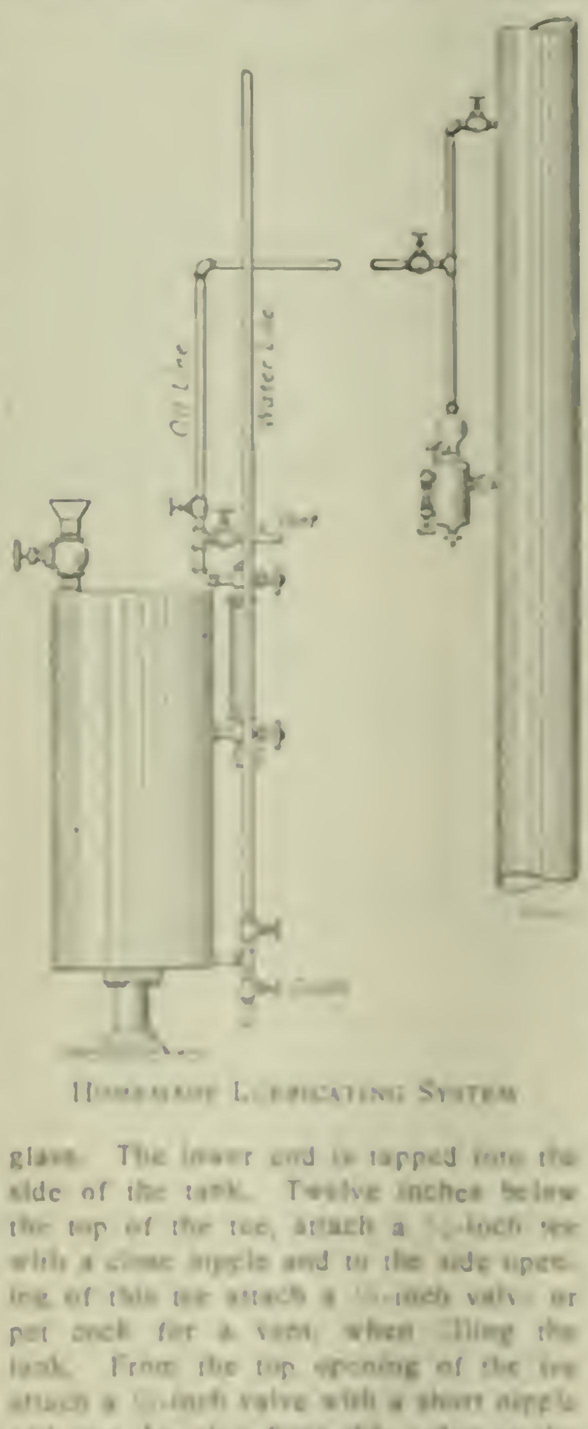
Cleveland, O.

Homemade Lubricating System

The accompanying illustration shows a gravity system for cylinder-oil distribution which works better than any system I have yet tried.

The oil tank is made of a piece of 10-inch pipe, 2 feet or more in length, with the ends capped. On the bottom there is a 2-inch pipe flange fastened by cap screws and into this is screwed a piece of 2-inch pipe about 2 feet long. The bottom flange serves for a floor stand for the tank.

At the bottom of the tank a hole is drilled and tapped for a [illegible]-inch nipple with a tee on the end. A nipple and valve is screwed into the lower end of the tee to serve as a drain. Into the upper end of the tee a short nipple with a valve is screwed and to this the water-condensing pipe is attached, which is connected to a steam pipe. This condensing pipe must not be less than 2 feet above the highest point to which oil is to be delivered. In case the boilers are below the engine level run the pipe up above the highest point of oil delivery and then down to the tank; the cap on the top of the tank should have one [illegible]-inch and one 1[illegible]-inch drilled hole. The larger hole is to be used for filling. It is better to have a short piece of pipe with a valve screwed into this hole, but a plug may be used instead. The [illegible]-inch hole should have a short nipple screwed in and a [illegible] and [illegible] by [illegible]-inch tee screwed securely to the side opening of the tee which is attached to the upper end of the gage



HOMEMADE LUBRICATING SYSTEM

glass. The lower end is tapped into the side of the tank. Twelve inches below the top of the tee, attach a [illegible]-inch tee with a close nipple and to the side opening of this tee attach a [illegible]-inch valve or pet cock for a vent, when filling the tank. From the top opening of the tee attach a [illegible]-inch valve with a short nipple and run the pipe from this valve to the engine or pump lubricators in as direct a line as possible, reducing to [illegible] inch for branch lines.

In case of single-connection lubricators, the oil line should be attached to the bottom of the lubricator where the drain comes out, by using a close nipple, tee and pet cock.

To start the system, fill the tank full of oil, close the valves in the drain, vent and oil line and open the valve in the water line, allowing it to fill with condensed water to its highest point. Have all valves in the branch lines closed and then open the valve in the oil line at the tank and loosen a union at the most distant point to allow air to escape very slowly, until oil shows. Then make the joint tight. The various lubricators are then ready to feed.

A. H. STRONG.

Los Angeles, Cal.

A Successful Municipal Electric Plant

It has been said by many that municipal ownership is a failure. This is true in some cases, but not in all. I believe that when a municipal electric light and water works fails to produce a revenue for the city, the cause is due to either mismanagement or graft and possibly both.

That one municipality owns and operates water and light plants successfully is shown by the figures given herewith.

After years, with an annual expenditure of $5000 for city lights, while the citizens were burdened with the rate of 50 cents a light, or 15 cents per kilowatt-hour, the council purchased the plant from the private corporation for the sum of $14,500 and ran it under municipal rule for about a year, when it was found that the equipment and capacity were entirely inadequate for the needs of the city—the electrical units consisting of one 75-kilowatt direct-current generator and one 30-light arc machine.

Therefore a new plant was built which consists of two high-pressure boilers and two 16x15-inch four-valve engines which run at 225 revolutions per minute. Ten dollars covers the cost of the repairs on both engines since they were put in operation three years ago. Two 150-kilovolt-ampere alternators with two 9-kilowatt exciters and a switchboard were also installed. Current is produced for 2 cents per kilowatt-hour. This includes the salaries of two engineers, two firemen and the cost of unloading the coal.

Current is furnished for the waterworks plant two miles distant. The waterworks plant consists of one 125-horsepower motor direct connected to a three-stage centrifugal pump.

A close record is kept at the electric plant of the coal, oil, grease, waste and packing and other supplies used. The amounts used are put down on the daily station report. All meters are read daily and the readings are kept on the daily station report. The total outlay, including the erection of the building, was approximately $[illegible].

As soon as the new plant was put into operation a continuous service was established which has given the people the advantages of both the day and night service, while formerly, under the old plan, only night service was available.

All rates were put on the meter basis of 12 cents per kilowatt-hour, but after the erection of the new plant, this cost was further reduced by the establishment of a sliding scale which ran from 12 cents per kilowatt-hour down to 8 cents, according to the amount consumed.

Under municipal rule, and in spite of the reduced rates for power, the plant has netted the city a good profit. Besides taking care of the indebtedness of a few thousand dollars, incurred at the time the new plant was erected, keeping up the necessary repairs to the machinery, paying salaries of the employees and other necessary incidental expenses, the commission now has on deposit the sum of $10,000, which, although a portion came from the water works, was largely made up from the revenues of the electric-light plant.

I believe this plant is doing as well as most of the privately owned plants and better than most of the municipally owned plants.

H. B. Adcock.

Newnan, Ga.

No Water—Burnt Sheet

The following paragraphs tell about what might have been a disastrous boiler explosion had the boiler in question been cut in on the header at the time of the accident. The boiler is one of seven, all of which were connected into one common header.

This boiler was washed out on a Sunday and was filled with water to the second gage cock and left for the night fireman to steam up and cut in on the header for work Monday morning.

The boiler was fired about ? o'clock a.m. When the day crew came on duty at 6 o'clock a.m., one of the firemen noticed that the boiler had only 75 pounds pressure and opening the fire door to put in a fire discovered that the sheet over the fire was red hot. He closed the door and had gotten about 10 feet away when the rupture occurred.

The boiler exhausted itself of what steam and water there was in it in about four minutes. It was then noticed that there was still two gages of water in the glass, and upon investigation it was found that the bottom water-column connection was closed. The ruptured sheet was down 8 inches and the diameter of the bag was about 10 inches. The opening in the sheet was 6 inches long and the metal was drawn until the thickness at this point was but 1/16 inch thick.

The fact that this boiler was not cut in is perhaps all that prevented a disastrous explosion. The safety column was a hindrance as the water in the column sustained the float and kept the pressure on the controller-valve diaphragm which prevented the cold water being pumped in on the hot sheet.

I write this letter merely to show how some of the so called mysterious boiler explosions occur. If this boiler had exploded violently, anyone who might have seen it five minutes before the accident could have sworn that there was but 75 pounds of pressure indicated by the gage and two gages of water at the time. In reality there was 75 pounds pressure and practically no water.

H. R. Rockwell.

Alton, Ill.

Worn Governor Links Cause Trouble

At the plant where I am employed, a new, medium-speed cross-compound engine of an uptodate make was installed. When I indicated the engine I got a card that showed an unequal distribution of the load. I made adjustments but found that when I got the cutoff equal on both ends, I had interfered with the lead. As I believe that proper lead is more important than equal cutoff I put the valves back where I found them.

The governor of this engine is fastened to the shaft by means of setscrews set into the holes in the shaft. If one wishes to move the governor it would be necessary to move the hub an inch or more in order to find a new place for the screw and this would set the eccentric too far ahead or behind to give the proper lead.

After this engine had been running about a year it would speed up when the load was thrown off. It finally got to racing so badly that I would have to cut out the condenser in order to prevent a dangerous speed.

I located the trouble in the governor-link bearings which connected the weight to the eccentric. They were badly worn. The stud pins on which the link worked are of brass, but the link is made of wrought iron. This wearing allowed the weights to move out to their farthest position without carrying the eccentric with them, thus allowing the valves to open a small amount. This, combined with a 27-inch vacuum, caused the engine to race. I put in new links and this stopped the trouble.

A. W. Griswold.

Adams, Mass.

Faulty Piping and Carelessness Wreck Engine

The Corliss engine in a mill plant became overloaded and a new high-speed engine was set up to take care of the lighting load.

Not wishing to install an extra condenser or to exhaust to the atmosphere, it was decided to connect the exhaust as shown in the illustration. The engineer wished to connect the engine direct to the condenser, but the makers of the engine connected it as shown. The engineer also wanted an automatic relief valve put in the pipe line, but the valve *B* was used instead.

The lights were on but a few hours, morning and night, and this small engine had to be cut in to the receiver connection while the mill was running. It was the custom to open the valve *B* in the morning and leave it open until the lighting engine was started in the afternoon. Then, while one man closed the valve *B*, another would open the valve *A*, which was placed where the back-pressure gage could be watched. It was, therefore, an easy matter to open the valve and keep a nearly even pressure.

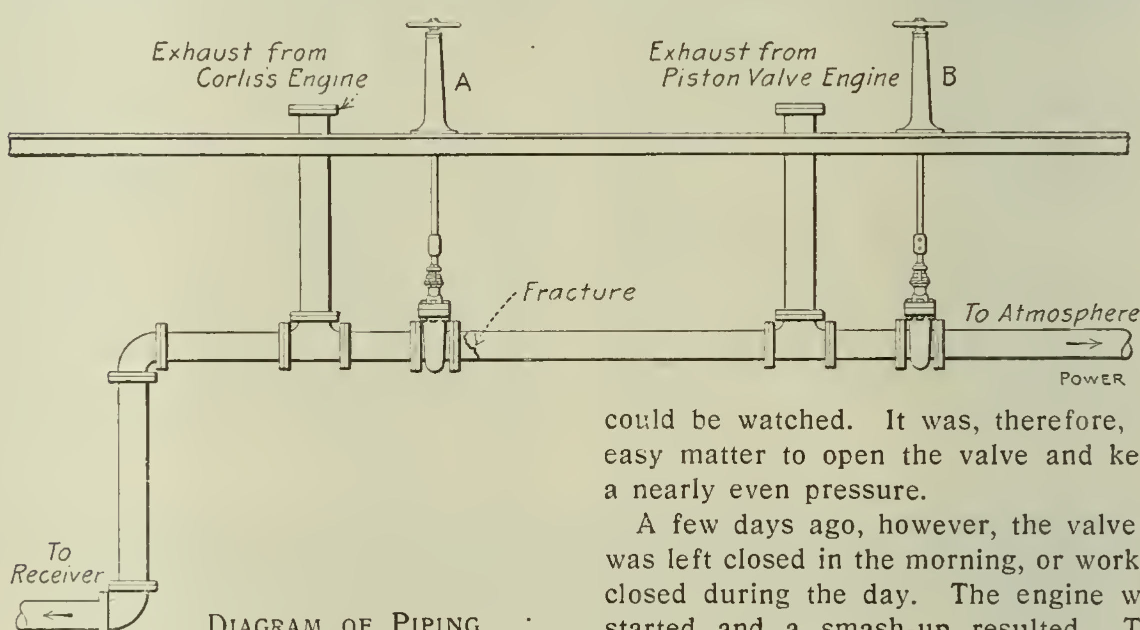


Diagram of Piping

A few days ago, however, the valve *B* was left closed in the morning, or worked closed during the day. The engine was started and a smash-up resulted. The irregular line shows where the exhaust pipe burst.

It is my opinion that the valve *A* was open just enough to allow the pipe to partly fill with water, thus causing the trouble. The engine had hardly turned over when the crash came. It is not strange that the exhaust pipe burst, but just why the engine was smashed so badly is puzzling. The engine accident indicates water in the cylinder while running at full speed, but the exhaust-pipe fracture would suggest water hammer.

Exeter, N. H. L. Johnson.

How to Condense Steam

I am working in a small steam plant where the drinking water is not fit to use.

Can some Power reader give me an idea of how to get up a cheap, convenient device to condense sufficient steam to get a couple of gallons of good drinking water a day?

E. G. Eldred.

Ellensburg, Wash.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Smoke Abatement

I agree with Henry D. Jackson, in the April 11 issue, on preventing smoke by the coking method of firing. I have used the coking method with good results, and prefer it to the spreading or alternate method for most kinds of coal. With this method we have had hardly any smoke, except when crowding the boilers beyond their rating, and then we did not have as much smoke as when other methods of firing were used. When burning run-of-mine coal we have had to resort to the spreading method for over the peak, which sometimes amounted to 50 per cent. overload; otherwise the coal burned too slowly.

Of course, no hard and fast rule can be laid down for firing, yet in the average plant the coking method can be used to advantage, although the fireman objects to it on account of the intense heat he must work in while pushing back the incandescent coal. If the bonus system were introduced and the fireman could see a few extra dollars in it, he would do it as cheerfully as going to a Sunday ball game.

I do not mean to say that firemen are of the shirking kind, but since they are paid a scant living wage for a 12-hour shift in a hot, dirty boiler room, with little or no chance for advancement, the inducement to save coal is not strong.

The coking method of firing and the bonus system of payment are certainly worth consideration.

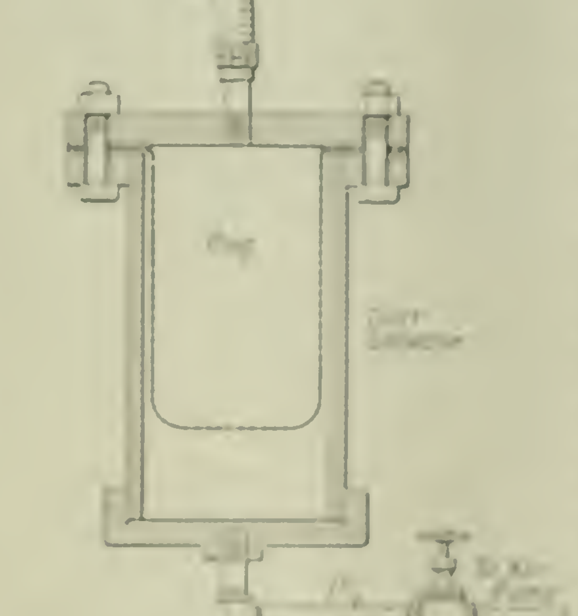
M. W. UTZ.

Minster, O.

Vacuum Cleaner

S. G. Rose, in POWER of May 2, page 688, asks for information upon how to construct a vacuum cleaner for use in his engine room. I will explain as well as I can how to construct a cleaner which will be found very useful in sweeping the floor and cleaning the walls and also will be found especially useful in the cleaning of street-car seats or steam-road coach seats. It can be used wherever there is an air pump or a condenser.

First, take a piece of pipe, preferably 12 inches in diameter, and cut it to the desired length (not less than 2 feet). Cover one end with a cap having a 1-inch pipe connection in it. Cover the opposite end as shown in the drawing. Make a bag out of good strong material like duck or canvas that will fit nicely inside the 12-inch pipe, not coming closer to the bottom than 6 or 8 inches. The top should be made flaring and will last longer if bound with a couple of sheet-iron rings the size of the flange. This sack is to catch the dirt and dust and is to be inserted inside the 12-inch pipe, the flaring top to be clamped between the halves of the flange union. To clean the bag, simply take it out and



VACUUM CLEANER

turn and brush it; it should go in either side out. The 12-inch vacuum chamber can be placed in any convenient location and connected to the suction side of the air pump or condenser with a 1-inch pipe, the connection being made in the bottom below the bag.

For the top there should be a 1-inch hose connection, taken preferably from the center of the flange union, or a pipe may be run from the flange union around the plant to any desired location and taps taken from it at different points, where a shorter length of suction hose will answer for the cleaner.

The cleaner may be made from hardwood, or a heavy brush may be used to advantage by cutting the bristles out of the center lengthwise of the brush, so as to form a slot about ½ to ¾ inch wide. The brush loosens the dirt and the air will draw it up into the hose. A slot will, of course, have to be cut through the wood of the brush and a holder for the hose may be made from a piece of pipe secured to the tin back with which it will be necessary to cover the brush.

J. G. DENNINGTON.

Oil City, Penn.

Solution to Coat Economizer Tubes

In the April 11 issue, page 573, a letter was published on economizer tubes corroding, by C. B. Smith.

The conditions he described are similar to other cases where the feed water used was remarkably pure and good. The deterioration of economizer tubes first came to my notice several years ago and seemingly nothing could be done to stop it. Then I thought it might be possible to plate or coat the inside of the tubes in some way to prevent the pure water from reaching the iron. I got prices, but the cost and expense was just double the price of the economizer.

Then it occurred to me that if I deliberately formed a lime scale on the surface of the tubes that it would accomplish the result I was after. I took the matter up with the Solvay Process Company and they recommended the use of a solution of lime to form such a scale. Some barrels of lime were bought and made up into a solution; the economizer was filled up and the gases were allowed to go through it for a day or so and thereby a nice fine glazed coating on the iron was obtained. The trouble immediately stopped and the machine remained sound and good for the following ten years without any repairs.

It is well known that lime is more soluble in cold water than in hot. Hence, I made a cold-water solution and, passing the gases through the economizer, the water precipitated the lime compound on the iron surface.

I would recommend that the next time after Mr. Smith's economizer has been bored and cleaned out, he have such surface coating applied to his machine and see if it does not stop further corrosion. This coating is as thin as tissue paper and makes no noticeable falling off in efficiency.

I do not think the coating has ever been renewed and, on account of the [illegible] pure water, no scale continues to form appreciably. Before, the scale was formed principally from the iron itself. I have applied the same treatment to one or two other machines where similar trouble showed, with success and no further complaints of corrosion.

H. G. Brinckerhoff.

Boston, Mass.

Cooling Hot Bearings

On the inquiry page of the April 18 issue of Power, H. C. B. asks for the best way to cool hot bearings while running and the answer is, "Use graphite and oil." I am aware that this mixture is what may be termed the standard cure for cooling hot bearings but, according to my experience, a good deal depends on other things. The best way to feed this mixture has always seemed to me to be through the oil or grease-cup hole, using a plug of wood to stir it through and having the mixture slightly warmed so that it runs through easily. Then, if the oil grooves in the bearing are cut on the small side or are shallow, this method of cooling off will not be so efficient as it will be if they are deep and of generous proportions. The same remark applies to short grooves leading "nowhere" which are not to be compared to crosscut grooves.

Another factor in the successful application of the graphite-oil mixture is the material of which the bearings are composed. Babbitt or antifriction metals are not as quickly cooled by the graphite-oil mixture as are gun-metal or bronze bearings. For antifriction metal bearings I prefer to use flake mica mixed with a good lubricating oil in the proportions (by weight) of 16 parts of oil to 1 part of mica. This mixture has indeed always seemed to me to be at least as efficient, if not more so, as the graphite-oil mixture in curing hot bearings, although I do not advocate its continuous use. I have been successful with the mica-oil mixture in cases which the graphite-oil treatment would not look at, and am acquainted with a railroad engineer in the running department of one of the largest railways in this country who advocates its use for locomotive hot boxes, although he uses more mica in his composition than I do for ordinary bearings—I think his is a 10 to 1 mixture.

Only a few weeks ago a friend of mine was having trouble with the gear box of his 25-horsepower automobile. This would run very hot in spite of all he could do and even the thickest oil he used would become thin enough to run out through the ball bearings and make a nasty mess in the undershield. The gear box has been back to the makers twice but has been returned, each time running hot again. The ball bearings are not the cause of the trouble, which appeared to originate with the gear wheels of the fourth speed, which is indirect and which my friend uses most of the time to save his engine. After he had tried oils and greases of all kinds and consistencies, including all sorts of graphite mixtures, I proposed giving the mica-oil mixture a trial. He did so with perfect success attending the experiment. The mixture was 15 parts of Vacuum Mobiloil, "C" grade, to 1 part of flake mica. I am inclined to the opinion that flake mica—more so than flake graphite—forms a more substantial cushion between the bearing surfaces, be they journal and brass or tooth against tooth, and it is not so easily squeezed out.

I have a case on hand at present of a 6-ton motor lurry, in which the steel timing wheels at the front of the engine make a loud buzzing noise in spite of their oil-tight casing being filled with lubricant of good repute and the right consistency. Encouraged by the success attained by it in the gear box above mentioned, I am going to give the flake-mica mixture a trial in this case. Were the gear-wheel case open to the engine-crank case I should hesitate before trying a mixture of more than 1 part of mica to 20 parts of oil because, the engine being provided with forced-feed lubrication with drilled crank shaft, connecting rods, etc., I am afraid that the small passages in these parts might become choked with the flake, with perhaps serious results to the engine.

John S. Leese.

Manchester, Eng.

The Position Higher Up

Mr. Miles' article on the above subject in the May 2 number contains some good points and moves me to submit a few comments on the subject of advertising for positions and answering employers' advertisements.

In writing an advertisement for a position it seems to me it should contain a brief description of ability, an offer to refer to past employers, a mention of sobriety, and, last but not least, a willingness to accept the position on trial.

I have always found it an easier matter to write an intelligent advertisement than to answer one of the ordinary kind placed by many employers. Even after corresponding with them it is a difficult matter to get them to state the full particulars of the position in question.

Several years ago I placed an advertisement for a position that would pay not less than a stated amount, and received an offer as head engineer in a 600-barrel flour mill in a small town of a few hundred inhabitants.

On asking for full particulars they informed me the mill operated day and night, I would be expected to do my own firing, and the plant consisted of two boilers and one Corliss engine.

I accepted the position and on arriving found two boilers, one Corliss engine, one high-speed engine driving a generator furnishing lights for the village and the mill, and one engine running the elevator. In addition there was a geared locomotive used for switching purposes to be kept in repair.

I refused to remain under those conditions, and was therefore out the expense of a 500-mile trip that could have been avoided had they given me the full particulars.

We often see an advertisement reading something like this: "Wanted: First-class engineer to take charge of complete steam-power plant. State experience and salary desired. References required."

There is nothing intelligent about such an advertisement. Possibly it is a 6000-horsepower plant and again it may be only a 1000-horsepower plant. If one were to make a price to fit the former and the plant was of the latter, possibly he might lose just the position that would suit him best. It might have been an uptodate plant in the locality he desired and had he known it could have made the price accordingly. The chances are the letter would never be answered.

Joseph Stewart.

Hamilton, O.

An Engineer's Views

Referring to the editorial on the first page of Power of February 21, it is only too true that a great many of us do become so absorbed in the routine work that we fail to see the advantage of adopting some new method or appliance, and at other times we realize the advantage but wait for some favorable opportunity to explain our views, and while we are waiting some specialist comes in and recommends that such and such be done. It also often happens that when the engineer does advise the purchase of some new machine or appliance, he is not prepared to show just what the advantages are or what the saving will be, while the expert is loaded with the necessary data to prove all that he claims. It would be unreasonable to expect the operating engineer to be as well posted on all subjects connected with the power plant, as half a dozen specialists would be on the different subjects.

The engineer and manager should be on friendly terms and should understand each other and the conditions under which the plant must be operated. The engineer should endeavor to prove that, while he is a necessity, he is the most valuable man on the place, not by doing all the dirty jobs that no one else wants to do, but by keeping up with the times, being posted on the latest and most improved methods, and last but not least by putting his knowledge into effect. A few years ago the engineer was the one called on to do all the odd jobs that no one else was willing to do, while today there are hundreds of plants where the engineer is highly respected and has all the authority he wants. There are hundreds of managers and owners looking for men capable of assuming the responsibility of their plants and making a success of them.

The refrigerating engineers have recently organized the Practical Refrigerating Engineers' Association, for the purpose of educating and elevating its members, and their constitution plainly states that the association shall at no time take part in any strike or anything that will in any way interfere with perfect harmony between its members and their employers. Owners and managers are eligible to associate membership and are welcome at any and all of their meetings. It is the earnest desire of the association to create a more friendly feeling between its members and their employers than generally exists.

J. B. Embrey.

Shreveport, La.

Water Coils Burn Out

On page 534 of Power, April 4 issue, is an article by R. A. Booth about water coils burning out. I would suggest that all the return bends be taken off and manifolds substituted. It is evident, with the coils burning out so rapidly, that the pipe is not always filled with water.

Suppose the boiler is being fed lightly, then the water having a slow but forced circulation would gradually increase in temperature until steam was generated. This would, of course, allow the coils to be burned.

To obtain proof of this, Mr. Booth could attach a thermometer cup to the line after it leaves the coil to enter the boiler.

If the feed pipe, after leaving the coil, does not come out of the brickwork, it would probably be an easy matter to extend the pipe and return it so that the temperature of the water could be taken. By doing this Mr. Booth might also obtain an answer to his second question, "Do these coils increase the efficiency or capacity of the boiler?"

Mr. Booth also asks what advantage the coils have over other kinds of feed-water heater? This is a question that can be best worked out individually. If Mr. Booth has plenty of exhaust steam that is going to waste, then without a doubt a good first-class exhaust-steam heater would raise the temperature of the feed water to around 212 degrees and would be a good investment. If the temperature of the feed water cannot be raised economically beyond 120 degrees, then I should think the coils would have the advantage.

Some time ago, at a plant where I worked, they decided to try coils in the furnace. The boilers were forced pretty hard and were fired with anthracite coal. Everything went along smoothly for about a month; then came the climax in the shape of a return bend bursting. Both fire doors were blown open and hot water, ashes and coal enveloped one of the coal wheelers, badly burning and scalding him. The brickwork inside the furnace had to be renewed.

G. H. Handley.

Newburgh, N. Y.

The Line Shaft Breaks

The question in reference to the breaking of line shafts in Power for May 2 comes under my observation and practice, generally with the following results: Hemp rope is continually expanding or contracting with weather conditions, and on the single-rope, or what is better known as the independent-rope, drive always gives the most trouble from breakage of the shafting. Take Fig. 1 for an example, which shows a central wheel with bearings placed a considerable distance from the hub. The shaft is sure to break sooner or later. By moving these bearings close up to the hub, the danger of breakage is greatly lessened.

The tension of the rope causes a continual springing of the shaft, and, to further sustain this statement, the shaft invariably breaks in damp weather when the rope would be the tightest. Another reason is that the rims of large rope wheels vibrate, due to the side swing of the rope. I believe this also tends to spring the shaft and compels it to yield when the bearings are placed as far apart as shown in Fig. 1. By moving the bearings A and B closer to the hub a much better support is obtained.

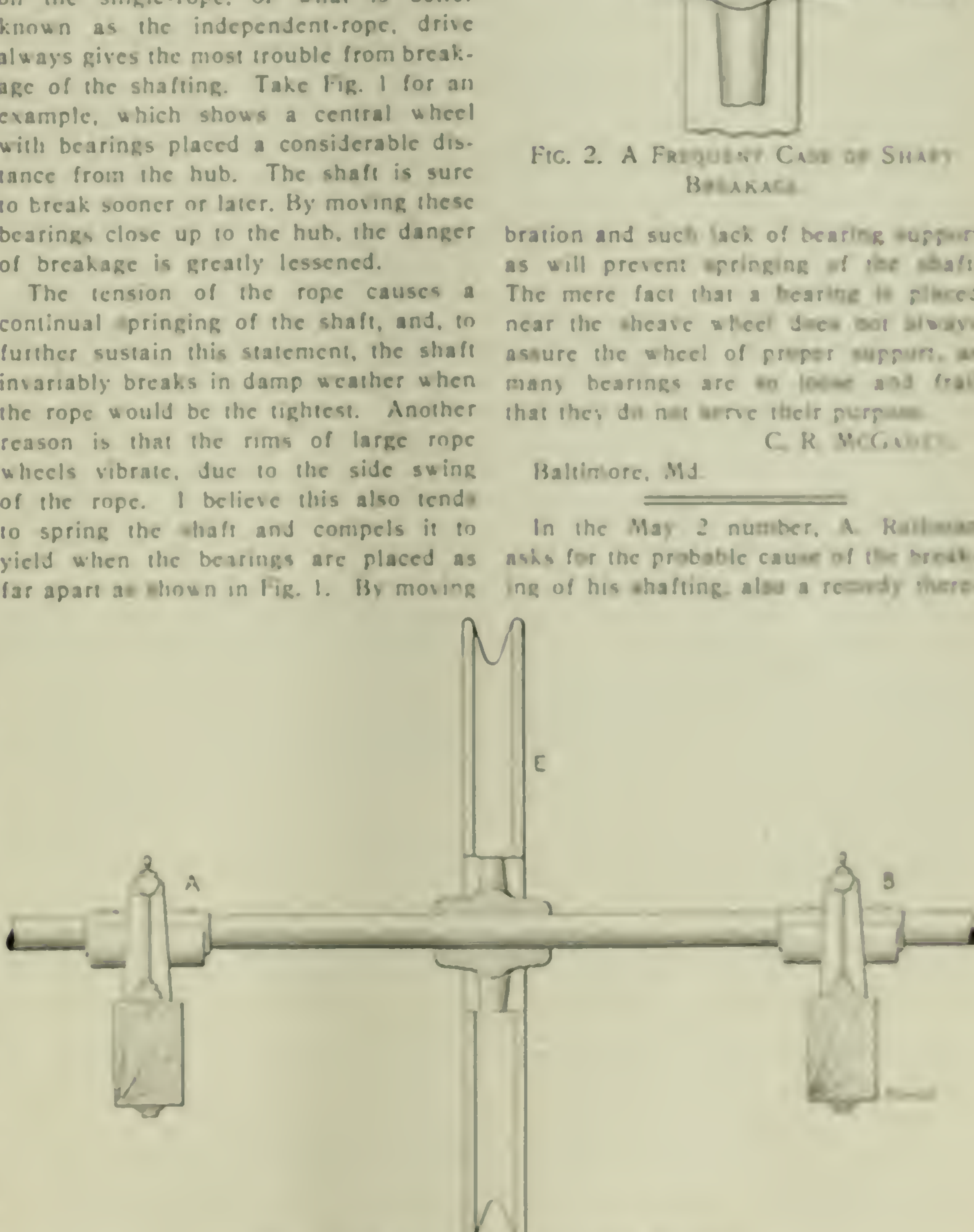


Fig. 1. Bearings Too Far from Wheel

Fig. 2 shows another example in shaft breakage. I have seen this both in belted and rope-drive wheels. The same shaft was broken several times in the same place, the break occurring in each case at the center of the hub, which was made with a long counterbore. This break would always occur at M. On one occasion the hub was bored out up to the counterbore and a sleeve inserted. No further trouble was experienced. Whether this proves the case or not it is a practical example. Possibly a piece of shafting was secured that was more homogeneous.

I believe that Mr. Rathman will find that his trouble comes from lateral vibration and such lack of bearing support as will prevent springing of the shaft. The mere fact that a bearing is placed near the sheave wheel does not always assure the wheel of proper support, as many bearings are so loose and frail that they do not serve their purpose.

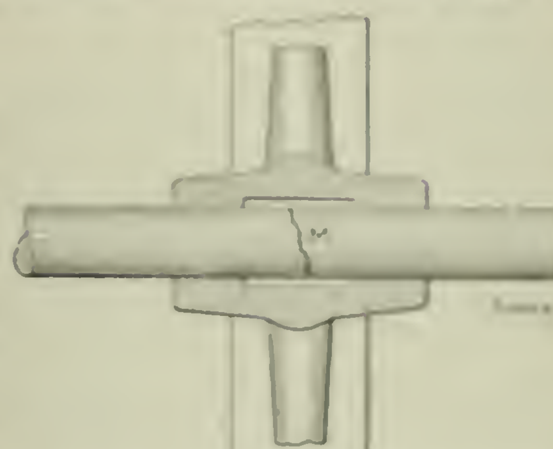


Fig. 2. A Frequent Case of Shaft Breakage

C. R. McGahey.

Baltimore, Md.

In the May 2 number, A. Rathman asks for the probable cause of the breaking of his shafting, also a remedy therefor. He has hardly given sufficient data for accurately diagnosing his case, for he might have mentioned the number of revolutions the shafts are making per minute, the distance between the hangers and the pulleys, the kind of machinery driven, etc. In the absence of such details only general suggestions can be offered.

Seeing that the shafts are carrying rope sheaves they should be proportioned for head shafts. Applying a rule used by Jones & Laughlin for cold-rolled iron shafts of this class, hangers not more than 8 feet apart, the following formula is obtained:

$$H.P. = \frac{Dia.^3 \times r.p.m.}{100}$$

It will be found that the $2\frac{15}{16}$-inch shaft, to transmit 50 horsepower, must run at a speed of not less than

$$\frac{50 H.P. \times 100}{2\frac{15}{16}^3} = 198 \textit{ revolutions per minute}$$

In the same way the $2\frac{7}{16}$-inch shaft, to transmit 20 horsepower, must run 138 revolutions per minute. If the shafts run slower they are overtaxed. When shafts are so loaded and supported that the deflection amounts to more than 0.01 inch per foot of clear length between bearings, they are apt to break. To guard against this use hangers at shorter intervals and, if possible, place a hanger close to each side of a sheave. If the full power is delivered by one sheave located in the middle of an 8-foot span, the $2\frac{15}{16}$-inch shaft ought to be increased to $3\frac{3}{16}$ inches.

It is stated that the shafting is in line; but while this may have been the case once, it should be verified periodically, especially after an accident, and the anchor bolts of the hangers tightened. Care should also be taken to allow sufficient end play, the shaft collars and couplings being set to allow full sway to expansion resulting from heating. A shaft 245 feet long will, in warming up from 60 to 110 degrees Fahrenheit, increase one inch in length.

If the shafting suffers from irregular vibrations, it might be advantageous to place a few small flywheels on it for equalizing. Keyways are known to weaken shafting and to affect its alinement. The diameter should therefore be increased, or split pulleys and couplings used, which are merely clamped to the shafting and strengthen instead of weaken it.

If the path of the ropes is not steeper than about 45 degrees from the floor up, the drive may, as a last resort, in some places at least, be changed over from the American system with its one continuous rope, to the English system with a number of independent ropes. In this way the shafts may be slightly relieved and in case one rope breaks the others will carry the load until opportunity permits making repairs.

Charles H. Herter.

New York City.

Judging from the sizes of shafting given by Mr. Rathman and supposing that they run at a moderate speed, the shafts should easily deliver the power mentioned without being strained, but the fact of their breaking is evidence of a strain beyond their power to withstand.

From the article it would appear that the shafting is suspended from the ceiling by hangers. I have seen hangers sprung out of line considerably by belt tension, thereby causing the very trouble of which Mr. Rathman complains. This can easily be tested by taking a broomstick, driving a wire nail into each end, the whole being long enough to reach from some point near and to just touch the shaft when stationary. Put the shaft in motion and the stick will show any bending or nonalinement.

I would next look at the distance from center to center of the bearings on each side of the driving wheels and would endeavor to place them as close as conditions will permit. If the bearings are as close as possible, then a new shaft should be installed with a "swell" of at least ½ inch where the driving wheels go and let the larger diameter extend some distance on each side.

I have in mind one shaft which had given a lot of trouble and had been replaced several times. Increasing the size did not overcome the trouble. When the broomstick method was tried it was at once apparent that the supports on the ceiling were not rigid enough to stand the strain when the shaft was in operation. The shaft was then placed on proper foundations on the floor, and no further trouble was experienced.

C. F. Sampson.

Philadelphia, Penn.

If Mr. Rathman's shaft is in line and is not overloaded. I would suggest that a hanger be placed near the sheave. Without much doubt the distance between the hangers is too great, and when the shaft is carrying the load the strain is at the sheave.

Albert T. Guilman.

Stafford Springs, Conn.

Installing Oil Burner

On page 694 of Power, May 2, E. W. E. asked for a little information on installing oil burners.

Having had some seven years' experience in that line of work, I would say that the answer gives him the *little* information, and very little at that, especially if he is in no way familiar with oil burning.

The proper arrangement of a furnace for the economical burning of crude oil depends on several conditions, one of which is the kind of boiler under consideration. As he does not state this, I will suppose he means a standard return-tubular boiler of the class usually employed in stationary work and 66 inches in diameter by 16 feet in length. In this case the bridgewall should be entirely removed and the grates should not be less than 24 inches or more than 36 inches from the shell of the boiler for economical results. The combustion chamber should be filled up with earth to within 16 inches of the shell at the back end of the boiler and continued on an incline toward and meeting with the back end of the grates, and may be rounded slightly up toward the side walls.

The entire surface should be covered with firebrick, including the grates, excepting a space 12x18 inches in each corner at the front of the furnace. These will admit a sufficient amount of air for most cases. Aside from this the interior of the furnace need not be changed from what it was for burning wood or coal.

The blowoff pipe should be protected by a firebrick pier built up in front of it to where it enters the shell. The burner should be set in the center of and extending into the furnace 4 inches beyond the door-jamb line. The distance from the top of the firebricks on the grates to the center of the opening in the burner should be 6 inches. Be sure to set the burner exactly level. If it is allowed to slant downward, the flame will strike the bricks and reflect against and injure the boiler shell. If it points upward, the oil will not burn steadily and the boiler, as in the other case, will be injured.

The opening in the burner tip should be of a sufficient width to just allow the flame to reach the side walls when working at its full capacity. If this plan is followed, no damage will result to the boiler under the heaviest firing. However, care should be taken not to crowd the fire until the setting has become thoroughly heated up.

Charles F. King.

Portland, Ore.

Buying Coal on B.t.u. Basis

I have followed with a great deal of interest the numerous articles in Power from the scientific writers who have been urging that a little more science is all that is required to make everything lovely in the power house, but I am afraid that these writers too often overlook the problems of human nature and established commercial conditions.

For instance, I have been greatly impressed with the arguments in favor of the purchase of coal on a B.t.u. basis, so I decided hereafter to buy heat units instead of mere carbon and ashes, and solicited bids from numerous mines for a shipment of 400 tons of pea coal for gas producers, payment to be made on a basis of B.t.u. Practically every mine on the line of the Central Railroad of New Jersey (to which we are bound hand and foot) replied in effect that they did not take any stock in heat units and I could buy the coal just as they offered it or go without, as I chose.

I agree in the abstract with everything that the scientific men have written, but, unfortunately, very few of their suggestions can be carried out under present conditions.

S. W. Rushmore.

Plainfield, N. J.

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Contents

POWER

The Oil Engine

There is probably no field in which prophecy is more futile or less likely to be vindicated than in engineering. People are continually developing apparatus which had been solemnly declared impractical years ago by those versed in the scientific principles involved. For example, before steamships were fully developed it was asserted by authoritative students of the subject that Fulton's efforts, while laudable and practical within a very restricted range, could never result in transatlantic steamboats because a boat could not carry enough coal to keep up steam throughout such a long trip, even if the engine could be made to run continuously, which was considered highly dubious. It was also proclaimed that Professor Langley's optimism regarding the possibility of building a flying machine was without solid scientific foundation because it would be impossible to make an engine light enough to enable it to sustain its own weight and that of the machine and the operator.

The same general kind of predictions have been made concerning the future of high-compression oil engines such as the Diesel. In the first place, the supply of petroleum products could never be sufficient to meet the requirements of any very large aggregate of power output; in the second place, the nature of the operating cycle demanded the unremitting care of a corps of highly skilled technical nurses which would cost more in excess wages than the saving in fuel expense and fixed charges would cover. These predictions are apparently being refuted as effectively as the others have been. Recognizing the limited supply of crude petroleum, the Germans have resorted to the production of fuel oils from almost as many and as unsuspected sources as have been pressed into use by makers of American breakfast foods. Also realizing that men trained in high-grade manufacturing are not commonly obtainable in Siberian wastes or South American jungles, they seem to have raised the mechanical structure of the oil engine to such a degree of dependability as to encourage its use almost outside the geographical limits of civilization.

We are reliably informed that the Diesel type of oil engine is in actual use in Siberia, under mechanically low-grade supervision, to the extent of thousands of horsepower, and we sincerely take off our hat to the men who have achieved the results which make such a thing possible and express a cordial wish that American engineers may emulate their fine example.

Mathematics and the Engineer

It is, perhaps, unfortunate that comparatively few operating engineers are mathematicians and that any matter containing algebraic signs is avoided like a pestilence by the most of them. But there is this mitigating condition: Mathematical talent and practical fitness for the care and operation of moving machinery are seldom found in one individual.

It is, however, fortunate that all of the mathematical knowledge that is really needed by an engineer may be readily acquired by anyone who has the attainments expected in a schoolboy fourteen years of age. It is not so much the lack of the little skill necessary to handle algebraic formulas and elementary trigonometry that handicaps the operator as his aversion to logical thinking.

As a boy, when playing seesaw, he instinctively took such a position on the plank that his weight balanced that of the boy on the other end, but he did not then, and probably has not since, considered that his weight multiplied by his distance from the supporting trestle or the fence rail exactly equaled the product of the other boy's weight and his distance from the fulcrum. If he had, and in consequence of this consideration had calculated the weight of his playmate from the relative distance of the two from the fulcrum, no safety-valve problem would require the hours of study sometimes given to the subject.

There is no good reason why the engineer should balk at algebra or trigonometry. The formulas are merely a "shorthand" way of writing a rule and they are much simpler and more easily remembered than the long-drawn-out statement of the same operations expressed in conventional English. When the electric generator, the refrigerating system, the air compressor and the hydraulic elevator were placed in his charge, the engineer did not balk because he did not understand them. He tackled the problems man-fashion and mastered them.

If he would pursue the same course with mathematics he would be surprised at the shortness of time in which formulas that previously seemed hopelessly complicated became clear.

No investment that an engineer can make will pay such dividends as time spent in the study of the elementary branches of the science most nearly related to his work.

Practice and Theory

At the recent meeting of the American Society of Refrigeration, in Chicago, it was said that when a need arises in this country for some application of refrigeration, when something needs to be done and done quickly, we go ahead and do it and then send to Germany to find out how we did it.

The one illustrates practice, the other theory. Seemingly they do not always go together. For instance, theory says that we should always keep the fire doors closed; that air, admitted over the fire, results in cooling the gases of combustion and therefore decreases efficiency. But many firemen who never heard of a heat unit have discovered that leaving the door cracked open immediately after firing results beneficially.

Careful experiments with pyrometers in boiler settings have verified the fact that the temperatures are actually higher and more water is evaporated when the door is opened slightly immediately after firing, than when the door is kept closed.

The nontheoretical fireman who first found this out was satisfied to know what he knew without knowing why he knew it, but the man who made the pyrometer experiments was not so easily satisfied. He called on theory to explain and theory responded with an explanation.

Of course, after practice had pointed the way it was easy to show that on account of the large amount of volatile matter being distilled from a freshly replenished fire, better combustion could be obtained by allowing some air to enter directly over the fire and burn the gases, which otherwise would not get sufficient air through the grate and would pass off unburned. Theory did not lead the way in this, however; it was practice which first demonstrated it.

The moral is: Do not be hedged in too closely by the theories that you already know; by trying something that seems to be contrary to those theories you may do something better than it has ever been done before, and the theoretical law governing the case will be promptly brought to the front. But do not take this as advice to waste time and money on things that clearly violate fundamental natural laws, such as perpetual-motion schemes.

The Passing of the Piston

Eight years ago we published an editorial under the above title. With the passing of the years the tendencies which were the theme of that article have become more marked. For large electrical work nobody thinks of anything but the steam turbine which is now built in units of twenty thousand kilowatts, with no indication that the limits of capacity or of efficiency have been reached, and is developing a horsepower-hour on less than ten pounds of steam.

More than four million kilowatts capacity have been sold by the three large companies, the far greater proportion of it since the editorial in question was written. The small steam turbine is making serious inroads into the field of the high-speed automatic engine. The turbine pump is continually winning favor even for pressures as high as those required for boiler-feed service.

And now comes the centrifugal blowing engine to contest the field with the massive air tub driven by a slowly running reciprocating engine. A sixty-thousond-foot centrifugal blower turbine driven with condenser complete can be had for sixty thousand dollars. A gas-engine driven blowing engine of the same capacity would cost two hundred thousand. Is the greater efficiency of the gas engine worth this difference in cost?

Chimneys

A subject about which the average engineer knows very little is that of chimneys. He may have a somewhat hazy recollection of having been taught that the principal factor affecting natural draft is the difference between the weights of the column of gas within the chimney and that of the outside air; but if called upon to calculate the size of a chimney he would probably be all at sea.

Both Rankine and Peclet attempted to solve the problem from a theoretical standpoint, but their formulas were more or less involved and it was found hard to apply them to practice. Later authorities have formulated empirical rules, but their constants have differed widely and the results, as a whole, are far from satisfactory.

The design of a chimney is much more complex than determining the dimensions of a steam engine to produce a given power at a given steam pressure and piston speed. In the case of the steam engine most of the quantities are fixed or under complete control, whereas, with the chimney, so many variables enter into the problem as to make it indeterminate except for assumed conditions. If more coal is to be burned per square foot of grate surface it means a larger volume of gas passing up the chimney, which must be provided for by increasing either the area or the velocity, the former requiring a larger diameter of chimney and the latter a greater hight. Furthermore, different thicknesses of fuel bed require different intensities of draft, or a wind blowing over the top of the chimney may produce suction and increase the draft. The length of flue, number of bends and the path of the gases through the boiler, all have their effect upon the draft.

With such conditions, it may seem strange that so many chimneys are built which successfully meet the conditions of service. The fact is, however, that chimney designers, while employing empirical formulas to a certain extent, really depend more upon their experience and the large amount of data at their disposal than upon the formulas.

A Good Suggestion

At the Illinois State convention of the National Association of Stationary Engineers, a valuable suggestion was made regarding the possibility of the organization coöperating with the University of Illinois in educational work. The Illinois State Association has an educational committee the duty of which is to promote, in one way or another, interest in engineering subjects among the different local associations.

This has been done by issuing, periodically, a list of questions to be answered by the associations, with a prize for the highest grade during the year, and by giving lectures on various engineering topics at different points in the State.

The suggestion was to consider the possibility of arranging with the university an annual meeting extending over perhaps two days and one night, at which lectures would be given and tests run on various power-plant equipment available in the laboratories, the subjects being such as would appeal especially to men engaged in the steam-engineering field.

There is no doubt that the university would welcome any such arrangement. A great deal of the information now gathered by the university is ineffective merely because of the failure to get it into the hands of the proper persons. One of the former professors, happening to be in the engine room of a power plant and noticing some bulletins of the university on the desk, asked the engineer how he came to get them. The reply tells how a great deal of this material goes to waste: "The university sends the bulletins to the superintendent; he throws them into the waste basket and I pick them out!" Undoubtedly there is too much of this waste-basket circulation.

It is to be hoped that there will in the future be more of an organized effort on the part of engineering societies toward closer relations with the various institutions of learning, not only in Illinois, but elsewhere.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Steam Engine Regulation

I have a 16x42-inch Corliss engine which takes steam full stroke a large part of the time. If I change the length of the knockoff rods to give a longer cutoff, the engine lags and seems to have little power. What can be done to improve the regulation?

W. H. M.

It appears that your engine is either overloaded or the valves are not properly adjusted and should be reset.

Place the wristplate in the middle of its travel; adjust the valve connections so that the steam valves will have 5/16-inch lap, and the exhaust valves stand open 1/32 inch. Block the governor 3/16 inch above the rest, and with the engine turning over slowly adjust the knockoff rod so that the head-end valve will unhook and the crank-end valve hook will just touch the knockoff block.

Changing the length of the rod as you do will only throw the governor out of adjustment, without helping in any way, and may be the cause of a runaway engine with a light load.

Pitch of Grates

Why are the grates in a boiler furnace, pitched toward the back of the furnace?

C. H. M.

Grates are inclined toward the bridgewall for the purpose of making it easy to distribute the fuel and to rake and slice the fire. It also tends to make the fuel bed thicker at the back of the furnace where the air tends to pass most freely.

Vibration of Reach Rod

We have a Corliss engine the rod to the steam valves of which vibrates to such an extent that it is feared it may break. The rod to the exhaust valves does not vibrate. The rod in question at the carrier arm is reduced from 1¼ inches to ⅞ inch. Will you give an explanation and remedy for the vibration?

A. E. S.

Vibration in the reach rods of Corliss engines is frequently caused by insufficient lubrication of the steam valve. It is usually most severe during the first hour's run. The dimensions of the rod are carefully calculated by the designer and are, as a rule, safe for the work they have to do. The vibration may be stopped by hanging a small weight to the middle of the length of the rod by a cord which will allow it to swing clear of the floor, or by a light truss on the underside of the rod. There is, so far as is known, no record of the breaking of one of these rods from excessive vibration.

If the vibration is severe and attention to valve lubrication does not remedy it, the matter should be taken up with the engine builders.

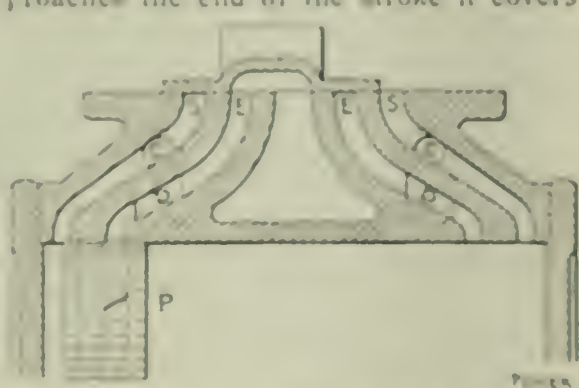
Duplex Pump Valves

Does increasing lost motion of a valve on a duplex steam pump lengthen the stroke? What keeps the piston from striking the head?

O. W. P.

Increasing the lost motion of a valve in a duplex steam pump lengthens the stroke.

In the duplex pump as the piston approaches the end of the stroke it covers



Section through Valve of Duplex Pump

the exhaust port, trapping some steam, which by compression stops the piston before it reaches the cylinder head, as may be seen by the sketch, in which *S S* are the steam and *E E* the exhaust ports. *D* is a cross passage from the steam to the exhaust port controlled by a valve at *C* which determines the amount of compression by regulating the flow of steam through the passage to the exhaust port after it has been closed by the piston.

Temperature Rise of Dynamos and Motors

What rise of temperature is safe for a dynamo or motor?

C. F. J.

Field-magnet coils and armature, 80 degrees; commutator and brushes, 90 degrees; bearings and other parts, 75 degrees, all Fahrenheit.

Effect of Service on Lamp Filaments.

When an incandescent lamp has been in service a long time, does it pass more current or less than it did when new, and why?

C. E. B.

It passes less current, because the filament wastes away during service, reducing its cross-section and thereby increasing its resistance. The candlepower decreases more rapidly than the filament section, however, so that the current *per candlepower* is greater than when new. A 16-candlepower lamp taking ½ ampere new will take about 0.47 of an ampere after burning 500 hours, but its candlepower will be reduced to about 13; the current per candle, therefore, is 0.03125 of an ampere when new and 0.03615 of an ampere after burning 500 hours.

Combined Motive Powers

Is it feasible to help out an overloaded steam engine by belting an electric motor to the line shaft to which the engine is belted?

B. S. Co.

Entirely so. It is only necessary to make the pulley ratio such that when the motor is running free, with normal field excitation, its speed will correspond to the normal speed of the line shaft. A small adjustable resistance in the field circuit of the motor will enable you to regulate the amount of power it delivers to the line shaft; cutting in resistance will increase the power delivered, by causing the motor to try to run faster, and thereby relieve the engine.

Why Allow Any Drop?

Why is any drop in voltage allowed in electrical circuits?

T. Y. H.

For the same reason that a bearing is "allowed" to consume power and heat is "allowed" to get away up the chimney of a steam boiler. Because it cannot be prevented. The drop in voltage is due to the electrical resistance of the conductors through which the current passes, and there is no material yet discovered which has no resistance.

Large Wire Gages

In speaking, how are the large wire sizes, such as Nos. 00, 000 and so on, expressed?

T. Y. H.

Number two naught, three naught, etc.

Baffles for Curtis Turbines

On the vertical Curtis turbine, a baffle similar to that shown in Fig. 1 is used between the oil pump and the step bearing. The oil, entering at the left, passes through a sieve of wire gauze and then through the threads of the helix *A* to the outlet. By screwing the bolt *B* further into the helix the latter is driven to the right and the tortuous path of the oil shortened. It serves, in effect, as a throttle valve for the oil, and prevents its sudden escape backward and the consequent sudden dropping of the step in case of the failure of the oil pressure.

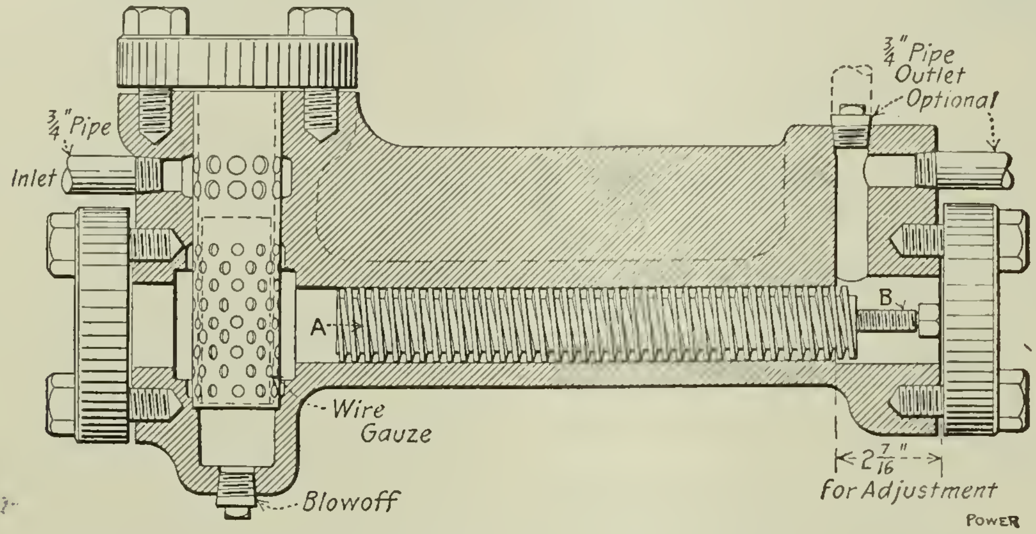


Fig. 1. Baffle Used between Oil Pump and Step Bearing

These baffles are ordinarily made of cast iron, and at a station where they are used under a pressure of 1500 pounds per square inch they failed after a year or two of service. An attempt was made to cast them in bronze to a pattern made to conform to Fig. 2, but out of a lot of 20 only one was found to withstand the required test pressure of 3000 pounds per square inch.

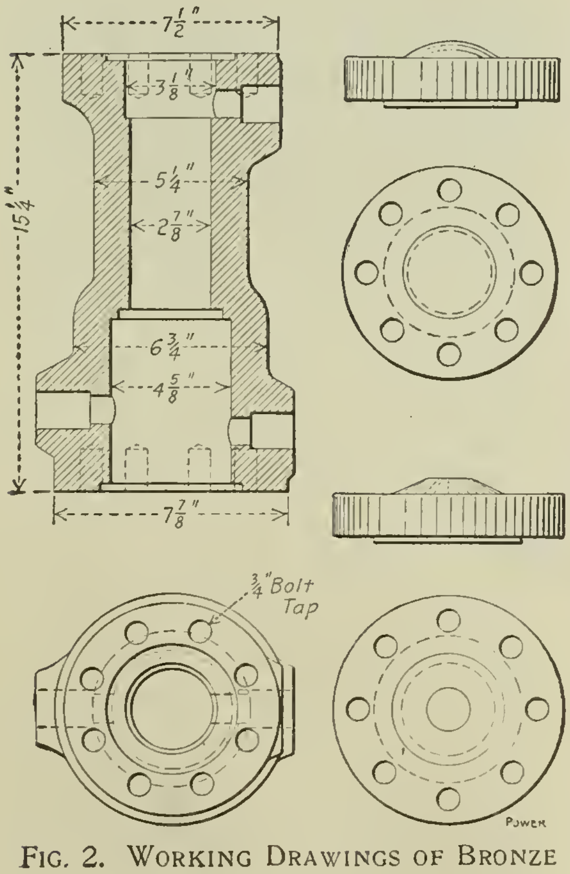


Fig. 2. Working Drawings of Bronze Baffle

An order was then placed with A. Allan & Son for 16 to be cast in manganese bronze to the same pattern. They cast one-half of these, and out of the lot of eight only two remained tight under the test pressure. They admitted their inability to fill the order and asked to be allowed to substitute for the manganese No. 2 Allan metal, an alloy consisting of 66 per cent. copper, 25 lead and 9 tin. Permission was accorded and out of 14 made in one cast 11 successfully withstood the application of the 3000 pounds. Five of these are now in use, and it remains to be seen whether they will endure the stress of continued service better than the cast-iron prototypes.

Fig. 3 shows one of the finished castings attached to the ram for testing. The ram is capable of exerting a pressure of 10,000 pounds per square inch, and is used for taking armatures off from and putting them on to the shafts.

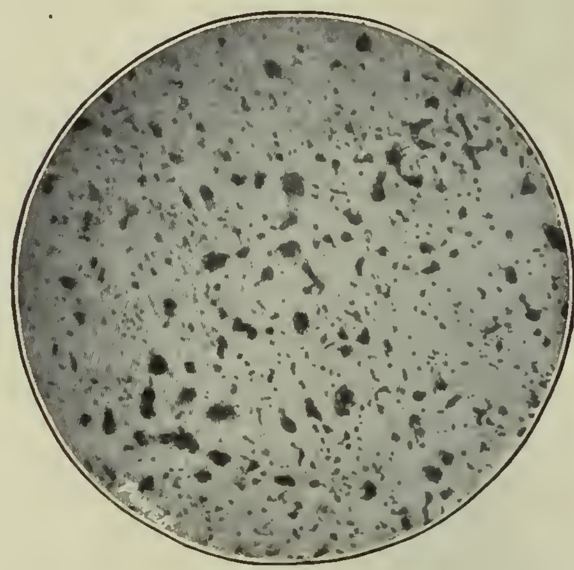


Fig. 4. Allan No. 2 Bronze Magnified 45 Diameters and Reduced from 2 3/4 Inches

The characteristics of the metal are given in the accompanying report of a test by Professor Pryor of samples, one from the commencement and the other from the end of the pour.

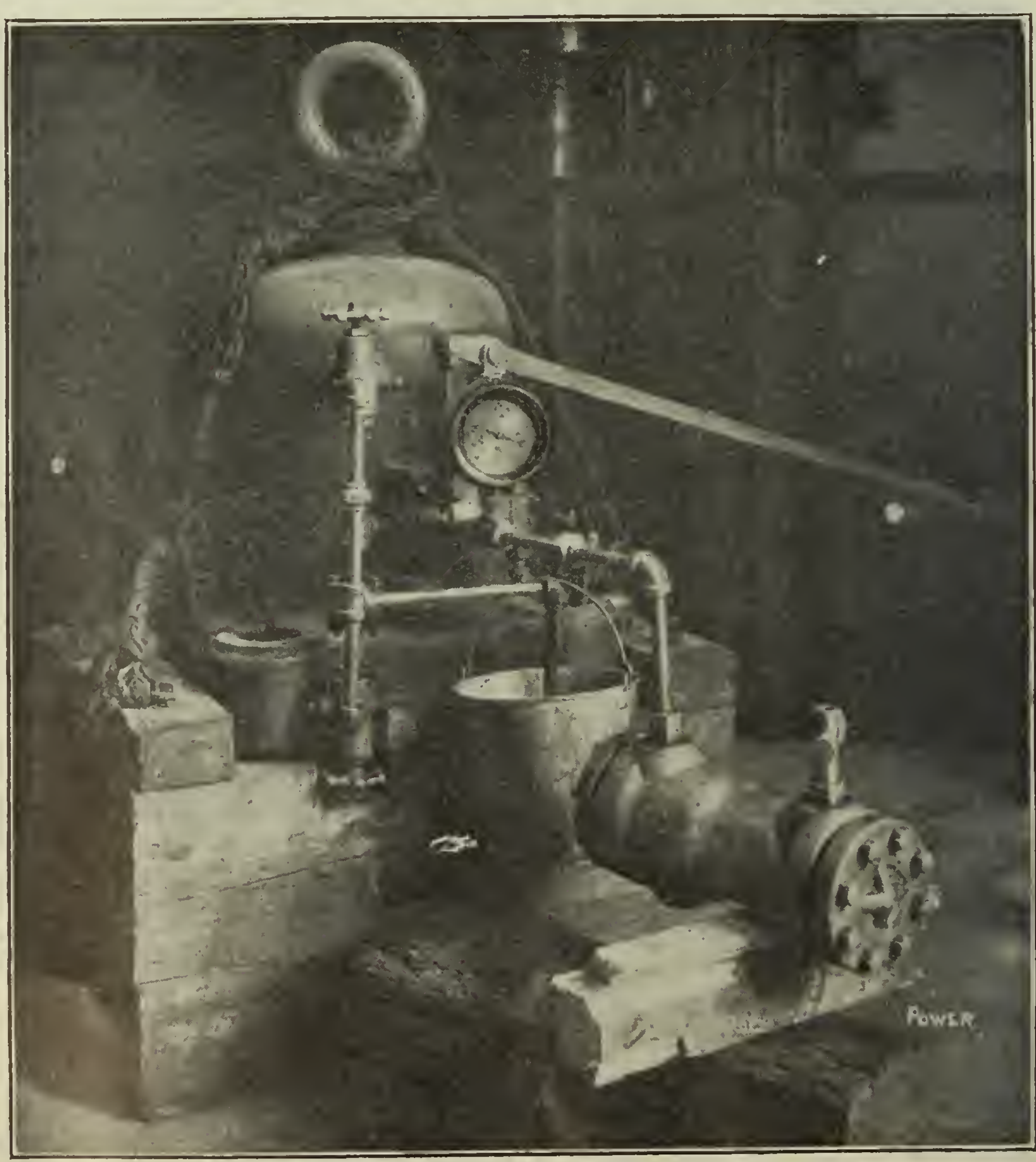


Fig. 3. Baffle Made of No. 2 Allan Metal under Test

RESULTS OF TESTS CONDUCTED BY PROFESSOR PRYOR

Designation of material	No. 1	No. 2
Diameter of specimen, inches.		
Original	1 496	1 498
Final	1 460	1 470
Area of specimen, square inches.		
Original	1 7577	1 7624
Final	1 6742	1 6972
Reduction of area, per cent	4 7	3 7
Elongation, measured over 9 inches, per cent	4 4	3 8
Elongation, measured over 8 inches, per cent	4 6	3 9
Yield point, pounds.		
Actual	25 500	21 750
Per square inch	14,370	12 340
Ultimate tensile strength, lb.		
Actual	30 710	30 100
Per square inch	17 470	17,080

A microphotograph taken by Prof. William Campbell, of Columbia University,

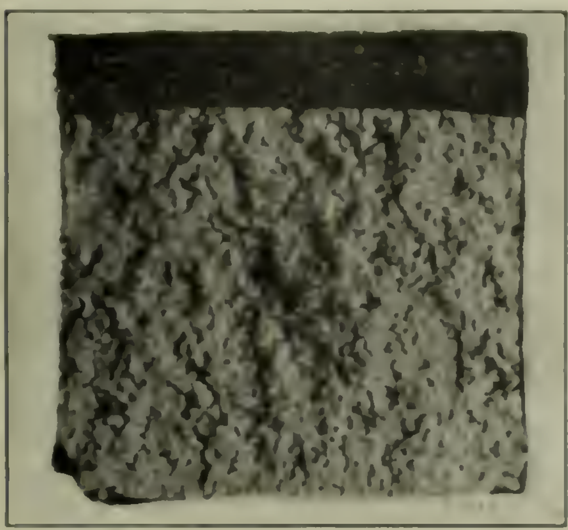


FIG. 5. A FRACTURE OF ALLAN NO. 2 BRONZE MAGNIFIED TO SHOW GRAIN OF ALLOY

and reproduced in Fig. 4, shows the density and character of the metal. The difficulty is not so much one of strength as of imperviousness or lack of porosity, and it is expected that the copper and tin will furnish the required strength and form a matrix for the lead, which will give the necessary density.

Engine Shaft Breaks

By CAREY GRANGER

Quite recently a remarkable accident occurred at the Anderson plant of the American Steel and Wire Company. The main shaft on a 36 and 72 by 18-inch Corliss engine broke while the engine was running under full load. The shaft was 22 inches in diameter and carried a rope pulley 18 feet in diameter and 30 inches wide, also two belt pulleys 20 feet in diameter by 48 inches wide. The engine was used to drive the 12- and 18-inch trains of rolls in the rod mill and ran at 100 revolutions per minute. The two 48-inch pulleys are clamped to the shaft with the rims fitting tightly together. This leaves a space of about 6 inches between the hubs, and it was in this space that the shaft broke. On account of the rims fitting together so closely, it was impossible for the pulleys to drop into the pit and no further damage was done to the engine.

The engineer stated that, when the shaft broke, it made a noise very much like the stripping of one of the pinions by which the rolls are driven. He shut down the engine and waited for orders from the millwright who has charge of the pinions. The millwright, wondering at the stop and denying that anything was wrong in his department, gave orders to proceed. The engine was started and ran almost up to speed before it was decided that the trouble was in the engine room and an investigation started. The break was soon located, and I heartily agree with the engineer that "it is better to be born lucky than rich."

Boiler Explosion at Arcadia, La.

By W. HOWSE

On May 8 a small portable boiler, used to drive a shingle mill near Arcadia, La., exploded, killing one man and seriously injuring another.

The boiler was of the locomotive type, 8[illegible] feet long, with a barrel 3 feet in diameter, and mounted on it was a small slide-valve engine. Its exact age was not known, but from all accounts, it appears to have been over twenty years old. One hundred pounds steam pressure was known to have been carried, although there appears to have been no safety valve nor water column attached. The imprudence displayed in carrying so high a pressure is magnified by the fact that the boiler had lain exposed to the elements for some time prior to being installed in the shingle mill, and was in a corroded condition.

The crown sheet, which was [illegible] inch thick, was ruptured in three places, each rupture extending lengthwise of the firebox. It is remarkable that very few of the threads on the staybolts were stripped, and, although some of the staybolts had been eaten away from an original diameter of [illegible] inch to that of a lead pencil, none was broken. The seams

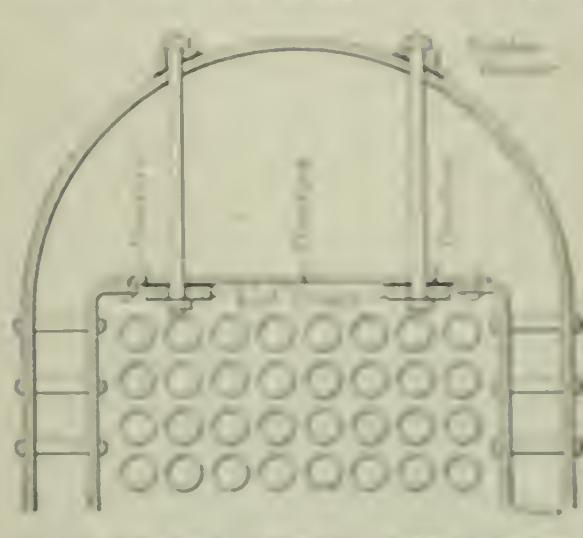


FIG. 3. SECTION THROUGH FIREBOX SHOWING POINTS OF RUPTURE

were single-riveted with [illegible]-inch rivets. These conditions, together with the fact that the crown sheet showed every evidence of having been overheated, leads to the conclusion that the explosion was caused by low water.

Feed water was supplied by an inspirator which was found after the explosion with all valves set for delivering water to the boiler; although, according to the statement of the injured man, he had just started over to the inspirator with the intention of turning it on when the explosion occurred.

The boiler had been leaking around the staybolts in the crown sheet and the owner of the mill had attempted to brace it by putting [illegible]-inch straps on the crown sheet. These were held by [illegible]-inch bolts extending through the top of the shell and some pieces of rubber belting were used as washers under the nuts to prevent leakage. He was tightening those nuts when the explosion occurred, which hurled him 125 feet and crushed in his skull as well as demolishing the entire building.

FIG. 1. BOILER AFTER EXPLOSION

FIG. 2. REMAINS OF BUILDING

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Improved Pressure Tubes for Recording Gages

The action of pressure on a tube or spring in a gage forces the sides apart, resulting in a greater radius of curvature,

Fig. 1. Showing Helical Gage Tube

following the motion of the free end. The principle of the helical form, shown in Fig. 1, is identical, for it is, in effect, a series of tubes placed end to end. When pressure is applied, it causes the tube to untwist and the free end to move a distance in proportion to the pressure applied.

In the improved helical pressure tube

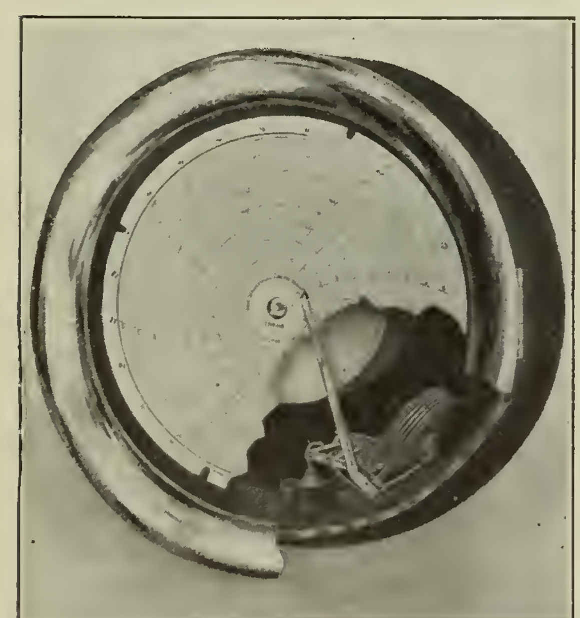


Fig. 2. Bellows Diaphragm

for pressure above six pounds, a simple but substantial support has been devised which supplies an axis of rotation, resulting in the precise travel of the pen over a definite predetermined arc. This support eliminates many of the possibilities of accident, as the support gives the required protection and ruggedness.

For minute pressures requiring reading in inches of water, a series of diaphragms built up into the form of a bellows are

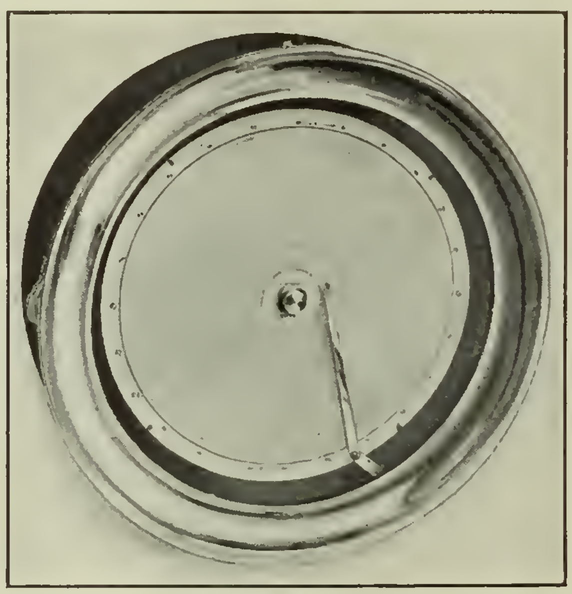


Fig. 3. Exterior View of the Gage

employed as shown in Fig. 2. Application of pressure tends to elongate the tube, but this motion is converted into a multiplied lateral motion by means of restraining coils secured to one side of the side of the tube. The motion thus obtained is transmitted through a very simple and effective device to the pen arm in such a way as to produce a uniform scale throughout the range of the chart. The feature of support similar to that employed with helical pressure tubes is of importance when it is used in conjunction with the diaphragms. It contributes to a marked degree to positive action of the recorder, at the same time giving strength and freedom from mechanical disturbance. Although designed for extreme sensitiveness and accuracy, the improved form insures great rigidity and durability under service. The exterior view of the gage is shown in Fig. 3.

These instruments are made by the Industrial Instrument Company, Foxboro, Mass.

"Durabla" Gage Glass

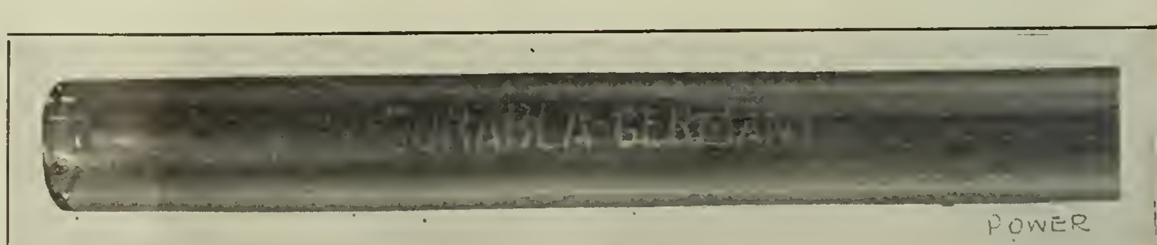
There is a demand for a gage glass that will be equal to the conditions now found in steam plants, and a gage glass to fill the new conditions must withstand high pressures and severe tests.

The Durabla high-pressure gage glass of the German navy has just made its appearance in America. This glass is used by such large plants as the Krupp iron works and the Hamburg-American line. The Durabla glass is claimed to be a peculiar scientific compound all its own.

As an example of its properties, the following results of an experiment made by a large testing station in this country may be of interest:

The glasses were immersed in oil at a temperature of 350 degrees Fahrenheit, and then dropped into water at a temperature of 40 degrees Fahrenheit. The experiment was repeated fifteen times, after which the same glasses were put into use on high-pressure boilers.

It is the mixture of different materials which gives certain glass the power to resist sudden changes in temperature, the action of steam, alkalis and impurities in water. It is the power to resist chemical action which keeps a glass clear for a long time under all conditions. The power to resist sudden changes in temperature reduces the possibility of accidents to a minimum.

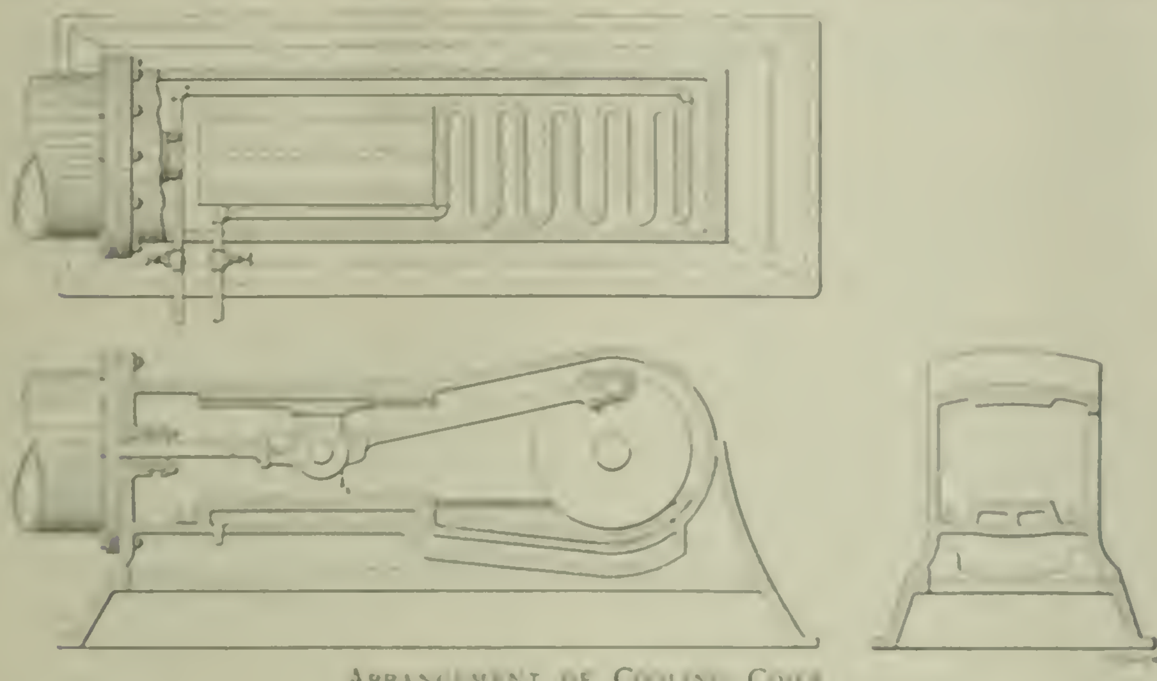


Durabla Gage Glass

The Durabla gage glass is manufactured by R. G. Von Kokeritz & Co., 114 Liberty street, New York City.

Oil Cooling Device for Steam Engines

This device consists of a flexible pipe entering the engine frame as illustrated, with a series of coils lying in the crank casing partly submerged in lubricating oil. A current of cool water is circulated through the pipe, after which the water may be discharged to the heater. The device is intended for application to inclosed, self-oiling engines. By regulating the amount of water flowing through the coil it is possible to keep the oil cool and eliminate, in a measure, the liability of heating journals.



Arrangement of Cooling Coils

This device is manufactured by W. J. O'Keefe, Foster building, Milwaukee, Wis.

Automatic Vacuum Breaker

A new design of automatic vacuum breaker is illustrated and described herewith. *A* is a pipe connecting with the exhaust or vacuum pump and is capped with a brass head on the upper end, as shown at *B*. The top of the cap is closed to the atmosphere by the cover *C*, which fits tight on the soft-rubber ring or seat *D*. The pressure of the atmosphere or suction of the vacuum holds this cap down on the seat *D* when running normally. The cap *C* extends back and is pivoted on the pin *E*.

The spring *H* has one end fastened in the extension arm of *C* and the other end is made fast to the tension adjustment *J* which is held by the projecting ear on the cap *B* and holds this spring in tension and acting as a resistance to the suction of the vacuum on the cap *C* so as to nearly counterbalance this suction. This tension can be adjusted by raising or lowering the pin *J* by changing the position of the lock nuts *K*. In this position the vacuum suction and the spring tension are nearly balanced, the force of the suction being somewhat greater so as to hold the cap *C* fast on the rubber seat *D*.

At the end of the extension of *C* is the loop *I*. *G* is a lever-like projection made fast to the rear stem of the stop valve proper, this stem being brought through the rear head for this purpose. The stem is in the position shown when the stop valve is open. The operation of the apparatus is as follows:

Closing the stop valve causes the rear valve stem *F* to rotate in the direction of the arrowhead, carrying the lever *G* with it. This lever strikes the link *I* when the valve is in a nearly closed position and when it has the most force due to the velocity of the steam rushing through the stop valve. The force of the blow with which the lever *G* strikes the link *I* is of sufficient force to overbalance the suction of the vacuum and lifting the cap *C* from the seat *D*. The spring *H*, now having nothing to counteract its tension, pulls the extension of the cap *C* down, opening the head *A* to the atmosphere,

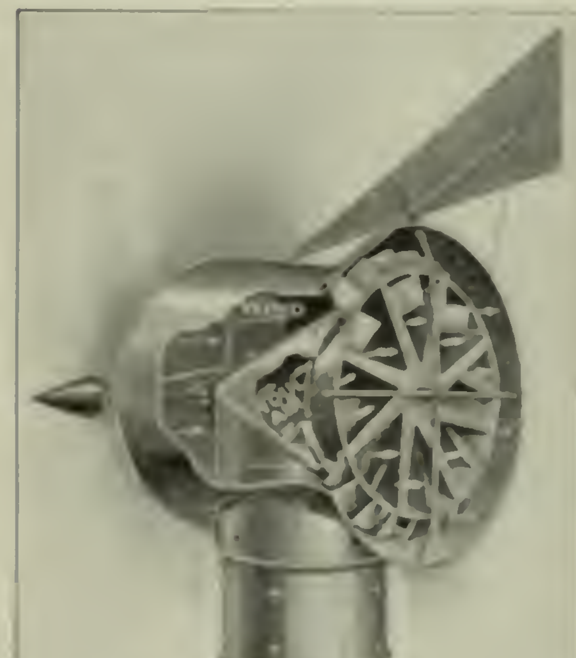
Automatic Vacuum Breaker

which, being in connection with the vacuum, breaks it at the same instant the steam line is shut off, thus doing away with danger of the engine cylinder filling up with water.

When the stop valve is opened by raising the hand lever, the lever *G* is brought back into place, carrying the extension on *C* with it and closing the head *A* so that when the vacuum pump is started the suction again holds the cap *C* to its seat, cutting the vacuum off from communication with the atmosphere. The head *A* is fastened to the rear head of the stop valve proper by means of cap screws. This device is manufactured by the Automatic Engine Stop Company, Sheboygan, Wis.

Bicalky Roof Fan Ventilator

The Bicalky ventilator fan does not depend upon any difference in temperature for its action, but a rotating fan



Semi-sectional View of Ventilator

wheel creates a vacuum and causes an upward circulation of air to insure ventilation.

A large area is exposed to the moving currents of air which the double cone-shaped opening brings into contact with the outer periphery of the fan wheel, while the inside portion of the wheel connects with the foul-air duct.

The intake and suction portions of the fan wheel are entirely separate, so that the current of air driving the wheel and the other exhausting the foul air from the building, in no way interfere with each other.

As no motor is required to operate this fan, there is no cost for repairs, and no power bills to pay.

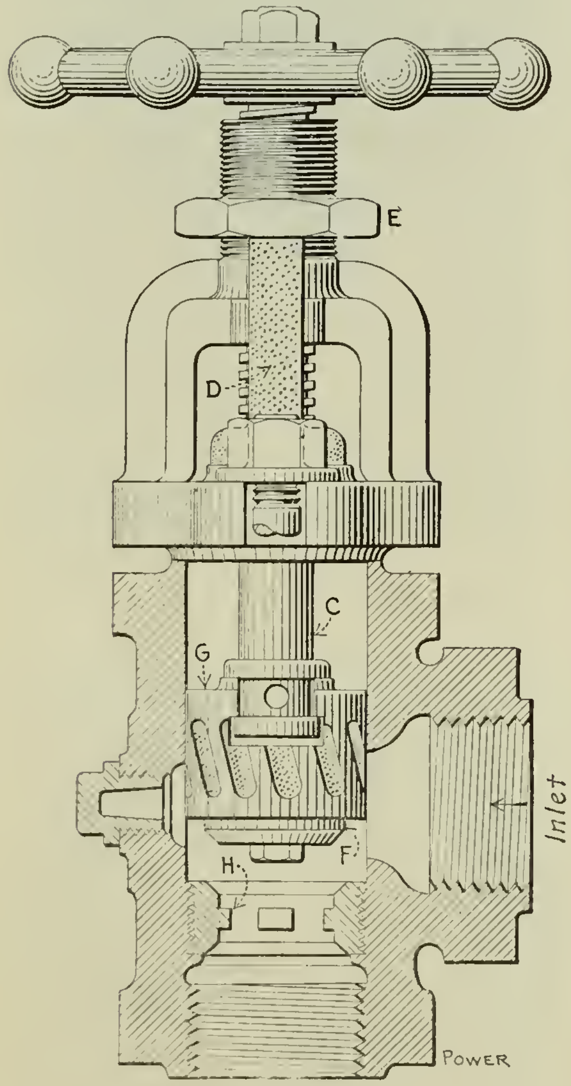
The fan wheel is mounted on ball bearings running in oil, which require lubricating once a year.

This fan is suitable for ventilating any kind of a room or building. It is manufactured by the Bicalky Fan Company, Buffalo, N. Y.

Cyclone Blowoff Valve

The body and yoke of the Cyclone blowoff valve are made of cast iron and are connected by steel studs and nuts. The sheet packing is housed in a recess in the body neck flange protecting it from a blowout, and is compressed by a projection on the yoke flange.

The stem *C* is made of a bronze composition and is cut with a square thread. The packing is secured and regulated by the pusher gland *D* which is operated by the outside screw nut *E* above the bridge of the yoke.



CYCLONE BLOWOFF VALVE

The disk and holder are made of noncorrosive bronze. They have two faces and are regrindable, reversible and renewable. The plunger disk holder *G* is of bronze composition, and is milled to receive the lower collar on the stem. This holder *G*, fitting snugly in the bed, is given a centrifugal motion by the steam striking the spiral grooves cast around the sides, when opening and closing the valve. This motion of the plunger tends to keep the inside walls of the valve clean and does not give scale or sediment a chance to collect. In closing the valve, the plunger, in passing the inlet orifice, shuts off all the steam before the disk reaches the seat and the vacuum created by the rush of matter through the valve prevents the lodgment of scale or silt.

The seat *H* is made of white bronze and is reversible, regrindable and renewable. The expansion and contraction of this metal are said to coincide with that of the iron casting, assuring a tight joint of the seat and body at all times. Each valve is tested to 250 pounds hydraulic pressure.

The valve is manufactured by the William Powell Company, Cincinnati, O.

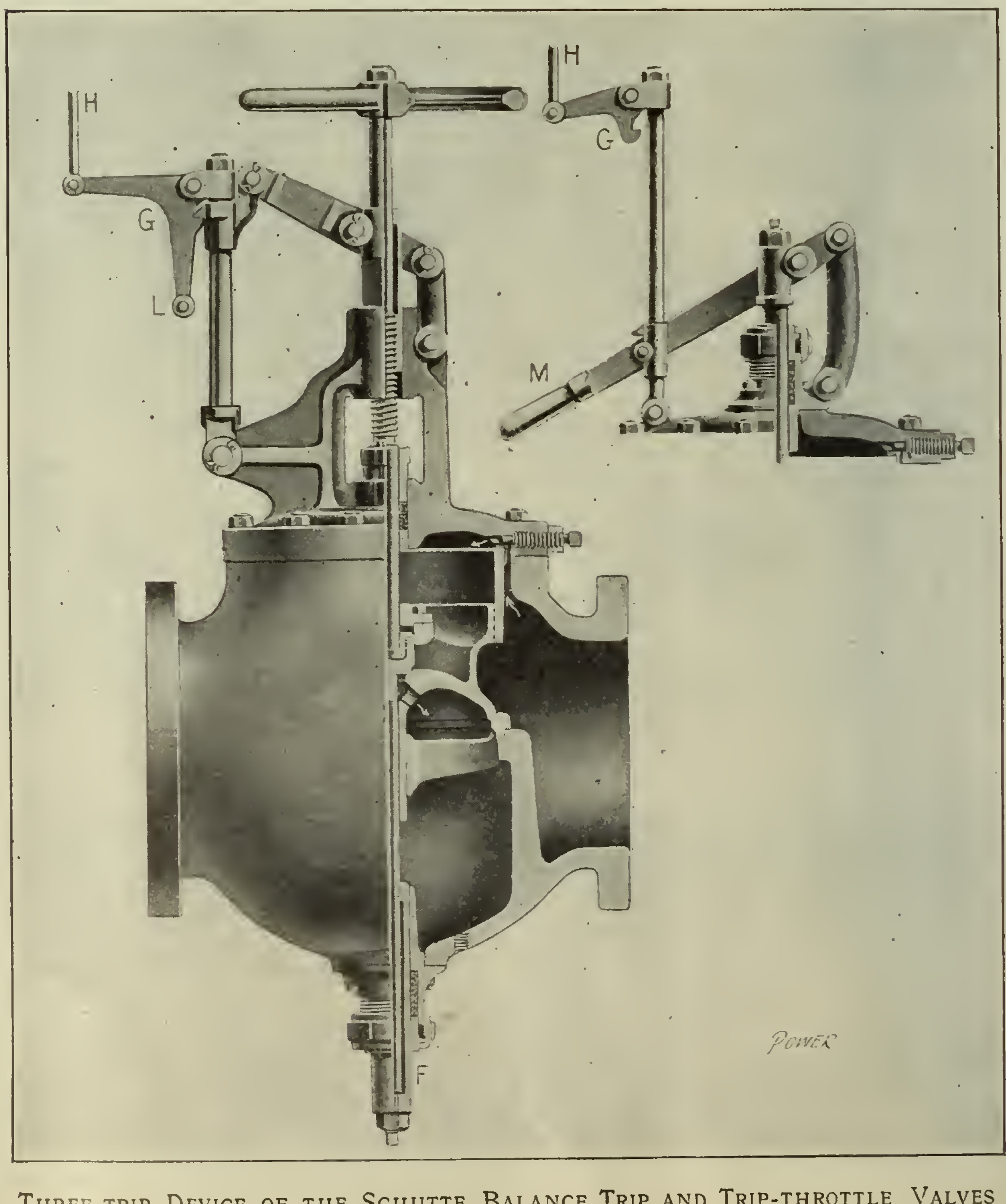
Schutte Balanced Trip and Trip Throttle Valves

These valves are intended as emergency shut-off or engine stop valves, and may be operated either by hand direct, with an electric solenoid and push button or automatically by the governor attached direct to the engine.

The trip valve is used in the steam-pipe connection to the engine and is operated independently of the throttle valve. The trip-throttle valve combines the features of a trip and throttle, thereby avoiding the necessity of two valves. It also has the advantage of being handled daily, thus assuring its being in operating condition; and will not, through lack of attention, or use from time to time, fail to operate when required.

The trip and throttle valve, shown herewith, when locked open, can be operated as a screw-spindle throttle valve. The screw is carried by a sliding trunnion that is connected by a lever and, when latched, forms a rigid connection with the yoke. The valve is then free to be operated by the handwheel and screw; should the valve be open or partially so, it may be instantly closed by tripping the latch *G*, either by a pull on the rod *H* or the handle *L*.

The balanced trip-valve locking device, shown at the right, is locked open by moving the handle lever until the catch on the same engages with the lever *G* that supports the upright bar. After the valve is open, steam pressure acts on the area of the piston *F*, shown at the bottom of the valve body, with a continuous downward force, which causes



THREE-TRIP DEVICE OF THE SCHUTTE BALANCE TRIP AND TRIP-THROTTLE VALVES the valve to close as soon as the catch is released. A hand lever *M* is attached to the rod *H* and the same rod extended to any desired location will permit operating the valve promptly and without effort.

These valves are manufactured by Schütte & Koerting Company, Thompson and Twelfth streets, Philadelphia, Penn.

The Short Flexible Stuffing Box

The Short flexible stuffing box shown in Fig. 1 is packed ready for the gland. The spring cases on the outside are fitted with caps of a standard size. When used for high pressure, or ammonia, the caps can be removed and oil fed to the rods.

Fig. 2. Sectional View of the Short Stuffing Box

Fig. 2 illustrates the box cut through the center and shows two of the four working bars. These bars are under the control of four master bars which are beveled at both ends and when the gland presses against them they slide on the 20-degree plane toward the center, taking four other bars together with the springs with them, leaving no opening or recess in which packing can catch. The position of the springs in relation to the bars is also shown. The bars are connected to the springs by means of a rod which is constantly pulling on them at an angle of 45 degrees. When it is necessary to repack, the gland is backed off and the springs pull the flexible parts back to place.

Fig. 3 shows an end view of the gland

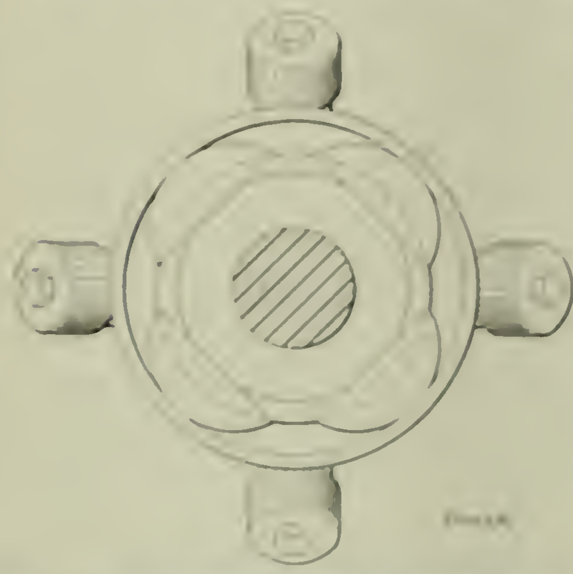


Fig. 3. End View of the Stuffing Box

and how it gets its flexibility. The master bars have a flat face against the packing and set; the bars to which the springs are attached have two flat sides that are at right angles with the packing

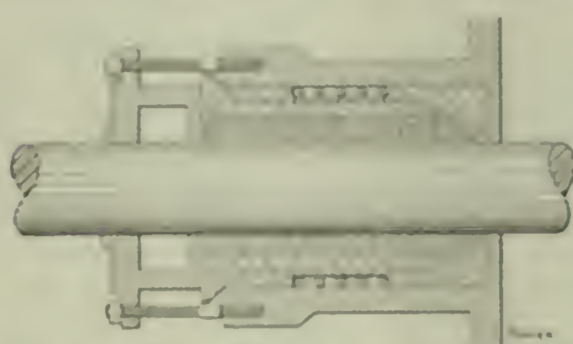


Fig. 4. Device as Applied to Ordinary Stuffing Box

rings. The sides that come in contact with the packing are cut so as to form a circle. These bars come in contact with the master bars with their right-angle sides tapering down to a feather edge. This allows a movement from one extreme to the other, keeping a steam-tight joint.

The method of placing the flexible parts into an ordinary stuffing box when a part of the cylinder or steam chest, is shown in Fig. 4.

This device is manufactured by W. C. Short, 1750 Park avenue, Denver, Colo.

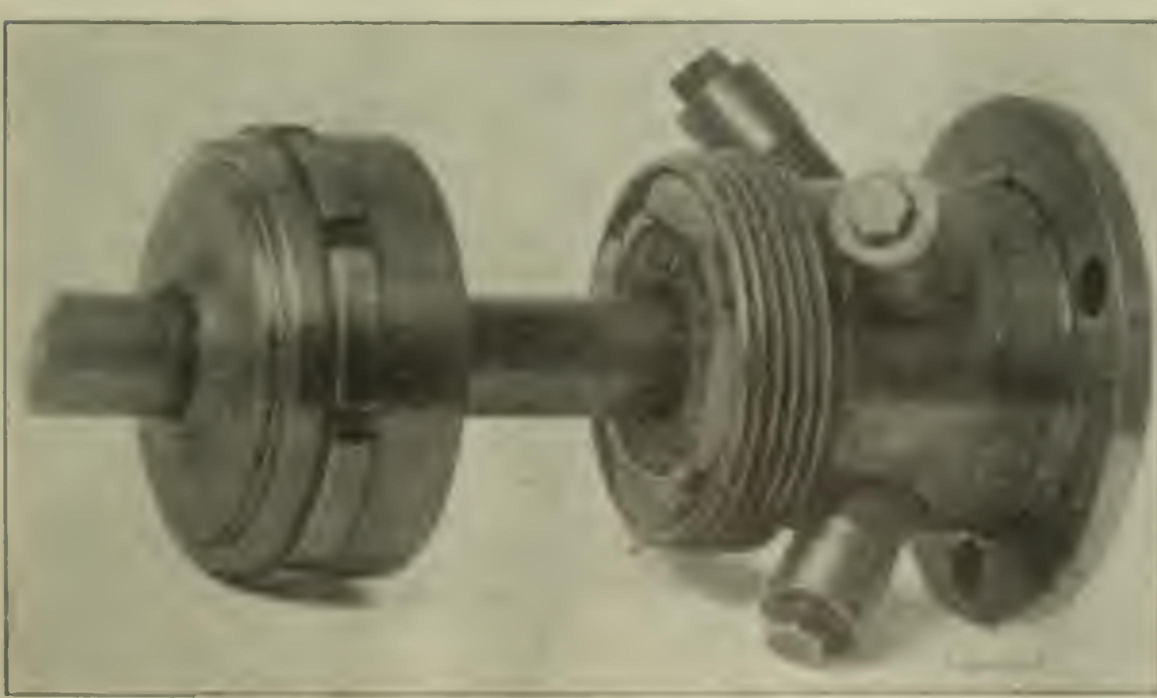


Fig. 1. Stuffing Box and Packing

Boilermakers Convention at Omaha

Pleasing and elaborate exercises marked the opening of the fifth annual convention of the International Master Boiler Makers Association, held at Omaha, May 23, 24, 25 and 26. Mayor J. C. Dahlman delivered the principal address of welcome, after which other prominent commercial and railroad men of the city spoke briefly to the visitors. A number of the leading members of the association responded, thanking the citizens of Omaha for their cordial welcome, and they were heartily seconded by President A. N. Lucas, in his annual address.

As the meeting extended over four days, it was arranged to have business sessions only in the morning, leaving the members free in the afternoons to take advantage of the liberal entertainment provided by the convention committee. As the temperature hovered around 90 degrees during the stay in Omaha, this was found to be a welcome arrangement.

Reports of various committees occupied the greater portion of the business sessions, the subjects having to do largely with railroad work, in which the membership is interested. Among the subjects discussed were: "Standardization of Shop Tools and Equipment," "Pipe Flanges and Templets for Drilling Same," "Advantages and Disadvantages of Fire Brick Arches," "Methods of Producing Better Circulation in Boilers," "Use of the Oxyacetylene Process Welding," "Best Method for Caring for Flues," "Best Methods for Staying Front of Crown Sheet," and "Steel Versus Iron Flues."

The entertainment program included visits to the Union Pacific Shops, Stock Exchange and Cudahy Packing Company, as well as numerous automobile rides and special excursions about the city, winding up with a banquet at the Rome hotel, followed by a dance in the convention hall. In all, the meeting was one of the most successful ever held by the organization.

The New York State Association of the National Association of Stationary Engineers will hold its annual convention at Albany on June 8 and 10. The committee of arrangements anticipates an unusually successful meeting.

Iowa State N. A. S. E. Convention

Ottumwa was the scene of the eighth annual State convention of the National Association of Stationary Engineers of Iowa, the dates being May 25, 26 and 27. The opening exercises included invocation, by Rev. W. D. Spiker, and addresses by S. H. Harper, mayor of Ottumwa, and M. B. Hutchison, president of the Commercial Association. F. W. Raven, national secretary, responded on behalf of the National Association of Stationary Engineers, after which C. A. Orr addressed the meeting for the local entertainment committee. E. P. Gould, secretary of the Central States Exhibitors' Association closed the opening exercises, with a few remarks on the possibilities of coöperation between the engineer and the supply man.

An illustrated lecture on "Petroleum—Its Products and their Manufacture," was given by W. A. Converse, of the Dearborn Drug and Chemical Company, and H. H. Dewey, of the General Electric Company, delivered an interesting talk on "Alternating Current Machinery."

The social features were well arranged and ample in every particular and culminated in a banquet given at the Hotel Ballingall, with Mayor Harper as toastmaster. One hundred and twenty delegates, their wives and visitors, sat down to the tables and partook of the full course dinner provided, after which F. W. Raven spoke on "The Objects of this Association." E. J. Doolittle, of Sioux City, was then called upon for some remarks in regard to the benefits to be derived from a license law, while others were called upon for five-minute talks on subjects of special interest to the members of the association.

Sioux City was chosen as the place of next meeting, the officers for the ensuing year being elected as follows: D. A. Coulson, of Sioux City, president; A. E. Powell, of Burlington, vice-president; Abner Davis, of Cedar Rapids, secretary, and George H. Beebe, of Marshalltown, treasurer.

The following firms had exhibits at convention hall: American Steam Gauge and Valve Manufacturing Company, Boston; Anchor Packing Company, Chicago; George B. Carpenter Company, Chicago; Commercial Lubricating Company, Philadelphia; Crandall Packing Company, Palmyra, N. Y.; Dearborn Drug and Chemical Works, Chicago; Fisher Governor Company, Marshalltown, Ia.; Garlock Packing Company, Palmyra, N. Y.; Greene, Tweed & Co., New York; Hawk-Eye Compound Company, Chicago; Hills-McCanna Company, Chicago; Hulson Grate Company, Keokuk, Ia.; Jenkins Brothers, New York; H. W. Johns-Manville Company, Milwaukee; Lunkenheimer Company, Cincinnati; Lyons Boiler Works, De Pere, Wis.; McMaster-Carr Supply Company, Chicago; Murray Iron Works, Burlington, Ia.; *National Engineer*, Chicago; Osborne High-Pressure Joint and Valve Company, Chicago; Ottumwa Iron Works, Ottumwa, Ia.; Penn Oil and Supply Company, Oil City, Penn.; POWER, New York; *Practical Engineer*, Chicago; The S. C. Regulator Company, Fostoria, O.; Standard Oil Company, New York; Stoersel Oil Works, Ottumwa, Ia.; Trapp Pressure Control Company, Sioux City, Ia.; Under-Feed Stoker Company of America, Chicago, and Viscosity Oil Company, Chicago.

STATE CONVENTION GROUP AT OTTUMWA, IOWA

Special Charter for Museum of Safety

A special charter has just been granted to the American Museum of Safety by the legislature of the State of New York, thus putting it in the same class with the Metropolitan Museum of Art and the Museum of Natural History.

Among the trustees of the museum are E. H. Gary, Philip T. Dodge, James Speyer, Thomas Lynch, Arthur Williams, Edson S. Lott, Frederick L. Hoffman, George F. Kunz, Charles Kirchhoff, T. C. Martin, Charles A. Doremus, Louis L. Seaman, Frederick R. Hutton, William H. Tolman.

The exhibits at the museum include protective devices for the safeguarding of human life in almost every field of labor, from the turning of a grindstone to the moving of a freight train. The collections are of interest even to the ordinary observer, and of great value to the manufacturer, for, at present, annually, in the United States, over 500,000 men are wiped out from the ranks of the wage earners.

A Correction

On page 762 of POWER for May 16, bottom of third column, the 90-inch boilers under discussion in Mr. Dean's article are credited with having tubes 18 feet long. The tubes are 20 feet long and this figure should have been given in the table.

N. A. S. E. to Meet at Cincinnati

The Cincinnati members are planning to make the convention of the National Association of Stationary Engineers, to be held in that city in September next, the best in the history of the organization. The headquarters' hotel will be the Sinton and the meetings will be held at the Music Hall, in one wing of which the Exhibitors' Association will have its display. A lunch will be served in the building to preclude the necessity of going back and forth between the hall and the hotel at noontime.

The program as tentatively laid out is as follows:

On Monday evening a reception at the Sinton, followed by dancing.

On Tuesday the formal opening of the convention with addresses by the governor and mayor.

On Wednesday the visitors will be the guests of the Lunkenheimer Company who will take them to the Government dam at Fernbank on the steamer "Island Queen" and from there to Coney Island where a barbecue will be held.

On Tuesday and Thursday evenings there will be entertainments at the Music Hall, one under the auspices of the local committee and one under the auspices of the Exhibitors' Association, and on Friday evening a ball, also at the Music Hall.

Liberal provision has been made for the entertainment of the ladies while the convention is in session.

PERSONAL

Frank E. Marcy, formerly with the Allis-Chalmers Company, has been appointed manager of the branch house of the Mine and Smelter Supply Company in Salt Lake City, Utah.

Messrs. Lucke and Ophuls have formed a partnership and have opened an office at 30 Church street, New York City, for the practice of engineering connected with the installation, operation and maintenance of breweries, cold-storage and ice making plants and other manufacturing establishments using mechanical refrigeration.

Joseph L. Hern, formerly superintendent of heating and ventilation with the school-house commission, Boston, and Francis J. Furlong, formerly superintendent of construction with the Claghorn Company, Bradlee & Chapman and J. P. Dwyer, have formed a partnership under the firm name of Hern, Furlong Company, engineers and contractors for power, heating and ventilation, 149 Pearl street, Boston, Mass.

C. E. Burgoon and H. W. Matthews have formed the Burgoon-Matthews Electric Company with headquarters at Atlanta, Ga. The company will conduct a general wholesale and retail electrical-supply business and will represent a number of manufacturers of power-station equipment. Mr. Burgoon was formerly chief engineer of the Federal building, Chicago; and Mr. Matthews was associated with the Westinghouse Electric and Manufacturing Company as an electrical engineer.

Fay Woodmansee, C. J. Davidson and E. O. Sessions announce their association under the firm name of Woodmansee, Davidson & Sessions, Incorporated, 1048 First National Bank building, Chicago.

Fay Woodmansee for nine years has been associated with Sargent & Lundy, as electrical engineer. C. J. Davidson for thirteen years has been in charge of the power-plant department and steam-heating department of the Milwaukee Electric Railway and Light Company, including during this period consulting work in St. Louis and other cities where the North American Company were interested. E. O. Sessions for twenty-three years has been associated with the General Electric Company in its engineering and sales departments.

It is the purpose of this firm to act in a consulting and supervising capacity in all branches of mechanical and electrical engineering, including designs and specifications for power plants, substations, hydroelectric equipments, transmission lines, electrical distribution systems and mechanical refrigeration. Reports on properties and appraisals will be made and particular attention will also be given to district-heating systems.

NEW PUBLICATIONS

THE "PRACTICAL ENGINEER" ELECTRICAL POCKETBOOK AND DIARY. Published by the Technical Publishing Company, London, 1911. Five hundred and sixty-seven pages, 3½x5½ inches; numerous illustrations and tables. Price, cloth, 1s.; leather, 1s. 6d.

A handy little book containing much valuable data and notes on current practice in electrical engineering, as well as the Board of Trade rules regarding the installation of electrical equipment. Several sections have been revised in this edition to keep pace with the developments in practice during the past twelve months.

MACHINE DRAWING. By Gardner C. Anthony. Published by D. C. Heath & Co., Boston, 1910. Cloth; 108 pages, 7¼x9½ inches; many illustrations; 10 tables. Price, $1.50.

This book is not for beginners but rather for those who are familiar with descriptive geometry. It contains considerable sound and good matter on the preparation of shop drawings. The tables are of practical value and enhance the worth of the book to the man in the drafting room. Some inconsistency is shown where the subject of lettering is treated. This, however, is unimportant. The book can be conscientiously recommended to all who would become efficient in the principles of this subject.

NOTES ON MECHANICAL DRAWING. By Horace P. Fry. Published by the University of Pennsylvania, 1910. Cloth; 57 pages, 6x9 inches; 51 illustrations.

Although this booklet is but an introduction to mechanical drawing, it should be correct and thorough for that very reason. Above all, it should not be irrational in dealing with points which must be left largely with judgment, even though the book is intended for specific use. The author claims to pattern after the Reinhardt system of lettering. This is slightly incorrect as the lettering displayed throughout is anything but after the Reinhardt system. Briefly, the book needs more careful revision than it has so far received.

ENGINEERING CHEMISTRY. By Thomas B. Stillman. Published by the Chemical Publishing Company, Easton, Penn., 1910. Cloth; 744 pages, 6x9 inches; 174 illustrations, numerous tables. Price, $5 net.

This is the fourth edition of Professor Stillman's manual dealing with chemistry as applied to the mechanic arts, and much of the text of the earlier editions has been amplified and brought up-to-date. The subjects covered are, coal analysis and specifications, feed-water heaters, economizers, flue-gas analysis, calorimetry, the manufacture of water gas, burning of natural gas under boilers, blast-furnace gas applied to internal-combustion motors, liquid fuel, lubricating oils, analysis of iron and steel, cement, asphalt, etc.

The book is not in any sense theoretical but deals, for the most part, with commercial processes, and as such should prove a valuable reference book for any engineer.

LOGARITHMS FOR BEGINNERS. By Charles N. Pickworth. Published by D. Van Nostrand Company, New York, 1910. Cloth; 53 pages, 4½x7¼ inches; three tables. Price, $1, net.

If the title of this book were "Logarithms," beginners would not have excuse for finding fault. As is indicated by the author in the preface, the increasing use of exponential and other complex formulas in the calculations involved in the later developments of thermodynamics and of the electrical, physical and chemical sciences, makes it highly important to have a thorough understanding of the logarithmic methods of calculation. Ability to make use of logarithms, however, does not presuppose great mathematical preparation. And it is because of this fact that we see the possibility of the beginner making complaint of the author's method of treating the subject. It is our opinion that to be benefited by this book, it is first necessary to have a considerable understanding of algebra; more of an understanding, perhaps, than would be needed to make use of logarithms.

Granting that the user has the necessary familiarity with algebra, this book fulfils its purpose admirably. Interspersed throughout are illustrative problems and the answers thereto. These add greatly to the worth of the book.

Applied Thermodynamics for Engineers. By William D. Ennis. Published by D. Van Nostrand Company, New York, 1910. Cloth; 450 pages, 6½x9 inches; 316 illustrations. Price, $4.50.

Nothing could better proclaim Professor Ennis' natural genius for the systematic exposition of scientific principles than this work. It is at once the most thorough, most lucid and simplest treatise on the subject that the reviewer has seen. There are numerous minor defects, of course; the days of miracles are long past. On page 7, for example, it would have been advisable to explain that the symbol for heat received is positive and that for heat rejected negative, in the general formula for heat transfer; on page 19, air is referred to as a gas and gases are said to "follow" Boyle's law; on page 20, Charles is properly given credit with Gay-Lussac for the law:

$$\frac{PV}{T} = constant$$

but nothing is said of how he derived it; on page 33 and elsewhere, specific heats are represented "in proper units" by the unusual symbols k and l and the letter R is given both the correct value of 53.36 (for air) and the inconsistent one of 53.36 ÷ 778, in conformity with the statements on page 37 that "no attention is paid to the ratio 778 as affecting the numerical values of constants in formulas involving both heat and work" and "the student should discern whether heat units or foot-pounds are intended." This is slovenly and cannot fail to blunt the student's regard for accuracy; it is the most serious lapse in the book.

It will be apparent from the foregoing that the flaws are not glaring; nearly all of them, in fact, are negligible in importance.

The book is very broad in scope. All known cycles are described and thoroughly analyzed (and the Rankine and Clausius cycles are not confused as is usually done in textbooks); the thermodynamics of all heat-converting engines, both positive and negative, are treated, and the relations between the abstract science and the actual conversion machines are very clearly presented. The book differs from most textbooks in being both an excellent tool for the college professor and a highly satisfactory reference book for practising engineers whose catholicity of ready knowledge has been impaired by specialization.

Steam Turbines. By Joseph Wickham Roe, M. E. Published by McGraw-Hill Book Company, New York, 1911. Cloth; 143 pages; illustrated. Price, $2.

The author, who is assistant professor of mechanical engineering at the Sheffield Scientific School, Yale University, has produced an excellent little work adapted to the needs of the engineer who wishes to inform himself on the principles and general design of turbines as well as for a textbook for a short course upon the subject. He who has wondered what all the velocity diagrams and velocity-pressure schemes so often published in connection with turbine discussions mean will find them explained here in all simplicity, requiring the possession of only a little elementary trigonometry for their comprehension. Each division of the subject is followed by a list of practical examples the solution of which requires the application of the principles which have been explained and the use of the formulas deduced, and a list of references to other works for those who wish to pursue that phase of the subject further.

The first chapter is devoted to the explanation of the energy in a jet. The consideration of the velocity derivable could have been improved by giving some of the simple formulas for the energy derivable from a pound of steam, which are precise within the limits of precision of the steam tables which are necessary for the working of the approximate formula which he gives.

The second chapter deals with the utilization of the kinetic energy in steam and shows by means of the velocity diagram how this energy is absorbed by the wheel. The method of finding the trajectory of the steam is also explained. About 30 pages are then devoted to "Calculations of Turbine Blading."

Under the title of "Mechanical Problems," the author takes up centrifugal strains but says little or nothing of critical speeds and balancing. Bearings and governing are treated in this section.

Chapter V is hardly a "Comparison of Types," but a description of the Curtis vertical, Terry, Kerr, Rateau, Zoelly and Allis-Chalmers machines, and of the Rateau regenerator and mixed-flow turbine.

The effect of superheat and vacuum, but not of pressure, is considered in the next chapter, which contains also a description of the Parsons augmentor. The concluding chapter deals with "The Position and Field of the Steam Turbine," giving the formula for potential efficiency and tables of test results and potential efficiencies of engines and turbines. The advantages and disadvantages of the turbine for various lines of service are considered and the fact pointed out that up to February, 1911, the sales of the three foremost manufacturers of large turbines in the United States had aggregated 4,100,000 kilowatts. Scarcely a dozen of the machines are over a dozen years old and the majority have been built within the last five years. The volume concludes with a heat-entropy chart and a summary of the bibliography of the subject.

BOOKS RECEIVED

Good Engineering Literature. By Harwood Frost. Chicago Book Company, Chicago, Ill. Cloth; 422 pages, 5x7½ inches; indexed. Price, $1.

Power. By Charles E. Lucke, PH. D. The Columbia University Press, New York. Cloth; 316 pages, 5¼x7¾ inches; 223 illustrations; indexed. Price, $2.

Monoplanes and Biplanes. By Grover Cleveland Loening. Munn & Co., New York. Cloth; 331 pages, 5½x8 inches; 278 illustrations; indexed. Price, $2.50.

Vacuum Cleaning. By Thomas D. Perry. The American School Board Journal, Milwaukee, Wis. Paper cover; 44 pages, 4½x6¼ inches; illustrated. Price, 15 cents.

Steam Turbines. By Joseph W. Roe. McGraw-Hill Book Company, New York. Cloth; 136 pages, 6x9 inches; 77 illustrations; tables and plate; indexed. Price, $2.

Seven Follies of Science. By John Phin. D. Van Nostrand Company, New York. Cloth; 231 pages, 5x7½ inches; second edition; 34 illustrations; indexed. Price, $1.25.

Hydro-Electric Practice. By H. A. E. C. von Schon. J. B. Lippincott Company, Philadelphia, Penn. Second edition; cloth; 383 pages, 6¾x9½ inches; 140 illustrations. Price, $6.

Storage Battery Engineering. By Lamar Lyndon. McGraw-Hill Book Company, New York. Third edition; cloth; 601 pages, 5¾x9 inches; 298 illustrations; tables; indexed. Price, $4.

Electric Crane Construction. By Claude W. Hill. J. B. Lippincott Company, Philadelphia, Penn. Cloth; 313 pages, 6x9 inches; 366 illustrations; 23 tables; plates; indexed. Price, $8.

A Treatise on Transformers. By Hermann Bohle and David Robertson. J. B. Lippincott Company, Philadelphia, Penn. Cloth; 356 pages, 6x9 inches; 332 illustrations; 18 plates; tables; indexed. Price, $7.50.

POWER

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JUST what does and what does not constitute success is a question that has taxed the minds of men of many ages and if the various definitions which have been given had only been compiled it would have made a most interesting volume.

A few years ago a famous platform orator defined success as, "Finding your place and filling it," and this would appear to be all sufficient.

The speaker in illustrating his definition said that the question of money, while believed by the average layman to constitute the measure of success, was absolutely immaterial and that a crossing watchman doing his duty in such a manner as to leave nothing more desired, was more of a success than the man who, through greed, selfishness or mere chance, accumulates several million dollars in a comparatively short time.

Now, to apply this to the engineer,—is the man who is chief engineer of a large central station or large manufacturing establishment, more of a success than the plain engineer of a small but flourishing factory, in a quiet portion of the city, who feels that the small position is the limit of his capabilities and operates it accordingly, leaving nothing undone that could be done to better the operating conditions?

He is not. He may be making more money, but he is not keeping his plant any nearer, or perhaps as near, the goal of perfection, measured by the limitations of the plant, as the man in the smaller position.

Most men lack one or more of the necessary requisites to success. Some men have all the necessary skill and knowledge, but lack the power of stick-to-it-iveness; others may lack that rare gift of handling subordinates; others may have the last two and not know just what to do when they get the crew together.

Neither is success measured by a diploma from some technical or other school, or an engineer's license with a gold seal, conspicuously displayed, or by a vast library of books pertaining to the profession, or even by all the various rules and formulas in common practice, memorized. All these things, while very desirable, are not absolutely essential to success.

A certain engineer on the railroad quite frequently called upon the fireman to "keep 'er hot 'n' wet," and almost had to have the fireman call out the names of the stations as they arrived. He always had the fireman read the train orders to him, and was known to report "flews lakin" and "new diver braike chu" on his return from a trip, yet when he coupled on to the limited, he would get it over the road on schedule time if the train held together, and on the least amount of fuel possible. Out of some 150 engineers on the road, he was never below the first half dozen in the monthly "performance sheet." That man found his place and could fill it, he was a success.

And it is just so in stationary practice. How many of the older generation, now operating engineers, the "Dad Eldridge" class, are there who received a college or technical education? Very few. Many there are who did not get even a fair country school education. But they had those necessary native qualifications that go to make a man a success; grit, ambition and a determination to win, and, last but not least, horse sense.

To be a success, it is thus clear that it is not necessary to be chief of a 100,000-horsepower plant. The thing to do is to find your notch, stick to it, work, be on the job and leave nothing to be desired in economy of operation and general appearance of the plant.

Horsepower of a Fan Blower

By Albert E. Guy

The results of some tests showing the influence which the form of the vanes has upon the horsepower and the head produced. Formulas are given showing the approximate velocity of flow and horsepower developed.

A problem frequently met with is that of finding the horsepower of a fan blower when the diameter of the rotor, width of vanes at the tip, etc., are known. This typical problem may be solved only when the necessary data embodied in the "etc." are known; otherwise it may be readily shown that two fans, having the same inlet and outlet diameters, the same width of blades, revolving at the same rate of speed and delivering the same volume of free air per unit of time, may produce widely differing pressures. Thus, with the lower pressure, the air horsepower would be almost negligible, while with the higher pressure, which might be an extreme for the class of fan considered, the air horsepower, and consequently the shaft horsepower, would be matters of prime importance. This discrepancy is due simply to the fact that in either case the vanes, although of the same width, must be designed to suit the required conditions of pressure.

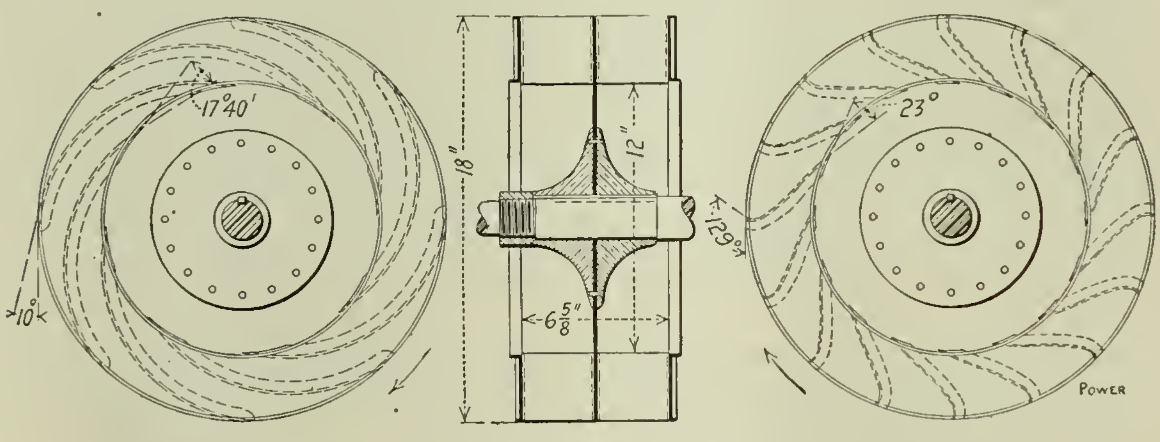


Fig. 1. Impellers Used Showing Curvature of Vanes

About two years ago the writer, to show the direct applicability of centrifugal-pump formulas to the design of fan blowers and to prove that a complete line of standard apparatus could be designed without making preliminary and special experiments for obtaining so called coefficients of correction, chose two extreme sets of conditions and designed special apparatus to meet them.

It was proposed in one case to furnish 7000 cubic feet of free air per minute at a static pressure of 22 inches of water, and in the other, 5250 cubic feet of air per minute at a pressure of 5 inches of water, the speed being 3600 revolutions per minute in both instances. A spiral form of casing was designed, and an impeller fitted into it, each set of conditions being met by a special impeller; but to add to the difficulties and to render the proofs more conclusive, the inlet and outlet diameters, and the width of the vanes, were kept the same for the two impellers. Fig. 1 shows the principal dimensions and forms of the impellers.

When completed, the apparatus was connected directly to a steam turbine and the high-pressure impeller driven at the specified speed. To determine the capacity of the fan and to obtain the curve showing the relation of volume to head, the speed was kept constant while the volume delivered was progressively increased by changing the nozzle areas at the end of the discharge pipe. The head was recorded simultaneously with the volume to which it corresponded. Various speeds above and below that specified were tried in the same way, the results being shown by the series of curves given in Fig. 2.

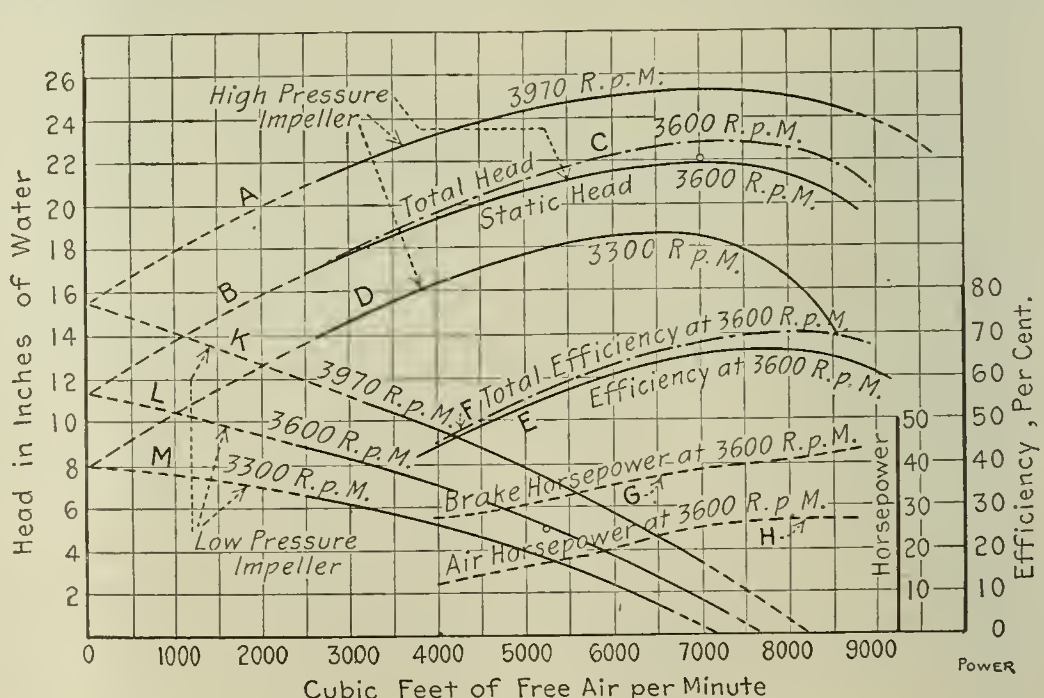


Fig. 2. Characteristics of the Two Impellers Tested

The steam and exhaust pressures at the turbine were recorded for each point of the curve, not for the purpose of ascertaining the steam consumption, but in order that later on, the blower being disconnected and replaced by a prony brake, the same steam and exhaust conditions could be reproduced at the proper speed and the corresponding brake horsepower recorded. With the latter data the efficiency of the apparatus was obtained and is represented by curves covering the useful range of the impeller.

The low-pressure impeller was tried next, but on account of the small amount of power required to drive it and the unsuitability of the turbine for the purpose of measuring that power, it was not possible to ascertain the efficiency with sufficient accuracy to permit representation by curves, as was done with the first impeller. However, it was observed that for the point aimed at in the design, the efficiency was not less than 60 per cent.

The curves *A* to *H* in Fig. 2 are for the high-pressure impeller and curves *K, L, M* are for the low-pressure impeller. It is apparent that neither impeller was suitable for the requirements of ordinary work. The usual requirements are that a practically constant head be maintained for a wide range of volume variation. In the present case such a condition could have been met only by varying the speed, and the turbine was not well adapted for such a speed variation.

However, a comparison of the capacities of these two fans is interesting. At 3600 revolutions per minute 7000 cubic feet of free air were delivered against a head of 21.8 inches of water by the high-pressure fan, while the same quantity was delivered against a head of 1.6 inches of water by the low-pressure fan. The air horsepowers were nearly proportional to the heads, or in the ratio of 13.6 to 1. At the same speed and for a volume of 5250 cubic feet of free air per minute, the brake-horsepower ratio would be about 4.5 to 1.

The impellers illustrated by Fig. 1 are not recommended for practical work. The speed of 3600 revolutions per minute is too low for the high-pressure impeller, or, the latter's diameter is too small for the speed. Moreover, the reversed form of vane is not desirable, as it entails a great frictional loss, and while it is theoretically correct for turbine work, it is not so for pumping purposes. The speed of 3600 revolutions per minute is far too high for the low-pressure impeller; the vanes are consequently too long and entail a frictional loss out of proportion to the head worked against.

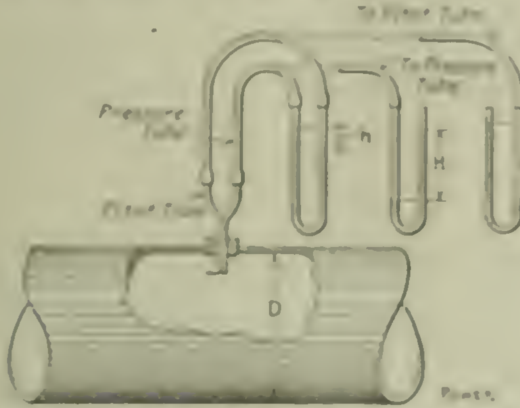


Fig. 3. Device for Measuring Pressure in Pipe

These two impellers, however, served to demonstrate the proposition as intended and further illustrate the fact that it is not possible to determine the horsepower required for a given blower, when only the diameter, width of blades and the number of revolutions per minute are known. It is necessary to know also the inlet and outlet angles of the vanes, the equation of their form, and the equation of the areas of passage from the inlet to the outlet of the impeller.

It is true that for a certain line of standard machines it is possible for the manufacturer to establish a set of approximate horsepower curves which are very useful for estimating; but such information is never given to the user of the machines.

When the fan takes the air from the atmosphere and delivers into a duct, and particularly when that duct or pipe is circular, it is comparatively easy to measure the approximate capacity of the apparatus when the air handled is at a moderate temperature. The instrument needed for the operation is very simple and can be easily made. Fig. 3 represents a combination of Pitot and pressure tubes connected to a glass U-tube containing water. The end of the assembled tubes should be inserted into the delivery pipe as shown. A straight part of the pipe should be selected where the flow is not likely to be disturbed by the influence of bends, valves, etc. The gage should be inserted into the pipe for about one-sixth the diameter and turned so that the open end of the Pitot tube is against the current. If the tube is not so placed the readings will not be correct.

With the two rubber tubes in place the difference in the hights of the columns of water in the U-tube shows the velocity head causing the flow in the duct. Disconnecting the Pitot tube from the glass gage and measuring the hight between the two levels, will indicate the pressure head against which the air is delivered. Again connecting the Pitot tube and disconnecting the pressure tube, will show, by the difference in the hights of the water columns, the total head produced by the fan. This total head is composed of the static head measured by the pressure tube, plus the velocity head shown when the two tubes are used together.

Calling the velocity of flow v feet per second, the velocity head h inches of water, and the static pressure head H inches of water,

$$v = \sqrt{2g\frac{p}{d}} = \sqrt{\frac{1,745,200 \times h}{406.7 + H}} =$$

$$1321\sqrt{\frac{h}{(406.7 + H)}}$$

where,

p = Pressure in pounds per square foot;

d = Weight, in pounds, of one cubic foot of free air at 50 degrees Fahrenheit = 0.077884;

406.7 = Inches of water corresponding to atmospheric pressure.

Knowing the inside diameter D, in inches, of the delivery pipe, the volume discharged in cubic feet per second is

$$\frac{\pi D^2}{4 \times 144} \times v$$

But this air is at a pressure H and the corresponding volume of free air per minute would be

$$\frac{\pi D^2 \times v \times 60 \times (406.7 + H)}{4 \times 144 \times 406.7} =$$

$$\frac{D^2 \times v \times (406.7 + H)}{1243}$$

cubic feet per minute

The horsepower in air delivered would be

$$\frac{\textit{Volume per minute} \times \textit{pressure per square foot}}{33,000}$$

One cubic foot of water weighs 62.35 pounds; one inch of water equals

$$\frac{62.35}{12} = 5.196 \textit{ pounds per square foot}$$

Hence,

$$\frac{\textit{Volume per minute} \times 5.196 \times H}{33,000} =$$

Air horsepower

or

$$\textit{Air horsepower} = \frac{\textit{Cubic feet per minute} \times H}{6350}$$

Substituting for the volume and velocity their respective values

Air horsepower =

$$\frac{D^2 \times v \times H \times (406.7 + H)}{1243 \times 6350} =$$

$$\frac{D^2 \times H \times \left(1321\sqrt{\frac{h}{406.7 + H}}\right) \times (406.7 + H)}{7,893,050}$$

$$= \frac{D^2 H \sqrt{h \times (406.7 + H)}}{5975}$$

As the efficiency of ordinary blowers is about 50 per cent., multiplying the air horsepower as just obtained by 2 gives approximately the shaft horsepower necessary to run the blower. While reading the gages the speed should be kept constant, and the time selected when the flow of air is uniform.

The gage readings and particularly that of the velocity head should be very close, for which reason it is preferable to use a U-tube of rather small diameter.

The formulas herein given are intended for approximate work only. The density of the air depends so much upon the temperature that the method would not apply to hot-blast work, for instance. Corrections should also be made for altitude and humidity. However, if the proper constants were determined to suit a given installation, the formula as modified would be found very useful.

Defects in Welded Flanges

In a paper presented at the May meeting of the Iron and Steel Institute by

Fig. 1. Metal Stripped at Drifting Tool, Showing No Fusion

Fig. 2. Section through Cracked Welded Pipe

Messrs. Lee, [illegible] and [illegible], some interesting facts are brought out regarding welded flanges. Two cases were considered: one a [illegible] weld and the other an arc weld, the observations of which serve to substantiate the stand taken by many consulting engineers in steadfastly refusing to employ welded flanges.

A welded pipe flange may be obviously mechanically imperfect, or it may be apparently perfect and capable of withstanding hydraulic-pressure tests. In the latter condition ignorance as to its internal condition produces a peace of mind which knowledge is liable to destroy.

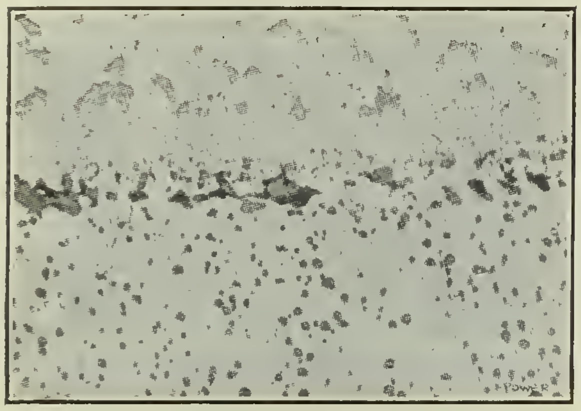


FIG 3. SLAG ALONG TRACK OF WELD

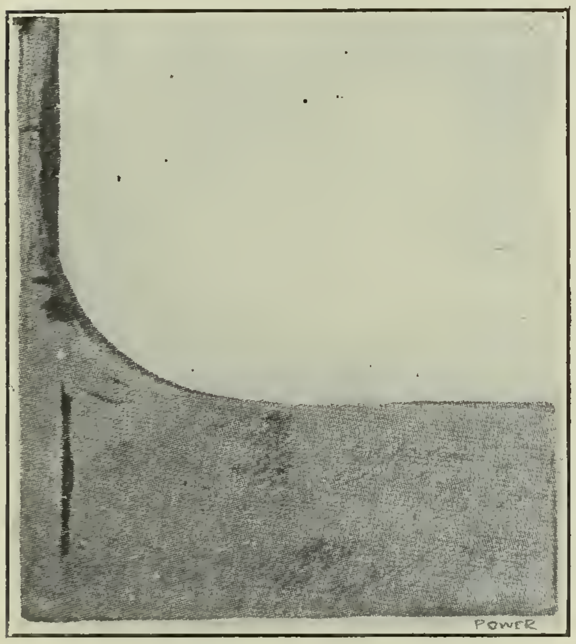


FIG. 4. ARC-WELDED FLANGE AFTER BEING SAWED AND ROUGHLY FILED

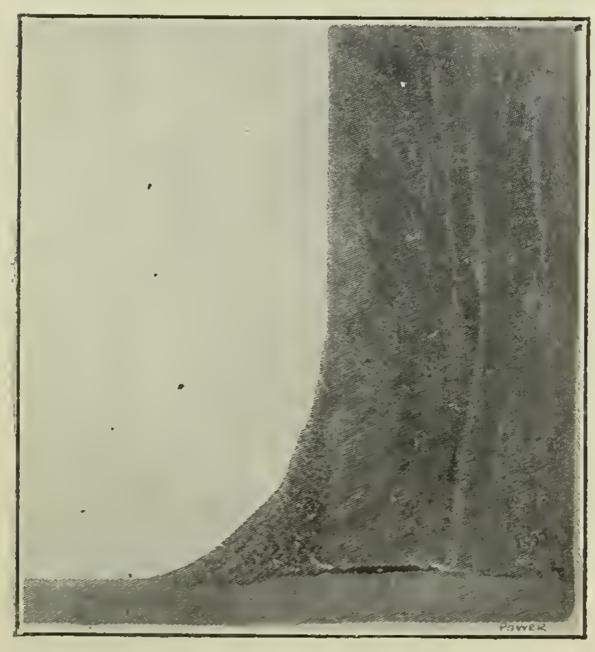


FIG. 5. ARC-WELDED FLANGE SHOWING DEMARCATIONS

Fig. 1 shows the segment of a wrought-iron flange nominally welded to a mild-steel pipe by the coke-fire process. As shown, it has been stripped away by the use of a drifting tool, and as there is no fusion of the metal it is only nominally welded. Fig. 2 shows another portion of the segment in which the pipe has not been mechanically forced away from the flange. The clear demarcation of the area shows that there has been no fusion of the metal. Fig. 3 shows, at one hundred magnifications, an accumulation of slag in the form of silicate along the track of the weld.

A segment of an arc-welded flange on a steel pipe is shown in Fig. 4, just as it had been sawed and roughly filed. It will be noted that the weld is only partial, over one-third of the area of junction having an air space. This pipe would probably have passed a reasonable hydraulic test and its defects would have been discovered only in service.

Fig. 5 represents the same view of the segment after polishing and etching. The excessive action of the corroding medium upon the area on which the arc has played, and the abrupt termination of these areas, are clearly shown.

Determining the Most Economical Vacuum

By THOMAS H. BROCKMAN

Assume a vacuum of 28 inches in the condenser. If this is reduced to 24 inches there will be a difference of some 40 degrees in the temperature of the hotwell. If this difference could be added to the temperature of the feed water it would mean a saving of about 3½ per cent. in the amount of fuel required to evaporate the same quantity of water.

Reducing the vacuum reduces the mean effective pressure in the cylinder and increases the temperature of the feed water. One means a loss and the other a gain. At what point do gain and loss so balance that an increase or decrease of the vacuum means loss? This question appeared in POWER a while back. In my spare moments I have been endeavoring to figure out what it all meant. The result shows the relation that exists between the temperature of the steam and the pressure.

Assume an indicator diagram as shown in Fig. 1 with the following:

$P_1 = 91$ pounds absolute;

$V_1 = 1$, $V_2 = 4$, $V_3 = 0.5$, $V_c = 0.04$;

$r =$ Ratio of stroke to cutoff $= 4$;

$r_c =$ Ratio of volume at exhaust closure to clearance volume

$$= \frac{0.5}{0.04} = 12.5;$$

$P_x =$ Some vacuum to be assumed;

$P_y =$ Some vacuum to be assumed.

Then, the mean effective pressure of the indicator diagram equals

$$\frac{\left(\begin{matrix} P_1V_1\,(1 + log.\,r) - P_xV_4 - P_1V_c - P_x \\ (V_2 - V_4)\,log.\,r \end{matrix}\right)}{(V_2 - V_c)}$$

Now, suppose that the vacuum has been reduced to P_y. Then the per cent. loss due to the increased pressure in the condenser will be,

$$\frac{\left(\begin{matrix} P_1V_1\,(1 + log.\,r) - P_xV_4 - P_1V_c - P_x \\ (V_2 - V_4)\,log.\,r_c - (P_1V_1\,(1 + log.\,r) - \\ P_yV_4 - P_1V_c - P_y\,(V_2 - V_4)\,log.\,r_c) \end{matrix}\right)}{\left(\begin{matrix} P_1V_1\,(1 + log.\,r) - P_xV_4 - P_1V_c - \\ P_x\,(V_2 - V_4)\,log.\,r_c \end{matrix}\right)}.$$

which reduces to,

$$\frac{4.725\,P_x - 4.725\,P_y}{213.26 - 4.725\,P_x} = \textit{per cent. loss of mean effective pressure} \qquad (1)$$

If $H =$ total heat in the steam at 91 pounds, and t_x = temperature of steam

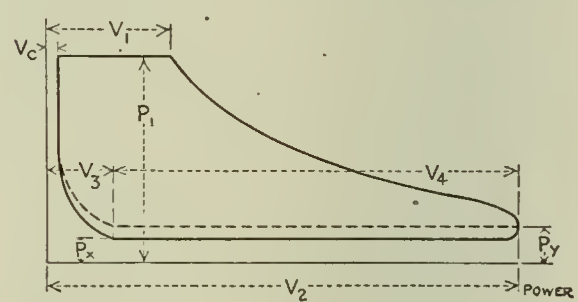


FIG. 1

corresponding to pressure P_x, t_y = temperature of steam corresponding to pressure P_y, and assuming that the temperature of the feed is the same as the temperature of the hotwell, the per cent. gain of fuel required to evaporate the same amount of water will be,

$$\frac{H - (t_x - 32) - (H - (t_y - 32)}{H - (t_x - 32)}$$

If $P_x = 1$ pound, $H = 1113.1$, $t_x = 102$; therefore,

$$\frac{t_y - 102}{1043} = \textit{per cent. gain in fuel} \qquad (2)$$

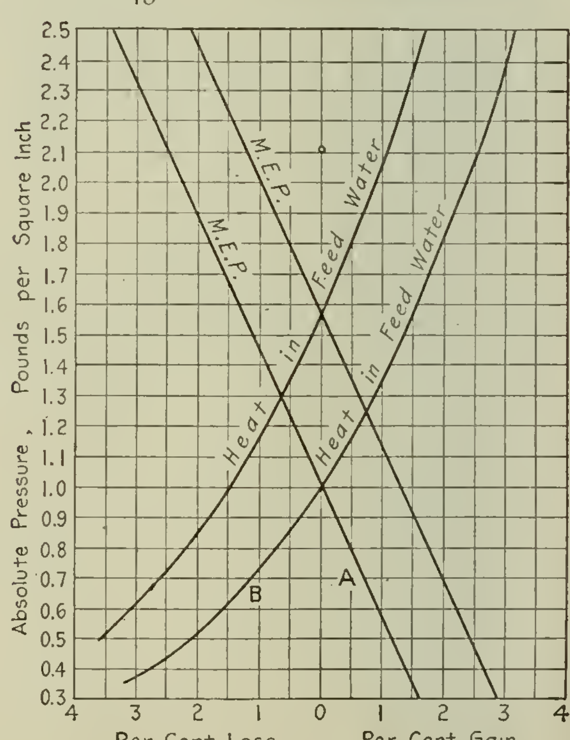


FIG. 2

By choosing values for P_y above and below 1 pound absolute in (1) and (2), the curves (A) and (B) in Fig. 2 were drawn. It was found by using two or three values for P_x that the curve (A) remained a straight line, while (B) only shifted to the right or left as P_x was increased or decreased. It will be seen by referring to Fig. 2 that there are two pressures at which the loss and gain are equal, at 1 pound and at 2.11 pounds. Any pressure below 1 pound means a loss and any pressure above 2.11 pounds means a loss. Therefore, halfway between these two points is a pressure where loss and gain so balance that any increase or decrease of pressure means a loss. This is shown by the two curves that pass through 1.56 pounds. They were platted by taking P_x equals 1.56, and choosing values of P_y above and below P_x.

Curves (A) and (B) show at a glance between what pressures a vacuum can be maintained without a loss. Of course, the foregoing is theoretical. The temperature of the hotwell is never the temperature of the feed water, but a few observations would give this relation.

Wave Motors and Compression

By F. L. Johnson

"This is he bald-head section. I have segregated these specimens for the purpose of collecting data on the growth of hair on wood," said the "Old Man" to a companion, as he swung open the door of our "box stall" one pleasant winter day. The door swung back as he passed on and it was not noticed that someone had entered, until, with a pleasant New Hampshire drawl, the visitor said:

"I suppose that is the way John A. expresses his appreciation of your efforts to keep on the pay roll. Well! All soils will not grow both hair and brains at the same time." It was Sawyer, and his trim, well-dressed figure, clean-cut face, alert glance and half satirical smile looked good to all of us. After shaking hands all around, exchanging the usual midwinter holiday greetings and good wishes, his attention was monopolized by the Dean, who always takes upon himself to settle offhand all questions, financial, social and ethical. He eliminates the other fellow by starting in first and keeps at it until all of the available time, as well as the listener's, is exhausted.

"I see that Professor Heck," he started this time by saying, "has taken most of the wind out of the sails of the noncompressionists, which, of course, includes you and Dwelshauvers-Dery. Mr. Heck is undoubtedly right for, as he says in the issue of September 13 and again in that of December 27 in his reply to Dery's criticism that"—Just here one of the counter girls announced that a gentleman was waiting in the library to see the dean.

"I saw an old friend of mine at Atlantic City the other day," Sawyer turned to me and said as the dean left the room, "in the form of the United States Wave Power Company's wave motor. You doubtless have not forgotten what I told you of boyhood experiences years ago at the foot of Gas House road. One of our motors was made by loading a 50-gallon tar barrel with about 400 pounds of water and running a rope from it over a sheave and around a drum fastened to the overhead timbers of the coal shed.

"A counterweight made by filling a bag with sand was fastened to the end of the rope which passed over the drum. On one end of the drum shaft there was a crank from which a connecting rod led to the handle of a twin-cylinder force pump. The whole apparatus was like this." As he talked along, he rapidly sketched a picture of his boyhood achievement in the wave-motor line.

"The pump was submerged for the purpose of making it reliable. No air leaks in the suction pipe could interfere with the flow of water to the cylinders, nor could air collect in the clearance spaces and keep the water out.

"Any movement whatever of the pump pistons forced some water up through the discharge pipe, which we designed later to connect with an elevated tank from which a stream could be drawn to run a small waterwheel. The thing would pump and I think it developed as much as one full catpower.

"There was a rise and fall of the tide of about eight feet which was all utilized in operating the pump as well as the rise and fall of the little waves; any movement of the barrel, whether vertical, horizontal or at any angle, was sure to move the pump pistons through a part of a stroke and a complete revolution of the drum corresponding to a rise or fall of the barrel through a space of about 18 inches would give a full stroke to the pump. It would do its best work when the waves rolled in at a hight of about two feet.

"At Atlantic City the machine is quite complex, and the same provision is made for all sorts of movement of the floats which furnish the power that I had, only they are more elaborate.

"A barker explained the operation to me and gave me some of the details. He said the floats weigh approximately 3000 pounds each and that the six floats would, with 2-foot high waves coming at the rate of eleven per minute, give an output of 120 horsepower. No one tried to sell me any stock and I came away mentally computing how much power could be gotten from the fall of six 3000-pound floats through a distance of two feet eleven times a minute. As all the energy that the floats could give up was that of falling from the hight to which the waves lifted them, I concluded that the claim of 120 horsepower from this machine was about 2000 per cent. higher than a reliable dynamometer would register."

Just here the dean returned and as he was about to start in again at the point where he was cut off, Sawyer said to him:

Sawyer's Wave Motor Made in Boyhood Days

"I have read both of Mr. Heck's contributions to the defense of his untenable premises. He practically begins by saying that Boyle's law does not apply to steam and then uses deductions from this same law to prove wrong what Dwelshauvers-Dery knows and what every engineer who has tried it knows to be true. He gets all tangled up in the labyrinth of his own logic and finally admits that more than a little compression may not be economical.

"It is not a question of vital importance but it is one that cannot be settled by discussion; and as long as mechanical engineers who have the equipment necessary for an exhaustive and competent test prefer argument to experiment, I shall believe that no one dares to try it. I have tried it on a commercial scale and know that compression saves money.

while not one of all the talented and educated gentlemen who believe otherwise has ever made even laboratory experiments, nor do I think they ever will.

"Something along this line may be done by the United States Geological Survey, but by any educational institution now flooding the country with sheepskin mechanical engineers, Nit.

"I am sorry I cannot stay the rest of the afternoon and tell you of several interesting little experiences in this line, but I must leave you for today." And without giving the dean, who had been on nettles all the while Sawyer was talking, time to put in a word, he winked to Rogers as he buttoned his overcoat and, saying good-by, went to the elevator.

Overcoming a Pound in the Cylinder

By A. J. Dixon

A pound caused by a loose liner in the high-pressure cylinder was stopped by placing setscrews between the end of the liner and the cylinder head, thus keeping the former in place.

The power equipment of a newly erected electric-railway generating station included a cross-compound condensing Corliss engine. About a week after this engine had been put in commission for regular service, a peculiar pound was noticed, but could not at first be located in any particular part of the machine. The pound was indistinct and scarcely noticeable at the beginning, but became more and more pronounced as the days passed. The various adjustments of crossheads, wrist- and crankpin brasses, main bearings, etc., having all been carefully attended to without producing any mitigating effect, the engineer finally decided to refer the trouble to the firm which supplied the engine. The manufacturers, accordingly, despatched the designer of the engine, together with a machinist and the engineering salesman, to look into the matter. By the time this trio appeared upon the scene, the pound had so increased as to leave no doubt that its origin was somewhere on the high-pressure side of the engine, with the indications pointing strongly to the cylinder end of the structure.

After pottering around for some time, the coterie of experts concluded that the source of the trouble lay in the connection between the piston rod and the crosshead. The rod was accordingly disconnected, the operation involving much time and labor, owing to peculiarities of construction, and then the parts were carefully put together again. However, when the engine was started again the pound was just as prominent as before. As this unit was the only one available for service at the time, it was imperative that it run until the next day, when the experts again went at it. This time they removed the caps from the main bearings, took out the quarter boxes and, finding nothing wrong, put them back again and started up, but with the same result. This procedure went on for several days, the experts tinkering first with one part and then with another, taking out the piston follower and packing rings and putting them back again; tightening every bearing, etc., but without any abatement of the pound which, on the contrary, continued to increase.

The high-pressure cylinder, which had a diameter of 24 inches, contained a steel liner, as shown in Fig. 1. It was claimed that this liner, which was 1¼ inches thick, had been set in the mold and the cylinder barrel cast around it, the steel thus becoming fused with the molten cast iron. The engineer advanced the supposition that this liner was probably the cause of all the trouble. The designer and his associates declared this to be utterly impossible, stating with much emphasis that inasmuch as the steel liner was not separate from the iron cylinder barrel it could not be the cause of the disturbance, as the mere

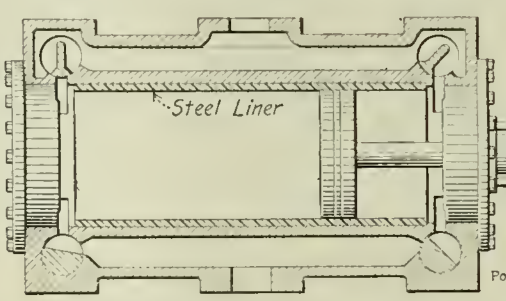


FIG. 1. SECTION THROUGH CYLINDER BEFORE MAKING REPAIR

fact of it becoming loose would mean a broken cylinder.

Nevertheless, the engineer steadfastly maintained that as every other part of the machine, in which a pound of this nature might possibly originate, had been inspected and nothing had been found

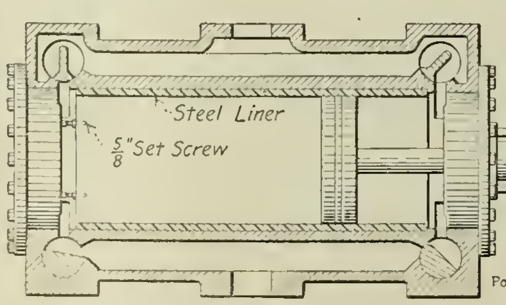


FIG. 2. CYLINDER SHOWING SETSCREWS HOLDING LINER

amiss, the only logical thing to do was to inspect the liner.

As the pound continued to increase at an alarming rate, keeping pace with the strokes of the piston with occasional muffled lapses as it apparently missed a stroke, the engineer finally concluded to take the matter into his own hands. Accordingly, he removed the cylinder head, ran out a timber with a screw jack behind it, between the edge of the bushing and the wall of the room, tightened up on the jack, and, as anticipated, the liner was found to be loose. Consternation reigned for a moment among the engine company's representatives, for it appeared at first that the only way to restore the engine to good order was to put on a new cylinder. The designer soon recovered his equilibrium, however, and began to devise plans for a serviceable repair with the least possible expense and delay. It was finally decided to patch the cylinder as shown in Fig. 2.

The edge of the liner was drilled at four equidistant points, the holes threaded by $\frac{5}{8}$-inch standard taps, and case-hardened setscrews secured with locknuts, were inserted as shown. The liner was forced firmly against the shoulder at the crank end of the cylinder, and then the setscrews were so adjusted that their heads bore solidly against the face of the cylinder head, at the same time permitting steam-tight contact in the ground joint between the head and the cylinder. This was a rather delicate adjustment and necessitated a dozen or more removals and replacings of the cylinder head before completion.

The engine continued in service and ran fairly well with this arrangement, but the engineer had a tedious job on his hands every Saturday night readjusting the setscrews after the previous week's run, for the thrust on the liner at each return stroke of the piston naturally tended to ram the screw heads hard against the cylinder head, wearing recesses in the comparatively soft metal and permitting a slight shuttling of the liner and the reappearance of the original pound.

A 16-horsepower internal-combustion motor is being tried for underground traction in the Langlaagte Deep mine, Transvaal. A special form of exhaust condenser is used, in which part of the cooling water is used to condense the products of the explosion, so that the vitiation of the air is stated to be less than would be the case if the many men required to deal with the load were at work.

Test of a High-Duty Pumping Engine

By Prof. R. W. Angus

The results of a twenty-four-hour duty trial on a new triple-expansion pumping engine at the Toronto city water works.

The supply of water for the city of Toronto is drawn from Lake Ontario, the water first passing through a steel pipe from the intake to Toronto island and thence through a large concrete tunnel under the bay to the well at the main pumping station. The tunnel is some distance below the bed of the bay so as to avoid seepage from the bay.

The engines of the main pumping station deliver directly to the mains, but the pressure is limited, due to the fact that a reservoir forms part of the system and is located at the opposite side of the city from the pumping station. The pressure maintained on the discharge main by the pumps at the main station is about 100 pounds per square inch.

The ground rises steadily from the bay northward through the city, and at the northern part, due to the high elevation, the water pressure is so far reduced as to make it necessary to provide some means of increasing it materially in order to furnish a satisfactory domestic supply. Hence, a high-level station was erected in which the pumps receive water direct from the mains supplied by the main pumping station, and discharge it into a separate system which serves the region named. The growth of this part of the city has been so rapid within the last few years, however, that it was found necessary to increase the equipment of the high-level station by the addition of new pumps, and it is to one of these that the present article refers.

FIG. 1. DIAGRAM OF ENGINE CYLINDERS AND PIPING

This pumping engine was built by the John Inglis Company, of Toronto, and is of the vertical, triple-expansion crank and flywheel type with three single-acting plungers and has a capacity of six million imperial gallons per 24 hours against a discharge pressure of 75 pounds per square inch, the suction pressure being 20 pounds. Dry saturated steam is supplied at a boiler pressure of 150 pounds.

A diagram of the steam cylinders and piping showing the path of the steam for the jackets, coils and cylinders is shown in Fig. 1. There are three steam cylinders, each of which is jacketed on the barrel only, but the design is such that the steam entering each cylinder passes over one-half of the corresponding head while the exhaust from the cylinder passes over the other half of the same head.

Corliss valves with separate eccentrics for steam and exhaust are used in all cases, except the exhaust from the low-pressure cylinder, where flat valves are used. The latter are opened by cams, the top pair being closed by compressed air and the lower ones by gravity. The exhaust steam may be passed through a feed-water heater on its way to the condenser if desired.

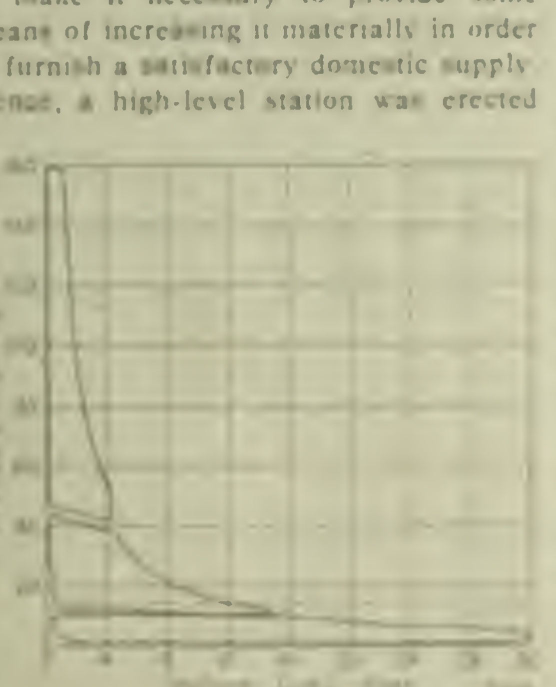


FIG. 2. COMBINED DIAGRAM, HEAD END

The air pump, boiler-feed pump and air compressor are attached to the low-pressure plunger, the compressor furnishing air for closing the low-pressure exhaust valves and also for replenishing the air in the pump-discharge chambers.

TABLE 1. PRINCIPAL RESULTS OF THE TRIAL

Pressure at engine throttle	[illegible]
Pressure in first receiver, pounds	[illegible]
Pressure in second receiver, pounds	[illegible] (below atmosphere)
Pressure in intermediate jacket, pounds	[illegible]
Pressure in low-pressure jacket, pounds	[illegible]
Vacuum, inches	[illegible]
Barometer, inches	[illegible]
Net pressure on pumps, pounds	[illegible]
Temperature of engine room, degrees Fahrenheit	[illegible]
Moisture in steam, per cent.	[illegible]
Average speed, revolutions per minute	[illegible]
Average plunger speed, feet per minute	[illegible]
Plunger displacement per 24 hours, imperial gallons	[illegible]
Work done per 24 hours, foot-pounds	[illegible]
Water horsepower	[illegible]
Steam used in jackets, etc., pounds	[illegible]
Steam condensed in condenser, pounds	[illegible]
Total steam used per 24 hours, pounds	[illegible]
Steam used per water horsepower per hour, pounds	[illegible]
Duty in foot-pounds of work done per 1000 pounds of steam used	[illegible]

There are three outside-packed, single-acting plungers of 21½-inch nominal diameter, the pump having a 24-inch suction and a 20-inch delivery pipe. All the water pumped passes through the surface condenser and is used as cooling water. The principal dimensions of the engine are as follows:

Cylinders	[illegible]
Diameter of piston rods, inches	[illegible]
Clearance volume, total: top end, high-pressure cylinder, per cent.; bottom or crank end, same cylinder, per cent.	[illegible]
First receiver, inches	[illegible]
Second receiver, inches	[illegible]
Condenser, cooling surface, square feet	[illegible]

DUTY TRIAL

A 24-hour duty trial of the engine was recently conducted by the writer. According to the contract the engine was to show a duty of [illegible] foot-pounds of work per 1000 pounds of steam used by the engine and auxiliary pumps. The steam to contain not over 1½ per cent.

FIG. 3. COMBINED DIAGRAM, CRANK END

moisture and to have a pressure of 150 pounds at the boiler, this pressure corresponding to 148.5 pounds at the engine.

Without going fully into the method of making the test it may be stated that great care was taken in getting the exact diameters and strokes of the several plungers, and special care was taken with other quantities used in computing the duty so as to insure accuracy in the results.

The water pressure averaged 74.92 pounds on the discharge main and 20.02 pounds on the suction main, and as these pressures were maintained very steady and the readings taken at five-minute intervals during the trial, these readings represent quite closely the true results. Table 1 gives the principal results of the trial.

This represents an extremely good performance in view of the fact that the power of the engine was so small, due to the low net water pressure. A set of combined indicator diagrams is given in Figs. 2 and 3 which show very good steam distribution.

Corrosion of Steam Boilers

By Walter C. Edge

Some of the common impurities found in feed water, their corrosive and scale-forming qualities, and the simple methods of treatment.

Water in a natural state always contains a great many other things than two parts hydrogen and one part oxygen. Sometimes it contains free nitric and sulphuric acids. River water, as a rule, is heavily loaded with vegetable and organic matter; nearly all lake waters contain limestone, and artesian and spring waters often contain soda as well as other foreign matter. These mineral substances are dissolved by the water in passing through the soil. The weight of the impurities in water varies greatly, but in moderately good water it is often from 20 to 50 grains per gallon. An analysis of a certain feed water showed it to contain the following impurities:

	Grains per Gallon
Silica	0.105
Oxide of iron and aluminum	0.362
Carbonate of Magnesia	13.794
Carbonate of lime	11.481
Sodium and potassium sulphate	3.569
Sulphate of lime	trace
Sodium and potassium chloride	3.300
Total solids	32.611

The total solid matter amounted to 4.65 pounds per 1000 gallons. A grain is 0.007 of a pound; hence, a steam boiler evaporating 600 gallons per hour (about 160 horsepower) would collect a deposit of

$$\frac{600 \times 4.65}{1000} = 2.80 \text{ pounds}$$

This is the approximate amount of impurities collected in one hour. Part of this would form sludge and the remainder would be converted into hard scale. If this boiler were worked a week of 60 hours, 168 pounds of solid matter would collect, and in less than three months this would amount to more than a ton.

The following table shows the principal impurities to be found in waters, some of them being in all waters and all of them being in some waters:

Impurities	Causing
Sulphate and bicarbonate of lime	Hard incrustation
Sulphate, chloride and bicarbonate of magnesia	Incrustation and corrosion
Chloride of sodium and carbonate of soda	Priming, foaming and incrustation
Bicarbonate and peroxide of iron	Incrustation and corrosion
Dissolved carbonic acid and oxygen	Corrosion
Sediment, mud, clay, etc.	Incrustation
Organic matter, sewage, etc.	Priming and corrosion
Grease	Corrosion
Nitric and sulphuric acids	Corrosion

The scale in a boiler is formed by lime, chalk and iron. While these solids are in solution in the original waters and cannot be detected by the eye, yet they are always left behind by the steam, and accumulate rapidly unless some means are taken to get rid of them.

Some of the evil effects of impure feed water are loss of fuel, loss of power and danger. The loss of fuel caused by a coating of scale on the heating surfaces of a boiler varies considerably, because it depends on the composition of the scale; some scales resist the transmission of heat many times as much as a boiler plate of the same thickness. It has been estimated that there is a reduction of from 2 to 4 per cent. a week in the quantity of water evaporated per pound of coal, due to the accumulation of scale. According to this, a boiler after working for four weeks would probably evaporate 8 to 16 per cent. less water per pound of coal than when in a clean condition, thus showing how important it is for the boilers to be kept clean.

If the feed water is of a corrosive nature it is advantageous to permit the formation of very thin scale as a preventive against corrosion. Corrosion, or the wasting away of the plates, is caused mostly by gases absorbed by the water, such as sulphurated hydrogen, and carbonic acid; grease and organic matter also promote corrosion. Even the purest waters when containing air, will cause pitting. More or less air is found in all waters, and this air escapes into the steam space when liberated by boiling, and being heavier than the steam, collects in bubbles, forming a layer between the water and steam and rapidly corroding the plate in the vicinity of the water line. The engineer should be careful to prevent the feed pump from drawing air, and should also be on the alert to prevent valve stems, etc., from leaking water on top of the boiler, as a great number of cases of external corrosion have been caused by a little neglect or carelessness regarding small leaks.

No doubt much corrosion in boilers is due to galvanic action; that is, when two different metals are placed in a solution capable of acting chemically on both of them an electric current is set up. The metal which is rapidly attacked and wasted away is known as the positive electrode, and in a galvanic battery, iron is always positive in the presence of copper. The inactive plate is known as the negative electrode. Iron is both positive and negative in the absence of other metals. In the presence of zinc, however, iron becomes negative.

Zinc then effectively protects iron from one form of corrosion. The presence of a small quantity is sufficient, a good proportion being a 12x6x½-inch slab for every 70 boiler horsepower. These slabs are usually attached to a stay, and should be renewed at regular intervals. Galvanic action is not nearly so common as some people seem to think, and it is doubtful if the action on the zinc slabs is always electrical, yet, if the corrosion of the boiler plates is lessened, their use should be continued even though the action is not fully understood.

In every section of the country the water has a different class of impurities, but the most common are the lime and magnesia. These substances are the principal cause of incrustation (hard scale formation) in boilers. Carbonate of lime (marble) and magnesia are almost insoluble in pure water, but dissolve readily in water containing carbonic-acid gas. This gas is driven off by boiling, and the lime and magnesia, before held in solution, are thrown in the solid form as insoluble deposits. A part of the mineral matter is deposited in the form of a fine powder, which forms mud, and the remainder settles on the plates of the boiler as hard scale.

The impurities are not all set free from the water at the same temperature. Thus the carbonates of lime are precipitated when a temperature of from 300 to 400 degrees Fahrenheit (corresponding to about 150 pounds pressure) is reached.

The small solid particles when set free remain for a time suspended in the water, being carried around by the circulation, but they settle down gradually on the tubes, plates and other internal surfaces. The lime matter then becomes scale, which soon bakes to the plates, and if no means of prevention are used a crust from $\frac{1}{16}$ inch to $\frac{1}{2}$ inch thick is formed on the inner surface of the boiler.

A good feed-water heater will serve to keep out the impurities which precipitate at temperatures in the neighborhood of 200 degrees Fahrenheit; this includes both the carbonates of lime and magnesia. The water will not hold these solids in solution when it is at 200 degrees or more, and consequently they are precipitated. But they are still held suspended in the water, and, unless given time to settle, will go to the boiler just as they would if still in solution. For this reason all purifiers should have space for from 5 to 15 minutes' supply of feed water.

Soda is the common antidote for carbonates of lime and sulphates of lime, the two most common impurities of water. Under the name of soda several substances are used as preventives of scale in steam boilers. The cheapest and most common is carbonate of soda, commonly known as soda ash. When soda ash is crystallized by dissolving in water, it becomes sal soda, which is synonymous with washing soda. Caustic soda is made by heating carbonate of soda with slacked lime. A solution of caustic soda in water is known as soda lye. For ordinary cases, 40 pounds of soda ash, 100 pounds of sal soda or 35 pounds of caustic soda per 1000 gallons of water will be sufficient to precipitate most of the scale-forming matter.

The cost of treatment with soda is very low, only about one grain of soda ash being required for each grain of sulphate.

If there are any free acids present they should be neutralized by additional soda. An excess of soda will impair the steaming facilities and will also have a corrosive effect on the iron. This is indicated by foaming, leaks, and the white salts of sodium oozing through the joints.

Boiler Plant Considered as a Factory

By Paul A. Bancel

Considering the coal, water and air as raw materials and steam as the finished product, the various losses in the process of manufacture are traced. The value of a CO_2 recorder for indicating these losses is discussed.

A boiler plant may be considered as a factory for making steam, from which standpoint an increase in boiler efficiency represents a decreased cost of production of the finished product—steam.

The raw materials supplied to the steam factory are coal, water and air. Of these, coal is expensive; water is expensive in some cases, but as the amount of water used is the same per pound of steam turned out, practically regardless of the method of operating the plant or its efficiency, it may be omitted at the outset from this discussion; finally, the third material, air, costs nothing except to move it.

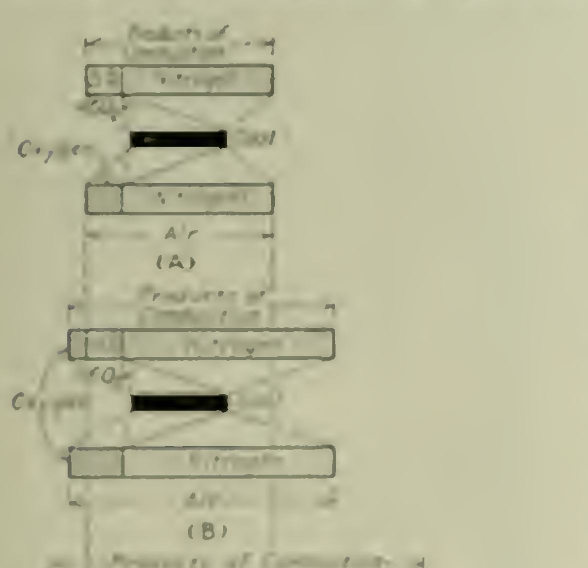


Fig. 1. Graphical Representation of Products of Combustion and Excess Air

The process of making steam may best be analyzed in two steps: First, the combination of the coal and air to form hot gases; second, the transference of the heat in the hot gases to the boiler surfaces, thence to the water and the formation of steam.

As with any other process of manufacture, there are wastes occurring in both steps of the process. These wastes occur due to the imperfect nature of the machinery used, the imperfect use of the materials, the formation of a waste product and the fact that the best of labor is careless. The waste or losses occurring in the process of making hot gases out of coal and air, may be summarized for the average plant as follows:

	Per Cent.
Loss due to incomplete burning of smoke	1
Loss due to unburned combustible gases such as hydrogen and carbon monoxide and hydrocarbons	[illegible]
Loss due to unconsumed carbon dropping through the grates with the ash	[illegible]
Loss due to radiation	[illegible]
Total losses	10

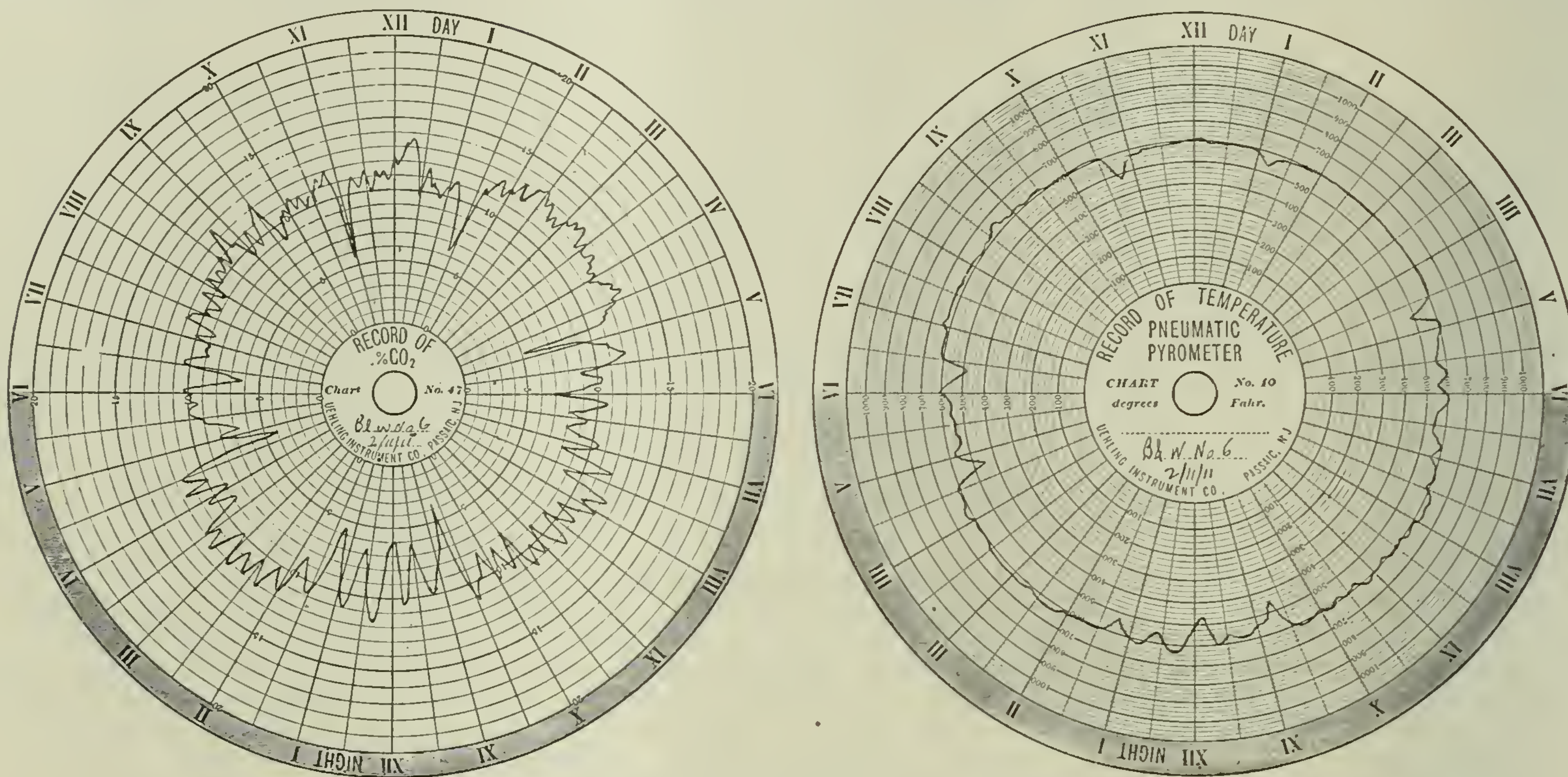
As is seen, the sum of all these losses amounts to 10 per cent. of the heat in the coal. If all the heat in the hot gases could be transferred to the water in the boiler, efficiencies of 90 per cent. or better would be obtained. It is in the second step of the process of steam manufacture that is found the chief cause of low efficiency.

The water within a boiler is at some temperature near 400 degrees Fahrenheit. The hot gases give up part of their heat to the water within the boiler, and are cooled down an amount depending upon the amount of surface used. If boilers were very large, then it would be possible to cool the gases to nearly the temperature of the steam and water. Unfortunately, it does not pay to put so much surface into a boiler, and gases are emitted from the chimney at temperatures near 500 or 600 degrees Fahrenheit. Thus the hot gases formed in the first part of the process with an efficiency of 90 per cent., are of no use for making steam under ordinary conditions, when their temperature has dropped below 500 or 600 degrees Fahrenheit. These gases are then a waste product of the steam factory, but not necessarily a useless product. They are valuable for heating cold water, cold air, for making draft in a chimney and for evaporating a liquid such as ammonia.

Fig. 2. Combustion Diagram

The amount of heat carried away from the boiler plant depends evidently upon the temperature of the gases, their specific heat and their weight. The specific heat is practically constant at 0.24 but the weight of the gases depends on how much air is used to burn the coal. Calculations will show that the heat value of the waste product in a boiler plant may run as high as 30 per cent. of the total heat of the coal. The very nature of this loss makes direct measurements difficult. If it were possible, the best method of determining the amount of heat in the waste gases would be to take the temperature of the gases going up the chimney and to measure their weight for each pound of coal burned.

The weight of the gases going up the chimney, however, cannot be readily measured and it is difficult to determine just how much coal is actually being burned at any time corresponding to the moment at which the weight of the gases is taken. There is no direct means, therefore, of measuring the amount of heat in the waste product emitted from the steam factory, or boiler plant. On the other hand, an indirect means of obtaining the weight of the waste product per pound of coal burned lies in the measurement of the carbon dioxide contained in the flue gases.



FIGS. 3 AND 4. DAILY CHARTS SHOWING PERCENTAGES OF CO_2 AND THE FLUE TEMPERATURES

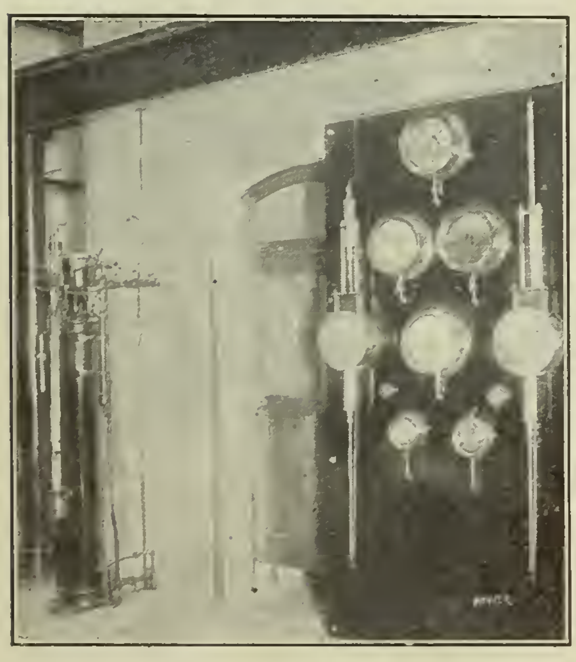


FIG. 5. UEHLING WASTE METER AND RECORDING GAGES

Air consists of oxygen and nitrogen. Only oxygen is necessary for combustion, but the nitrogen must be carried along with the oxygen into the furnace without entering into the process of combustion. Coal consists of carbon, hydrogen, ash and minor constituents, the first two entering into the process of combustion, the latter being mineral material not combining with the oxygen and not developing heat. The carbon in the coal combines with a definite amount of oxygen to form carbon dioxide gas or CO_2. Furthermore, it is an established fact that when a cubic foot of oxygen combines with carbon to form carbon dioxide, the volume of the carbon dioxide formed is also one cubic foot, the temperature of oxygen and carbon dioxide being the same. As the volume of all the gases varies in the same way with the temperature changes, any volumetric relations holding true when the temperature of the products of combustion as 500 or 600 degrees will also hold true when their temperature is that of the atmosphere.

Referring to Chart A, Fig. 1, assume that the coal consists of carbon only and below the coal bed a certain amount of air consisting of oxygen and nitrogen is supplied, the coal burning so that the products of combustion consist of carbon dioxide and nitrogen. If the combustion were complete with just enough air supplied to effect complete combustion, then as the carbon dioxide displaces the oxygen, the volumetric relations of the gases in the products of combustion would be the same as the relations of the gases in the air. The percentage by volume of oxygen in the air is 21, and with theoretically perfect combustion of carbon, the products would consist of 79 per cent. of nitrogen, 21 per cent. of carbon dioxide and no percentage of oxygen. Charts B, C and D, Fig. 1, show the relations when more than the theoretical amount of air has been supplied. The amount of coal burned being the same, the same amount of carbon dioxide must be formed. But as more than the theoretical supply of air has been furnished, a part of the oxygen, together with all the nitrogen, must go through the coal without entering into the process of combustion. The products of combustion consist then of nitrogen, carbon dioxide and also a supply of uncombined oxygen. If twice as much air and oxygen as is theoretically needed were supplied, then as shown in Chart C, the volume of carbon dioxide formed would be half the volume of the oxygen originally in the air. The percentage of carbon dioxide in the gases formed would then be, instead of 21 per cent., one-half of 21 per cent. or 10½ per cent.

These relations may also be shown by the charts in Fig. 2. The area of the circles in each case represents the amount of gas going up the chimney for one pound of carbon burned. As it requires a definite amount of oxygen to burn a pound of carbon and a definite amount of carbon dioxide is formed, the volume of carbon dioxide remains the same in each

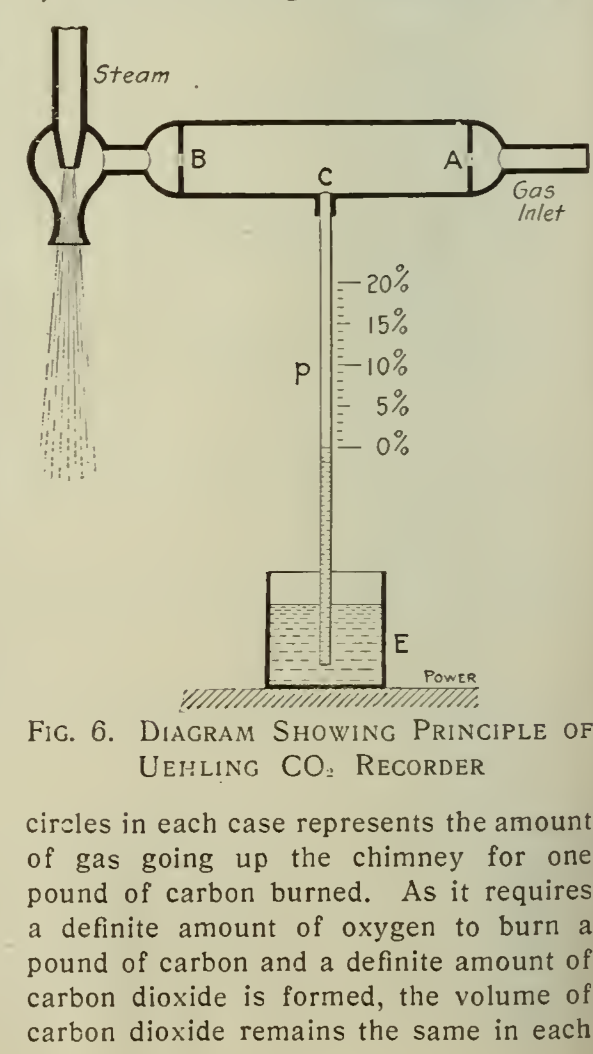


FIG. 6. DIAGRAM SHOWING PRINCIPLE OF UEHLING CO_2 RECORDER

case, shown by the small shaded area. In the case of Chart A, all the oxygen is transformed into carbon dioxide and all the remaining area is nitrogen, the percentage of carbon dioxide in the flue gases being 21 per cent. In Chart B the total volume has increased, the amount of nitrogen being increased and the the amount of oxygen available for burning one pound of carbon increased; the amount of carbon dioxide formed remains the same as in the first case.

Just as the factory manager can look over his books and note the value of his raw materials, the cost of manufacture, the price of the finished product, the profit, the value of the waste product, etc., so can the engineer record, in connection with the plant load, the draft, thickness of fire, kind of labor, coal burned, amount of water used, temperature of the flue gases and percentage of carbon dioxide; and thus be guided in running his steam factory so as to turn out the finished product at the least cost.

Typical records of carbon dioxide and temperature are shown in Figs. 3 and 4, which were obtained from a Uehling combined CO_2 machine and pyrometer, or "waste meter," installed in the Edgewater plant of the Corn Products Refining Company. This waste meter is shown in Fig. 5, where also the recording gages can be seen mounted on the board. The recording gages are simply vacuum-recording gages, and it is because this waste meter measures both carbon dioxide and temperatures by changes in partial vacuum, that it is possible to record by independent gages and indicate by water columns, and also that continuous measurement is obtained.

Referring to the sketch of Fig. 6, the flue gas is drawn through the two apertures A and B by constant suction produced by a steam aspirator. The suction in chamber C will remain constant so long as the same amount of gas passes through both apertures. If, however, part of the gas, that is, the CO_2, be absorbed in the space between the two apertures, the vacuum will increase in proportion to the amount of gas absorbed. All that is necessary then in order to measure the percentage of CO_2 is to connect chamber C with an indicating water column, or a light vacuum-recording gage.

The engineer aided by a waste meter of this kind is guided in operating his plant so as to cut down the cost of steam production to the least amount compatible with the cost of coal, character of coal, kind of grates, draft available, kind of boiler, etc.

Progress in Return Tubular Boilers

By William Kavanagh

Showing the improvements that have been made in the settings and fittings of horizontal return tubular boilers during late years.

Improvements in the design of horizontal tubular boilers and settings have been slow as compared with other types. Those improvements that have been made in late years, however, include dispensing with staggered tubes, leaving out the middle vertical row of tubes, placing manholes above and below the tubes, dispensing with the handhole in the rear head, the proper protection of the blowoff pipe against overheating, omitting the steam dome and carrying the boiler on rollers or suspending it from girders.

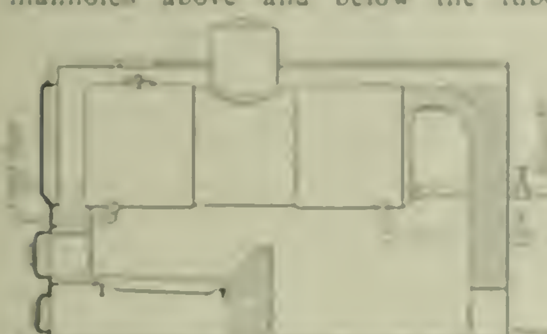


Fig. 1. Old Method of Connecting Feed and Blowoff

Fig. 1 represents what may be termed an "old time" setting in which the feed pipe is attached to the bottom sheet, directly over the fire, the object being to heat the feed water before entering the boiler. The blowoff is attached to the rear head some distance above the bottom sheet, which arrangement prevents, to a large extent, the mud and scale from being forced out of the boiler. The dotted lines, Fig. 1, represent the feed introduced through the lower part of the front head; also, the proper connection for the blowoff pipe which is protected by a sleeve or covering of asbestos.

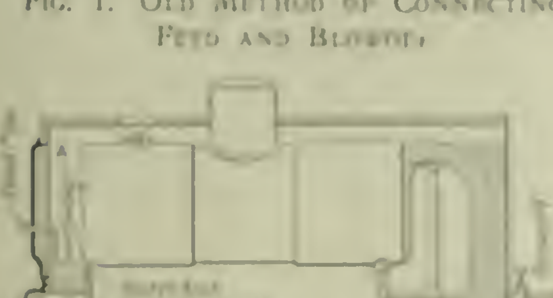


Fig. 2. Water Arch at Front and Continuous Circulation through Blowoff

In Fig. 2, the blowoff pipe is protected from overheating by a circulation of water through it. Here, also, the feed is admitted through a water arch, thence through pipe A to the boiler at some distance below the water line.


Fig. 3. Water Arches at Both Front and Rear

A progressive step toward utilizing waste heat and preventing cracked walls and falling fronts and rear arches, is shown in Fig. 3. Both front and rear water arches are supplied; the feed entering at B and after circulating through the rear arch, which is exposed to the hot gases, passes to the front arch and thence into the boiler where it is discharged through a perforated pipe. The main blowoff pipe, besides being protected by the circulation of water, is fitted with an asbestos-packed cock, an auxiliary blowoff valve and a "tell tale." When the latter indicates leakage, the auxiliary blowoff may be closed and the

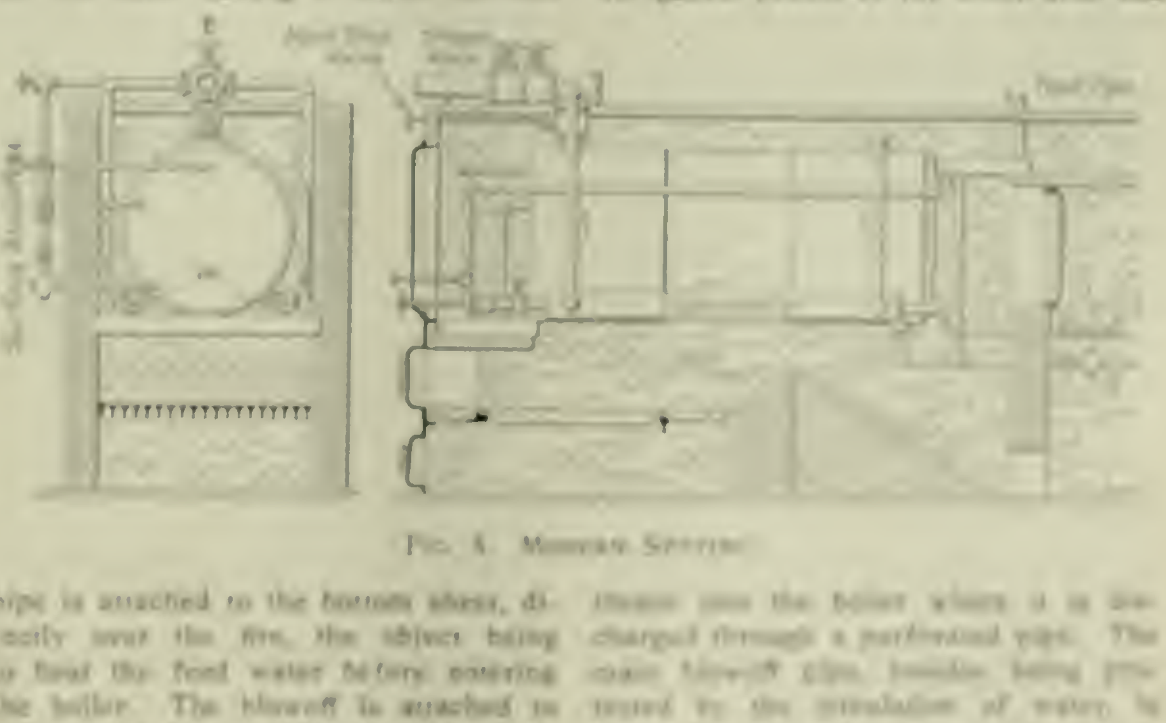


Fig. 4. Modern Setting

main blowoff repaired. Previous to the use of auxiliary blowoff valves there was no way of making repairs to the main blowoff cock without shutting down the boiler.

The boiler shown in Fig. 4 embodies the good points gained through many years of experience and represents probably the most uptodate practice with return-tubular boilers. The lugs rest on rollers allowing free longitudinal expansion and contraction of the boiler and both front and rear water arches are fitted. The rear wall has a door permitting inspection and cleaning of the rear head. The steam is taken from the rear of the steam space and passes through a superheater extending the whole length of the boiler, thence to the main header which is also connected directly to the steam space of the boiler. Both an ordinary steam gage and a recording steam gage are fitted.

The furnace is hand fired and at the rear of the grate is a dead plate used for banking and cleaning the fires. The damper shaft is carried on roller bearings which permit a very sensitive regulation of the steam pressure. A surface blowoff is attached at the front of the boiler and an improved arrangement of regular blowoff, similar to that shown in Fig. 3, is fitted at the rear.

The water column is fitted with both a high- and a low-water alarm in addition to self-closing gage-glass valves. Also, the water connection to the column is fitted with a tee and brass plug for use when cleaning the connection.

In raising steam the valves *W W* are first opened to allow a circulation of water through the superheater and after the desired pressure has been reached they are closed and any water in the superheater is blown out at the rear, through the valve *I*. Near this valve is placed a small valve *J*, used to indicate the quality of the steam in the superheater. When this valve shows dry or superheated steam the main valves *E E* are opened, and the boiler is put into service.

The boiler-feed pump should be fitted with a safety valve to prevent excessive pressure on the feed line; also, a bypass allowing the pump to run at practically constant speed, any surplus water being discharged back into the suction line. The check valve on the feed line should be placed between two globe valves, thus permitting repairs at any time.

An essential feature with the foregoing equipment is that all pipes and fittings are extra heavy and the connections allow movement and compensate for expansion and contraction. Furthermore, no expansion joints are used, the connections being so arranged as to screw and unscrew in the direction of the stress.

Determining the Value of Fuel

By R. L. Ellis

It is pointed out that the method of purchasing coal upon either the analysis basis or upon an evaporation basis alone, is inadequate, but a combination of the two has been found to give excellent results.

Discussions upon the subject of fuel have, in general, advocated some particular theory as to the best method of determining the value of the fuel to be purchased, the best method of combustion, or a reduction of the smoke nuisance, etc., rather than a sincere desire to ascertain the facts in the case. There is the man who is bent on the elimination of smoke and who has tried to show that all the profits go up the stack in the form of smoke. As a matter of fact, the visible element in smoke amounts at most to but a very small percentage of the total heat and it is easily possible to have absolutely smokeless combustion and far from economical operation, although from certain standpoints the elimination of smoke is desirable.

There are others who maintain that the B.t.u. in the coal is the proper basis of purchase, attempting to class the whole carload or more from a sample weighing a gram or less. The contract of a certain concern which proposes to purchase coal on B.t.u. specifications, provides for certain penalties for excess of ash, a deviation in the proximate analysis from that specified, an excess of sulphur and for deficiencies in the heat contents. But might not the coal vary rather considerably in each particular and there be no marked difference in the actual results obtained? Also, if these penalties and bonuses apply, how are the amounts to be determined for the variations? Certainly the penalties and bonuses should represent not arbitrary amounts but only real variations in the worth of the coal to the consumer.

Again, there are those who are opposed to the scientific analysis and buying of coal; they contend that the only measure of the value of a coal is the quantity of water it will evaporate per pound. There is a measure of truth in each treatment of the subject, but the solution of the problem lies in a combination of the practical and the scientific methods. It is desirable to eliminate smoke but it is more important to secure economical combustion. It is important to obtain a high percentage of CO_2 in the flue gases but one may get too much for the overall economy. It may be desirable to know the character of coal used and its heat contents, but for the particular furnace conditions in which the fuel is to be used this may not furnish a true guide as to the desirability of the coal. On the other hand, without the analysis one may fail to get the proper results from a really economical coal and discard it as worthless on account of not being able to interpret the facts furnished by the scientific analysis.

The real measure of the value of coal for commercial use is its cost per unit of finished product. The total cost of the coal includes its cost at the mine, cost of delivery, unloading, stoking and handling the ashes, together with any other expense due to the use of the coal. The finished product may be supplying a certain number of square feet of radiation at a given temperature, yards of cloth made, kilowatt-hours, etc.

Coal as usually specified by analysis contains a certain amount of moisture, volatile matter, fixed carbon and ash, with a separate determination of the sulphur, and finally, a certain number of B.t.u. per pound. Usually with the dealer this means a mine sample or a sample taken by cross-cutting the seam and a careful elimination of any dirt above or below the seam, but with the purchaser it should mean an average car sample, which is an entirely different proposition.

Some contracts make deductions for moisture, but unless the coal be weighed at the point of delivery this is manifestly unfair for the reason that the excess moisture may represent water in the form of rain which fell after the coal left the mines. On the other hand, if the coal be shipped in fair weather and remain several days on the road it might be flooded with water at the mine and be practically dry upon delivery, which would afford the seller a very large advantage. Unless the quantity of coal is sufficient to warrant scales at the point of delivery, it is inexpedient to make any provision for correcting for moisture in the coal. About the only thing that can be done is to weigh an occasional car under different weather conditions to ascertain whether the mine owners are attempting to act unfairly in the matter and, if so, it has been the experience of the writer that the sooner a contract with a concern of such character is broken the better.

In the proximate analysis it is desirable to know if the volatile matter be determined with or without a previous drying-out process; the results may be markedly different in the two cases. Furthermore, it should be known whether the volatile matter is all combustible and whether it distils off quickly or slowly. These affect the adaptability of the coal for a particular furnace unless the furnace be designed to handle economically coals of widely different characteristics, but very few of the commercial forms are so arranged.

At the plant with which the writer is connected, the average cost of coal stoked and the ash removed was $2.76 per ton, and the coal per kilowatt-hour averaged for the year 8.60 pounds. With this information at hand, several carloads of coal were ordered and placed in the bin, samples being taken during unloading. These samples were sealed in quart jars, labeled by car numbers and sent to a chemist for analysis. The coal was then burned under the boilers and data taken as to the evaporation and the kilowatt-hours delivered at the switchboard.

Having done this, the question then arose as to what had actually been accomplished. It was known that a certain amount of coal had been burned per kilowatt-hour at a certain cost per ton of coal fired. But what of it? The results were not of such a character as to determine whether the coal was or was not desirable for the particular conditions. It was known that the coal ran about 8 per cent. in ash, 35 per cent. in volatile and 57 per cent in fixed carbon, with less than 1 per cent. of sulphur and a heat content of 13,750 B.t.u., but the actual performance of the coal could not be correlated with the results of the analysis, and, furthermore, wide variations were observed from day to day in the actual results with apparently no change in load or weather conditions. Manifestly there were the personal equation of the fireman and other factors to consider.

To this end, a thermometer was placed in the feed-water supply, another in the uptake of the stack, a gas-sampling apparatus in the base of the stack and at several places in the furnace proper, an Orsat apparatus was purchased, the engines were reindicated and the integrating meters on the switchboard recalibrated. A water-weighing apparatus was installed on the feed-water line and the coal scales were overhauled and calibrated. Some more coal was bought and the conditions of the whole plant were studied thoroughly. It was then found that coal from different mines behaved very differently in the boiler and in order to obtain the cheapest and most economical fuel it would be necessary to design a furnace that would economically handle coal of wide variation in character. This work took quite some time, but finally a furnace was produced that would successfully handle coal varying all the way from coke to the highly volatile coal from the Alabama fields.

It is now the practice at this plant when purchasing coal to take a sample from each car for analysis. In a day or two, after the fireman has become familiar with the coal, results are noted. Of course, records of all conditions are taken daily but the results are expected to be poor with a given coal until the fireman has learned to handle it properly; hence in estimating the value of the coal these experimenting days are eliminated.

After the fireman has become familiar with the coal, frequent readings are taken of the thermometer in the uptake, also frequent determinations of the flue gas, as well as a 12-hour sample. The temperature of the feed water is so nearly constant at 212 degrees Fahrenheit that it is not recorded and only checked occasionally to see that the heater is in good working order. The amount of water fed to the boilers is noted at the end of each 12 hours and corrected for difference in the level of water in the boiler. The coal is also corrected for the amount on the firing floor at the end of each 12 hours. Readings are taken on the integrating wattmeter as are also readings on the indicating meters to ascertain if the load conditions are normal.

Having previously determined the most economical percentage of CO_2 in the flue gases for the particular coal, it is kept as nearly as possible at that point. It has been found unnecessary to make a complete analysis of the flue gases except occasionally, as the furnace efficiency follows very closely the CO_2 content up to a certain point. The density of the smoke is noted, but this is a very minor consideration since there is no smoke ordinance and with practically perfect combustion the smoke is rather negligible.

The uptake temperature indicates the heat loss through the stack; the record of feed water checks the boiler performance as distinguished from the engine and generator performance; and by weighing and examining the unconsumed portion of the coal, its clinkering character is noted; also, it can be ascertained if there is any considerable amount of unconsumed fuel mixed with it.

From the foregoing, it will be seen that the coal tests at this plant are a cross between the rule-of-thumb methods of the so-called practical school and the refinements of the scientific school. The combination might properly be termed the commercial method of testing. To sum up, in determining what coal shall be purchased, the analysis and heat determination as supplied by the seller are gone over and it is ascertained whether the mine owner is willing to guarantee this as an average car-sample analysis. The financial condition of the mine is then looked into, also the railroad facilities for a continuous supply of coal. These factors serve as a general guide as to what may reasonably be expected of the coal. If the ash be low, the B.t.u. contents reasonably high, and the coal from a field that has given good results and the price attractive, several cars will be purchased for trial. It is usually possible to purchase with the price on the sample cars open and to be determined by the results in comparison with the coal then in use; in other words, at so much per kilowatt-hour for coal cost.

In making up an estimate as to the probable value of the coal, the proposed price of the coal plus the freight, the cost of unloading the coal and the cost of handling the ashes for each per cent. of ash in the coal are considered; this total is divided by the number of B.t.u. The result is strictly arbitrary, since the costs are per ton and the B.t.u. are per pound. This figure, however, in comparison with figures previously obtained from other coals gives a fairly accurate predetermination of the probable value of the coal in comparison with others.

At the time of testing the coal commercially, if the results are good, the samples are analyzed and compared with the mine analysis, each other and the actual commercial results. If the results all told show that the fuel is a desirable one a contract is made.

The existing contract is ideal for simplicity and practically gives results that are believed to be equally as good if not better than those obtained by the more involved contracts, and it is manifestly fair to both concerns. It provides that the coal to be furnished shall not differ materially from that sent as a sample in the proportion of volatile matter and fixed carbon; it shall be from the same seam and furnished with regularity at a specified rate. The price is specified. In the particular coal now being purchased the ash from the sample cars did not exceed 8 per cent. and the B.t.u. did not fall below 14,000. It is, therefore, specified that if the ash habitually exceeds 10 per cent. and the B.t.u. falls below 13,500, the purchaser shall have the right to reject the coal and cancel the contract, or a new price shall be agreed upon between the parties to the contract.

In this it will be seen that the actual value of the coal is determined by its use in the plant in which it is to be used and the conditions are checked to ascertain if the shortcomings of any sample are due to lack of quality or improper handling. The analysis of the coal is only used as a check and to insure the furnishing of coal on the contract of substantially similar character.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

A New Interpole Dynamo

The development of heavy electric traction and large factory equipments has created an extensive demand for direct-current dynamos that will work sparklessly under widely and rapidly fluctuating loads and abnormal overloads and for meeting such requirements the interpole construction, now well known, is admirably fitted. The accompanying engravings show the essential features of a machine of this type which has been recently brought out by the Westinghouse Electric and Manufacturing Company for direct mounting on the extension of the prime-mover shaft.

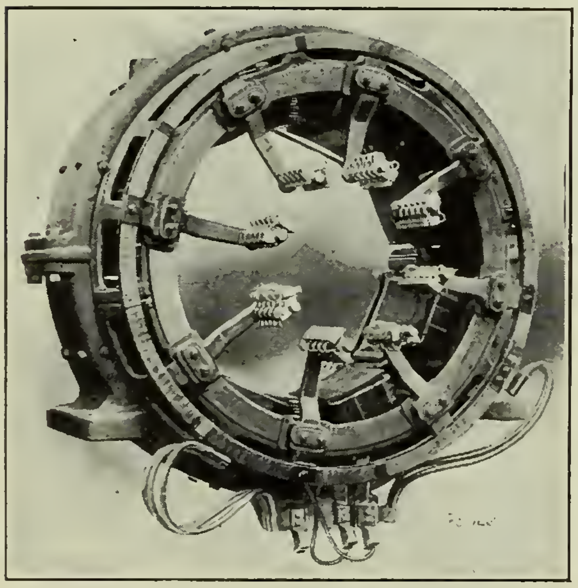


Fig. 1. Interpole Field Magnet

The complete field magnet is shown in Fig. 1, from which it will be evident that the brushes are not provided with the means for adjustment which is always found on ordinary generators without interpoles. The brush rigging is set accurately at the factory and the field-magnet yoke and the ring which carries the brush holders are marked so that this position can be duplicated instantly when the machine is erected in its working position. The magnet yoke ring is of cast steel and only a little wider than the magnet poles; consequently, the field-magnet coils extend beyond the yoke edges and their heat is readily radiated. The projecting portions of the coils are protected from mechanical injury by a skeleton framework at each side of the yoke ring and the brush rigging is supported by one of these frames, as shown in Fig. 1.

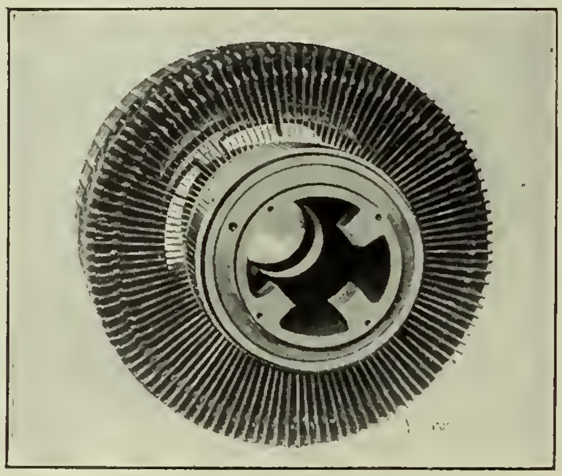


Fig. 4. Commutator End of Complete Armature

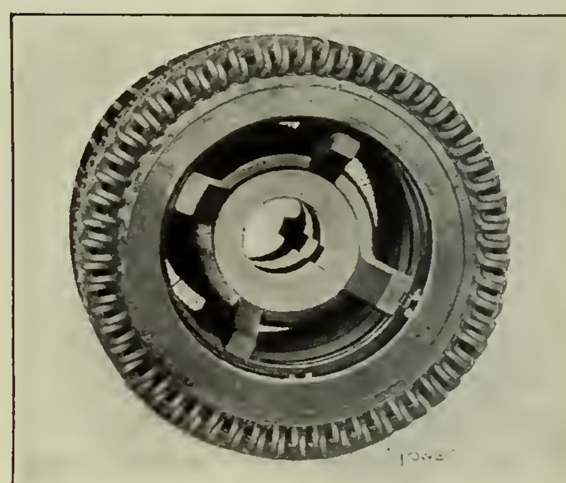


Fig. 5. Rear End of Complete Armature

The main magnet poles are built up of thin steel sheets riveted into a solid mass, as indicated in Fig. 2; these are bolted to the inner face of the yoke ring, which is machined smooth all the way around and across the face. The interpoles are solid steel blocks, also bolted to the yoke ring.

The armature core is built up of annular segments dovetailed to ribs on the central spider and the latter is cast with internal ribs also, instead of being solid down to the shaft. Fig. 3 shows this construction; the barrel projecting toward the observer supports the commutator, forming the drum and one flange of the commutator core. The armature core is provided with spacers at intervals along its length, as usual in large machines, forming ventilating ducts between the adjacent laminations of the core. The core is, of course, slotted to take the coils, which are form-wound and individually insulated. The winding is of the straight-out or barrel type, leaving

Fig. 2. Magnet Pole

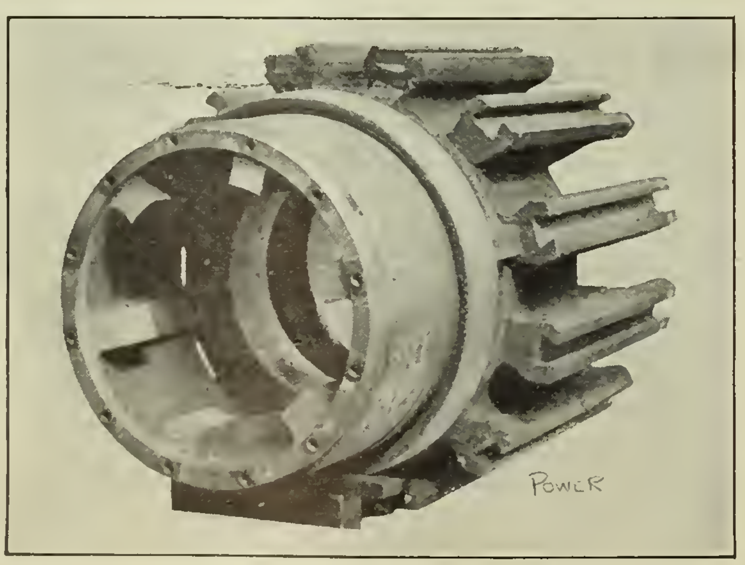


Fig. 3. Armature Spider and Commutator Core

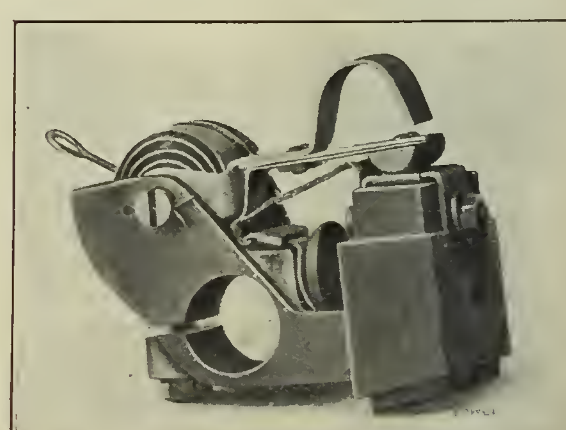


Fig. 6. Brush and Holder

the heads of the core open to the surrounding air, as Figs. 4 and 5 show; these views indicate how clean-cut and well ventilated the armature and commutator are.

The brush holders might be characterized as "the usual pocket type," but there are several details which, though relatively minor, deserve special consideration. The "pigtail," for example, which is of flat copper-wire braid, is attached to the frame of the brush holder by means of a large thumbscrew and to the brush by means of a through bolt; moreover, the "pigtail" is so located that it cannot foul the spring or interfere with the movement of the brush, although it is easily accessible for removal. See Fig. 6. The bolt which attaches the "pigtail" to the brush passes through the ends of a ∩-shaped strap which straddles the top end of the brush and affords a seat for the end of the pressure finger; the latter is equipped with a rounded pressure block which touches the brush along a line, no matter what the position of the brush, and therefore does not tend to tilt the brush or jam it against the wall of the pocket. The pressure finger is forced against the brush by a flat spiral spring the tension of which is adjustable by the usual spindle and lever.

These machines are built in sizes ranging from 25 to 1000 kilowatts and of the standard direct-current voltages. They are compounded to give a rise of 7 volts in the low-voltage machines, 20 volts in the middle-voltage machines and 50 volts in the railway machines.

National Electric Light Convention

The thirty-fourth convention of the National Electric Light Association was held this year at the headquarters of that body, the Engineering Societies building, New York. The convention was opened on May 30 with the usual formalities; the delegates were welcomed to the city by acting mayor John Purroy Mitchell, the president of the association delivered his annual address and several important committees presented their reports.

Overhead Line Construction

The report of the committee on overhead-line construction was an admirable piece of work, embracing detailed specifications for materials and methods to be used in building overhead lines for 2300-volt alternating-current distribution and for street-lighting circuits. Because of the completeness of these specifications it is impracticable to abstract or summarize them beyond stating that they cover the dimensions and appearance of chestnut, white-cedar and yellow-pine poles; dimensions and quality of pine, cypress and fir crossarms; sizes and quality of wooden and metal insulator pins, pole-steps and guywires; copper, aluminum and copper-covered steel wires and cables, bare and insulated. Methods of putting up poles and stringing wires are also described and illustrated. The report is really an encyclopedia of modern line construction and worthy of a substantial binding to withstand the constant reference which it justifies.

Meters

The report of the meter committee, presented at the afternoon session of the first day's proceedings, contained some excellent material on the practical care of meters which will be published very fully in an early number of Power.

Grounding Low-tension Circuits

In a paper of the above title, Paul M. Lincoln pointed out the advisability of grounding low-tension alternating-current circuits for protection to life and explained how and why breakdowns frequently occur between the high-tension and low-tension windings of transformers.

The fundamental reason why breakdowns of this sort occur simultaneously with disturbances on the high-tension system, he said, is that transformers act to a considerable extent as condensers because of the interleafing of the sections of the winding; that is, the high-tension "pancakes" act as one set of condenser plates and the low-tension sections as the other. Under such conditions, an alternating difference of potential between the high-tension system and the ground will induce a corresponding difference of potential between the low-tension system and ground.

The amount of potential difference between the low-tension winding and the ground will depend on the relative static capacity between the two windings and between the low-tension winding and ground; also on the average departure from ground potential by the high-tension windings. In a transformer of the shell type with coils arranged as indicated in Fig. 1, the condenser capacity between the low-tension windings and the ground was three times the capacity between the two windings. When the external circuit connected to the low-tension windings also has capacity with respect to the ground, this modifies the danger of breakdown; the maximum danger exists, therefore, when the low-tension windings are entirely disconnected from the external circuit.

Fig. 1. Sandwiched Transformer Coils

The remedy, or preventive, for the evil under discussion is to ground the low-tension windings of the transformers and thereby give the induced static potential an easy and harmless path instead of giving it a chance to break down the insulation. Increasing the insulation of the low-tension windings does no good; it merely increases the relation between the primary-secondary capacity and the capacity between the low-tension windings and the ground, the increase being such as to increase the dangerous static potential between the low-tension windings and the ground.

Improvements in Single Phase Motors

Under this title, W. A. Layman presented an interesting analytical description of a type of self-starting single-phase motor which the Wagner Company is developing under the patents of Val. A. Fynn. The rotor contains two distinct windings, one a simple squirrel cage and the other a polar winding, in the same slots. The polar winding is connected, through a commutator and brushes, in series with the stator winding and serves to produce the torque necessary for starting; at normal speed an automatic switch connects the brushes to an auxiliary stator winding which "compensates" the inductive effect of the main winding and raises the power factor of the machine. The construction and principle of operation will be described in this department in the near future.

Relation of Load to Power Station Equipment

J. D. Newbury presented a paper dealing with the effect of the character of the load upon the equipment of a generating station and with the adaptation of the station equipment to meet the requirements of the kind of load with which the present day station has to deal.

In the alternating-current system the characteristic that has led to more trouble in the generating equipment than any other was that of the effects of low power factor. A simple way of considering this question is to assume that the actual load can be divided into two components, one equivalent to the noninductive load and the other equivalent to the combined leading and lagging wattless load.

The wattless component of the load may be a demagnetizing component, such as required by induction motors and inductive loads in general; or it may be a magnetizing component supplied by overexcited synchronous motors or static condensers.

A distinction should be made between raising the power factor by increasing the energy load and by decreasing the wattless load. While the former is desirable the latter is more desirable, since a low power factor is a positive detriment only when the load is a maximum and station capacity is at a premium, while a decrease in the wattless load is always of advantage, since it means an increase in operating efficiency.

Practically all loads supplied by central stations have a demagnetizing component. Power factors above 95 per cent. are obtainable only when the load consists of synchronous motors or rotary converters. Power factors of 90 to 95 per cent. can be expected only when the load is entirely noninductive or when synchronous motors are supplied together with a relatively small proportion of inductive apparatus. For the average central station carrying a lighting and power load, 80 per cent. power factor should be assumed [in considering the station equipment]. For a plant to supply a large proportion of induction motors, arc lamps and other inductive apparatus, 70 per cent. is a fair estimate.

It is necessary to estimate the power factor of the load in order to choose the relative rating of the generators and engines intelligently, because the engine rating should correspond to the generator ability in true power at the power factor that will be imposed by the load.

When it is a question of adding new load to an existing station the probable power factor of the load may be estimated as follows:

Kind of Load	Probable Power Factor
Incandescent lighting with small transformers.	From 90 to 95 per cent.
Alternating-current inclosed arc lamps with constant-current transformers.	From 60 to 75 per cent., depending upon the proportion of full load on transformers. An average figure would be 70 per cent.
Direct-current metallic arc lamps with rectifiers.	From 55 to 70 per cent., depending upon load on rectifiers. An average figure would be 65 per cent.
Single-phase induction motors; squirrel-cage rotors, 1/20 to 1 horsepower.	From 55 to 75 per cent.; average 68 per cent., at rated load.
Single-phase induction motors; squirrel-cage rotors, 1 to 10 horsepower.	From 75 to 86 per cent.; average 82 per cent., at rated load.
Polyphase induction motors; squirrel-cage, 1 to 10 horsepower.	From 75 to 91 per cent.; average 85 per cent., at rated load.
Polyphase induction motors; squirrel-cage, 10 to 50 horsepower.	From 85 to 92 per cent.; average 89 per cent., at rated load.
Polyphase induction motors; phase-wound rotors, 5 to 20 horsepower.	From 80 to 89 per cent.; average 86 per cent., at rated load.
Polyphase induction motors; phase-wound rotors, 20 to 100 horsepower.	From 82 to 90 per cent.; average 87 per cent., at rated load.
Rotary converters, compound wound.	At full load the power factor can be adjusted to practically 100 per cent. At light loads it will be lagging, and at overloads slightly leading.
Rotary converters, shunt wound.	The power factor can be adjusted to any desired value, and will be fairly constant at all loads with the same field rheostat adjustment. Rotary converters, however, should not be operated below 95 per cent. power factor leading, or lagging, at full load or overload.
Small heating apparatus.	The power factor of the load is practically unity, but the distributing transformers will lower it to some extent.
Arc furnaces.	From 80 to 90 per cent.
Induction furnaces.	From 60 to 70 per cent.
Welding transformers.	From 50 to 70 per cent.
Synchronous motors.	Adjustment between practically zero power factor leading, to zero power factor lagging.

From the foregoing table it is evident that the only kind of load which affords any control over power factor is the synchronous motor. This fact has led to an increasing use of synchronous motors by central stations in order to improve the power factor of the system. Unfortunately, the complication of a separate exciting source and the ability to start only under a comparatively small load restricts the use of synchronous motors largely to location at the station, where skilled attendance is at hand, or to motor-generator sets.

Synchronous motors have been operated without load to improve the power factors of systems but it is more economical to utilize the motors to do mechanical work at the same time. The required capacity of such a motor is the vector sum of the required wattless and energy inputs; that is, the total input in kilovolt-amperes is equal to the square root of the sum of the squares of the wattless kilovolt-amperes and the kilowatts. For example, if the wattless intake from the line be 600 kilovolt-amperes and the energy intake, converted into mechanical work, be 800 kilowatts, the total intake will be 1000 kilovolt-amperes.

To determine the proper size of synchronous motor to use for effecting a given improvement in station power factor and to do some mechanical work also, it is necessary to consider the characteristics and size of the station load. To the existing station load must be added the true kilowatts that the motor will require to do the mechanical work and supply its own losses. From the *desired* power factor and the total load in kilowatts the total kilovolt-amperes and the future wattless kilovolt-amperes are obtained and subtracting these from the existing wattless kilovolt-amperes gives the wattless component to be supplied by [to] the motor.

For example, with a load of 1200 kilowatts and a power factor of 70 per cent., the wattless kilovolt-amperes will be 1220 [1224 is the theoretically accurate figure. —Ed.]. If the synchronous motor is to do work (including its losses) requiring 240 kilowatts intake, the future energy load will be 1440 kilowatts. If a power factor of 90 per cent. is to be obtained, the future wattless kilovolt-amperes will be 698 and the difference between 1220 and 698 being 522, that is the number of wattless kilovolt-amperes for the motor to take. The total intake of the motor, then, must be

$$\sqrt{240^2 + 522^2} = 575$$

kilovolt-amperes. In general, it will not be found worth while to raise a station power factor above 90 per cent., since the investment necessary is seldom warranted by the improvement in operation.

Power Required by Industrial Machinery

The report of the committee on power should be of immense value to central power stations. It contains an extensive list of industries which are operated by electricity from central stations in various cities widely distributed about the country, in which the kind of machinery, type of drive, service hours per week and kilowatt-hours of actual service per year are stated; also, an astonishingly full list of motor ratings for industrial machines of all kinds and sizes, from a ⅛-horsepower pamphlet stitcher up to a 250-horsepower stone crusher. In between are printing presses, wood-working machines, cement machinery, boiler-shop machines, textile machinery, laundry equipment, etc.

Ventilation of Turbine-driven Generators

A paper on this subject was read by R. B. Williamson. The author pointed out that alternators driven by steam turbines are very small for their output, because of their high speed, and that therefore the problem of getting rid of the heat developed in the windings is a difficult one. Forced air circulation is the means commonly applied in this country. The generator is completely inclosed and the air is conveyed through passages to the parts where heat is evolved.

Theoretically, the cubic feet of air required to be passed through the machine per minute for each kilowatt of loss in the machine would be equal to 1650 divided by the temperature rise in Centigrade degrees, but as all of the air is not uniformly heated and the heat-developing parts of the machine are hotter than the discharged air, a larger amount is necessary. For the usual limit of temperature rise, cooling air should be supplied at a rate of from 100 to 150 cubic feet per minute for each kilowatt of internal losses; 125 is a fair average figure.

The total internal loss will usually be from 4 to 6 per cent. of the rated kilovolt-ampere output, being larger for the smaller machines. As a rough estimate, therefore, the allowance of cooling air may be taken as 5 to 7½ cubic feet per minute per kilovolt-ampere of rated output. In some cases from 4 to 6 cubic feet per kilovolt-ampere will be sufficient, but the larger allowance is preferable, especially if the turbine has to operate in a hot locality.

In order to handle such large quantities of air, careful attention must be paid to the pipes through which it is supplied and the air should be as clean and cool as practicable. In some cases it may be drawn directly from the basement, but this should not be done if the space below the generator is occupied by auxiliaries which heat the air. Good results have been obtained by partitioning off the generator end of the basement so that the heat from the auxiliaries will be confined to the steam end.

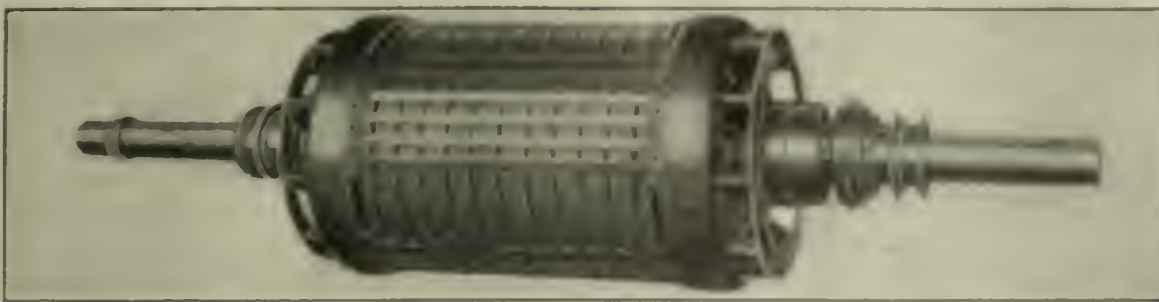


Fig. 2. Circulating Fans Attached to Field Magnet

In case cool air cannot be obtained from the basement, a pipe or duct should be run outdoors and the opening protected so that rain or dirt cannot be drawn in. Ducts should be as straight as possible and of such cross-section that the air velocity will not exceed 1000 to 1200 feet per minute. When air is drawn from outdoors, it is advisable to have dampers arranged so that it can, if necessary, be taken from the basement in cold winter weather.

It is important that the air be clean. The quantity of air passed through these generators is so large that even a small percentage of dust soon results in a large amount of dirt within the machine. Cheese-cloth filtering screens over the intake or in a box in the air duct are a good means of keeping out dust. These must be easily removable so that they can be frequently cleaned without requiring too much time and effort.

A number of methods of forcing the air through the generator have been tried but the most common one is to drive a centrifugal fan at each end of the rotor, the fans being built on the rotor spider, as shown in Fig. 2.

The air discharged by the fans must be passed through the machine with great rapidity and in such manner that all parts will be reached and the heat carried off. This is not easy, because air friction is by no means negligible in its heating effect and any attempt to force large quantities of air through long restricted passages will lead to unsatisfactory results.

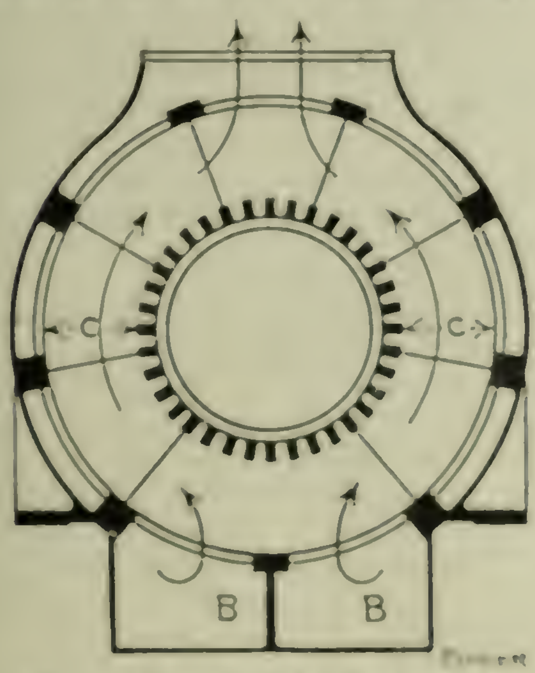


Fig. 3. Air Circulation in Small Machines

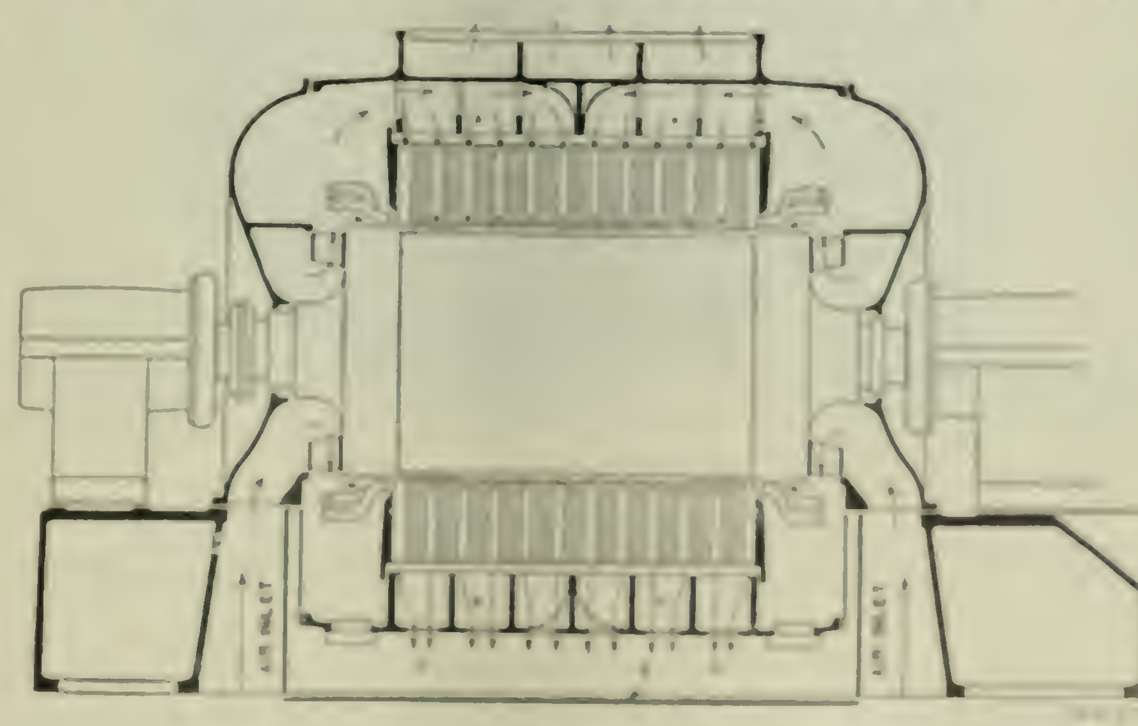


Fig. 4. Multipath Air Circulation through Generator

The greatest loss is in air friction and core loss; hence the greater part of the cooling air is required for the stator. The loss in the rotor is comparatively small, and in high-speed machines little can be done in the way of ventilating the rotor core by means of air ducts. In fact, in generators running at 3600 revolutions per minute, the rotor core is usually a solid forging without ducts of any kind. However, if the heat developed in the rotor windings is passed into the surrounding mass of metal, it is rapidly conducted to the outer surface and is thence carried off by the scrubbing action of the air.

Fig. 3 illustrates diagrammatically a method of ventilating that has been extensively used and is satisfactory for machines of moderate output. For large high-speed generators, however, the arrangement illustrated in Figs. 4 and 5 gives better results. With the arrangement indicated in Fig. 3 the air passes in two streams through the machine, one stream on each side of the shaft, and if the generator is of large diameter the air becomes heated before it reaches the upper parts; these parts, therefore, are inadequately cooled.

The arrangement shown in Fig. 4 is such that the air is divided into several streams, entering the core ducts through directive passages *A A*, and emerging into the outlet chambers through the passages *B B*. These passages *A* and *B* alternate all the way around the circumference; they are not arranged in two groups at the top and bottom of the structure, as the longitudinal section would seem to indicate. The final discharge can be taken out at the top, bottom or side of the housing. The stator shown in Fig. 5 is provided with this arrangement; an air intake is provided on each side of the bottom of the housing and the outlet is at the top.

This multipath method of ventilation for large machines has a number of advantages. One-half of the outside circumference of the stator punchings is exposed directly to air from the fans and the stator is not dependent for its cooling on hot air that has already passed over the rotor before reaching it. The use of a number of short paths in parallel through the core greatly reduces the resistance offered to the flow of air, and at a given pressure, therefore, a much larger quantity of air will pass through the machine. The air, from the time it enters until it leaves the machine, does not have to pass through a long path and, being divided into a number of parallel streams, the velocity in the ducts is very moderate compared with that in the two-path arrangement. The whole mass of iron directly behind the teeth and coils is maintained at a low temperature and any slight inequalities in temperature are equalized by the ready flow of heat in the plane of the laminations. Extensive tests made with this arrangement show that machines of large output can be cooled very evenly.

Prime Movers

The committee on prime movers presented an extensive report which contained a good deal of important information. As the committee had no new types of prime mover to investigate, it confined its attention to the performance of existing types in the stations of the member companies, or such of them as could be prevailed upon to supply the desired information.

No troubles which would seriously affect continuity of service have been reported in steam power plants. A number of minor defects have been mentioned which are discussed in the report, but it would seem that insofar as steam turbines are concerned this type of apparatus is rapidly reaching a standard which leaves very little room for criticism in the way of economy of operation or reliability of service. The auxiliaries, however, were the subject of some criticism from the operating companies, and these criticisms were referred by the committee to the makers of the various machines, who either announced changes in design to correct the troubles or offered to make such changes as were necessary in the machines. An abstract of the report on steam turbines will be printed next week.

Very little new development has been found in gas-power apparatus, and like steam power the general tendency has been toward the perfection of the apparatus. A detailed report on that subject, prepared chiefly by J. B. Klumpp, of the committee, formed a part of the general reports; this special discussion will be printed in abstract in the Gas Power Department next week.

Protection from Lightning

In its annual report, the committee on protection from lightning stated that those transmission lines having overhead ground wires seem to suffer the least damage; in fact, one operator reports that the troubles from broken insulators, shattered poles, burned-off wires and crossarms on lines protected in this manner are less than 20 per cent. of those on the lines without this type of protection. Similar results are reported in a great many other cases, and, in fact, the importance and value of the overhead ground wire is now so firmly established by experience that in almost every case where new lines are constructed provision is made for it.

In some particular cases, where an unusual amount of trouble was experienced from insulators spilling over, special devices have been developed as an alternative of the overhead ground wire. One of these devices is in the form of a grounded metal ring for each insulator. These are reported as being effective, though the use of them has not eliminated all line disturbances and is no protection against the direct stroke. In some other cases a grounded spark gap has been provided for each insulator; still another form is that of installing a grounded wire on each pole and carrying this wire well above the top of the pole. Some of these devices are used in connection with and others without the overhead ground wire, so there are few definite data at hand on which to base judgment as to their relative value. These experiments are reported as being more or less successful, and especially to the end of reducing the interruptions to the service, but it is still a question if the expense of installation will be justified in all cases.

In some few instances attempts have been made to protect the transmission lines by the installation of arresters at points far removed from the stations, but in most cases these experiments have resulted in failure. The tendency of the older type of arresters to arc over and short-circuit the line and the frequent inspection and care required for the electrolytic type reduce their usefulness to a minimum for use at remote points.

A special device known as the arcing-ground suppressor is now being experimented with for the relief of transmission-line troubles, due to an arc around the insulator. This device is designed to be used at the busbars of the principal station, to take care of the entire system. The arcing-ground suppressor consists essentially of an electrostatic and electromagnetic selective relay. This selective device picks out the faulty phase and closes the release circuit of a single-pole oil switch which is connected between the faulty phase and ground. The oil switch shunts out the accidental arc at the insulator and opens up again immediately. If the insulator is properly designed, the arc will invariably take place around the porcelain skirts, and, therefore, the arcing-ground suppressor will entirely eliminate the trouble. If the insulator should be punctured, the switch of the arcing-ground suppressor is again automatically closed and thereby prevents the high-frequency oscillations in the circuit which would otherwise result, due to the make-and-break of the arc at the faulty insulator.

The committee recommended that where lines are operated separately each line should be provided with a lightning arrester, installed beyond all station apparatus; where several lines are invariably supplied from common busbars, a lightning arrester at each busbar is sufficient. In addition to lightning arresters, the committee recommended the use of choke coils on every circuit leaving a generating station. For stations to be equipped newly with lightning arresters, the committee favors the electrolytic type; also for stations where other types of arrester have not afforded satisfactory

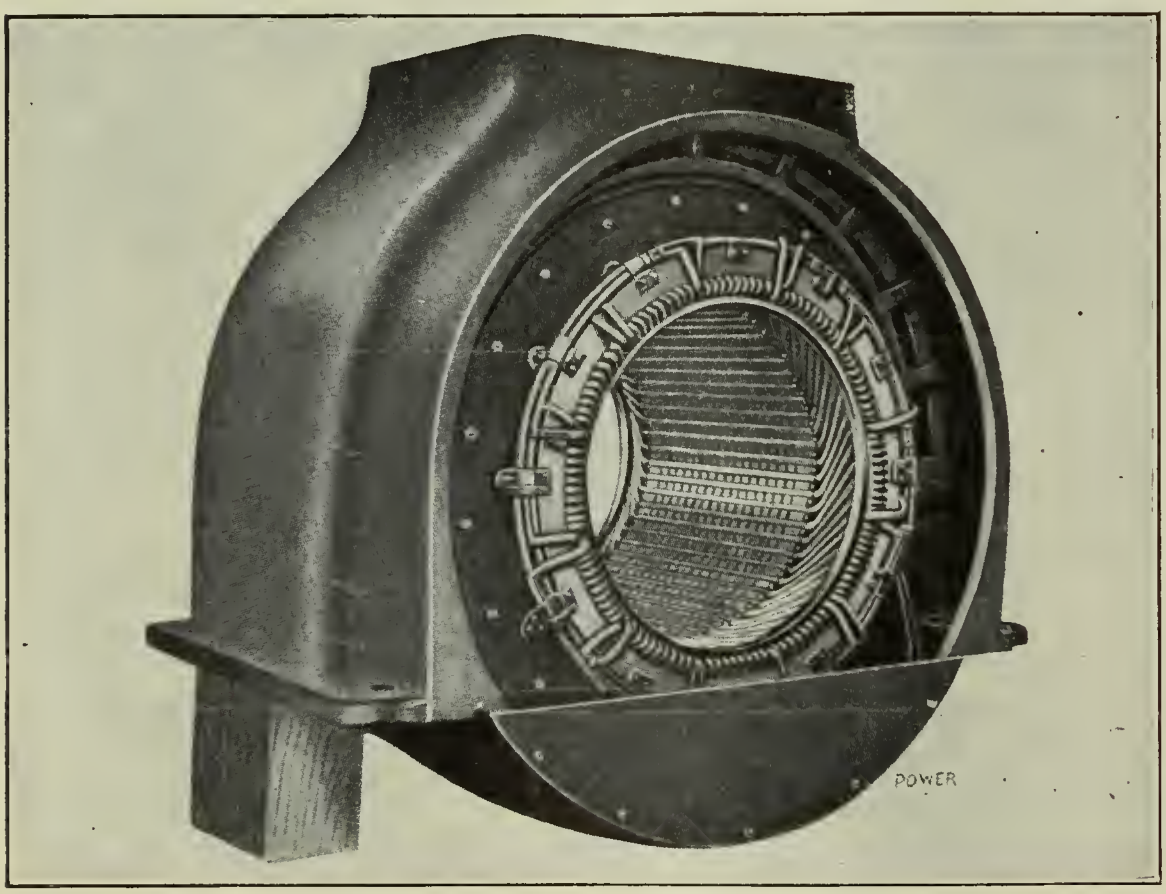


Fig. 5. Stator Equipped for Multipath Air Circulation

protection, if investigation shows that the arresters have been properly installed and maintained.

Lightning arresters on distribution systems do not usually protect any apparatus that is appreciably more than 500 feet distant. On four of the larger systems, where arresters are installed an average of 2000 or 3000 feet apart, the minimum distance being about 1000 feet, the losses of arresters vary from 0.07 per cent. to 0.7 per cent. of those installed, while in other places, where the spacing is about one mile, the losses run as high as 3 per cent. of the arresters installed.

Election of Officers

The annual election of officers held on the final working day of the convention resulted as follows:

John F. Gilchrist, of Chicago, president; Frank M. Tait, of Dayton, Ohio, first vice-president; Arthur S. Huey, of Oklahoma, second vice-president; T. C. Martin, of New York, secretary; George H. Harries, of Washington, D. C., treasurer.

Conduit Wiring Data

By O. B. Arland

Although the National Board of Fire Underwriters and various municipal inspection bureaus have established extensive rules thoroughly covering the quality and thickness of the rubber insulation, as well as the strength of braiding, for interior light and power conductors installed in unlined metal conduits, as a rule, they leave the proper size of such conduits to the judgment of the individual engineer or contractor.

This is an important matter and one that is not always sufficiently appreciated, with the frequent result that, through ignorance or unwise economy, a conduit of too small an internal diameter is used, causing injury to the conductors and their insulation by reason of excessive friction on the covering and tensile stresses imposed upon the conductor while being hauled into such a conduit.

A table of conduit wiring data based on an experience and observation of several years was worked out by the writer in 1900 for his personal use and has since been successfully used by several contractors and construction men.

This table has been revised this year and is based on the present requirements of the National Board of Fire Underwriters for interior low-potential wiring for voltages up to 600. It is reproduced here in convenient form for use.

The wire diameter and conduit sizes below the first six horizontal rows are restricted to stranded conductors because it is not good practice in conduit work to use solid conductors for sizes larger than No. 8 Brown & Sharpe gage.

Although no conductor smaller than No. 14 is permitted by the fire underwriters for this class of work, two smaller sizes are given because they are frequently used in signaling systems.

The carrying capacities of wires with weatherproof insulation are given in the fourth column of the table for convenience in other work. This kind of insulation is not permitted in conduit work.

The diameters specified in the fifth column in thirty-seconds of an inch are the over-all measurements, outside of the finishing braid.

given up to 21 conductors. The conduit diameters are carried up to 6 inches, although, as a rule, conduits of 4 inches internal diameter are the limit of ordinary practice. ½-inch conduits are also given, but these are permitted only under special conditions.

A supplementary table is added in the lower right-hand corner, showing how many circuits consisting of No. 14 B. & S. gage duplex cables can safely be put into one conduit.

CONDUIT WIRING DATA

	Size: B. & S. Gage	Size: Circular Mils	Amperes: Rubber Insulated	Amperes: Weather Proof	Diam. Rubb. Insul. Double Braid in 32ds Inch	Size of Conduit—Inches, for Wires Rubber Insulated and Double Braided: Permissible Number of Wires in One Conduit
Solid	18	1,624	3	5	5	[illegible]
Solid	16	2,583	6	8	7	[illegible]
Solid	14	4,107	12	16	8	[illegible]
Solid	12	6,530	17	23	9	[illegible]
Solid	10	10,380	24	32	10	[illegible]
Solid	8	16,510	33	46	11	[illegible]
Stranded	6	26,250	46	65	11	[illegible]
Stranded	5	33,100	54	77	15	[illegible]
Stranded	4	41,740	65	92	16	[illegible]
Stranded	3	52,630	76	110	17	[illegible]
Stranded	2	66,370	90	131	19	[illegible]
Stranded	1	83,690	107	156	21	[illegible]
	0	105,500	127	185	23	[illegible]
	00	133,100	150	220	24	[illegible]
	000	167,800	177	262	26	[illegible]
	0000	211,600	210	312	28	[illegible]
		250,000	235	335	[illegible]	[illegible]
		300,000	270	400	[illegible]	[illegible]
		350,000	[illegible]	[illegible]	[illegible]	[illegible]
		400,000	[illegible]	[illegible]	[illegible]	[illegible]
		450,000	[illegible]	[illegible]	[illegible]	[illegible]
		500,000	[illegible]	[illegible]	[illegible]	[illegible]
		550,000	[illegible]	[illegible]	[illegible]	[illegible]
		600,000	[illegible]	[illegible]	[illegible]	[illegible]
		650,000	[illegible]	[illegible]	[illegible]	[illegible]
		700,000	[illegible]	[illegible]	[illegible]	[illegible]
		750,000	[illegible]	[illegible]	[illegible]	[illegible]
		800,000	[illegible]	[illegible]	[illegible]	[illegible]
		850,000	[illegible]	[illegible]	[illegible]	[illegible]
		900,000	[illegible]	[illegible]	[illegible]	[illegible]
		950,000	[illegible]	[illegible]	[illegible]	[illegible]
		1,000,000	[illegible]	[illegible]	[illegible]	[illegible]
		1,100,000	[illegible]	[illegible]	[illegible]	[illegible]
		1,200,000	[illegible]	[illegible]	[illegible]	[illegible]
		1,300,000	[illegible]	[illegible]	[illegible]	[illegible]
		1,400,000	[illegible]	[illegible]	[illegible]	[illegible]
		1,500,000	[illegible]	[illegible]	[illegible]	[illegible]
		1,600,000	[illegible]	[illegible]	[illegible]	[illegible]
		1,700,000	[illegible]	[illegible]	[illegible]	[illegible]
		1,800,000	[illegible]	[illegible]	[illegible]	[illegible]
		1,900,000	[illegible]	[illegible]	[illegible]	[illegible]
		2,000,000	[illegible]	[illegible]	[illegible]	[illegible]

Table for Conduit Sizes for No. 14 B. & S. Duplex [illegible]

Internal Diameter of Conduit	No. of Duplex Cables [illegible]
[illegible]	[illegible]

The succeeding columns give the safe internal diameters of conduits to be used for all ordinary construction in buildings of any description where the total number of 90-degree turns in one line of conduit does not exceed four. Where special conditions necessitate a lead armor over the rubber insulation, slightly larger conduits must be used.

Ordinarily, the fire underwriters do not allow more than four two-wire circuits or three three-wire circuits in one conduit, but it frequently becomes desirable under special conditions to install a larger number of circuits in a common conduit; the required conduit sizes are therefore

The conduit sizes in the main table, as will be observed, are calculated on the assumption that the various conductors will be all of the same size. If, therefore, in laying out a conduit for a three-wire system having a neutral of double the capacity of each of the two outside wires, the proper internal diameter of the conduit will be found by using the conduit required for four wires of the size of the main wires of the system. For instance, the conduit for a three-wire feeder of two No. 0000 outside and one 350,000-circ. mil neutral should be sufficiently large to contain four No. 0000 cables, or 3 inches in diameter.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Taking Gas Samples with an Aspirator

By J. C. Parmely

An aspirator may be used to good advantage at times around a gas-producer plant; I once found it very convenient, for example, in making a test of a suction producer and engine. In this test it was desired to operate a Junkers calorimeter to determine the heat value of the gas made by the producer. The usual method of taking samples of gas by the use of aspirator bottles could not be employed in this case because a continuous sample was required and because, in addition to taking the sample from the suction main, where it was at a pressure less than that of the atmosphere by about two inches of water, a pressure of nearly 0.3 of an inch of water was required to force the sample through the meter and other parts of the calorimeter outfit. It was decided, therefore, to use an aspirator to take the sample from the main.

As the aspirator operates upon the principle of the injector, the gas it draws from the main passing from it with the water, it was necessary to provide a chamber in which the gas could separate from the water and where the pressure necessary to force it through the calorimeter apparatus could be applied. This was easily provided by the use of a few pipe fittings, as shown in Fig. 1. A piece of 6-inch pipe *A* was cut about 8 inches long and threaded on both ends, which were capped, as shown; a hole was drilled and tapped in the side about two inches from the bottom, into which a long nipple of ½-inch pipe was screwed; an angle valve *B* was put on its outer end and into the upper outlet of the valve was screwed a ½-inch nipple long enough to reach about half-way up the 6-inch "barrel." Just below the upper cap another hole was drilled and tapped in the side of the chamber to take a ⅛-inch nipple *D*, which provided a connection for the removal of the gas from the chamber. A hole was drilled and tapped in the center of the top cap and a plug was fitted in this hole, the plug affording sufficient metal to take the aspirator outlet in one end and a ½-inch pipe in the other. This pipe reached nearly to the bottom of the separator chamber and provided a water seal which would prevent the leakage of air into the gas main in case the water supply for the aspirator should fail.

The arrangement was connected up as shown in Fig. 2 and its operation was essentially as follows: The aspirator, operating like an injector, drew the sample of gas from the main and this gas passed into the chamber *A* mixed with the water. In the chamber the gas separated from the water, rose to the top of the chamber and passed out through the ⅛-inch connection *D* to the calorimeter. By throttling the water outlet of the chamber at the valve *B*, pressure was applied to the gas to force it through the calorimeter. The apparatus was tried by connecting U-tubes containing mercury to both the suction *E* of the aspirator and the outlet *D* of the separator. By adjusting the valve *C* the suction pressure shown by the column attached at *E* could be varied within the necessary limits and the pressure at *D* could be varied by adjustment of the valve *B*. When the tube *E* was left open, the pressure at *D* could be maintained, as before, and the air taken in through *E* escaped in the form of bubbles in the water.

Having constructed the apparatus and being convinced that it would operate

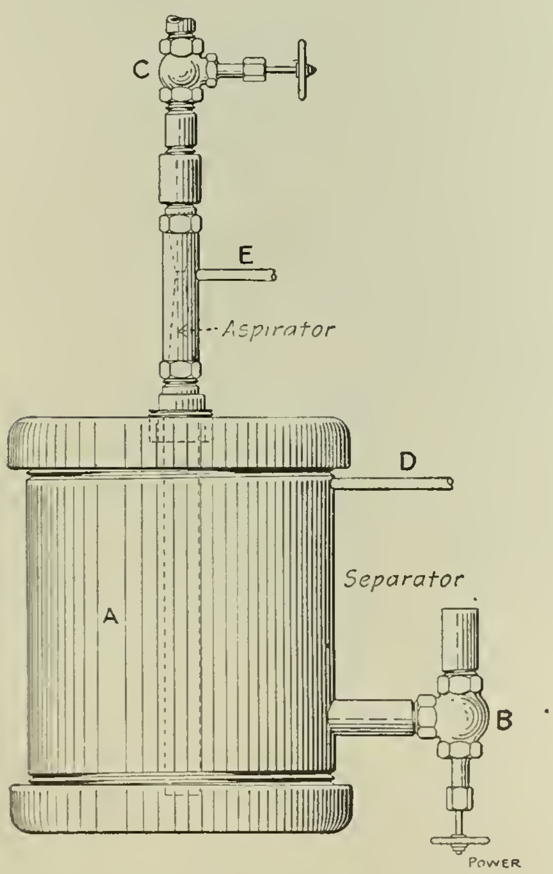


Fig. 1. Aspirator and Separator

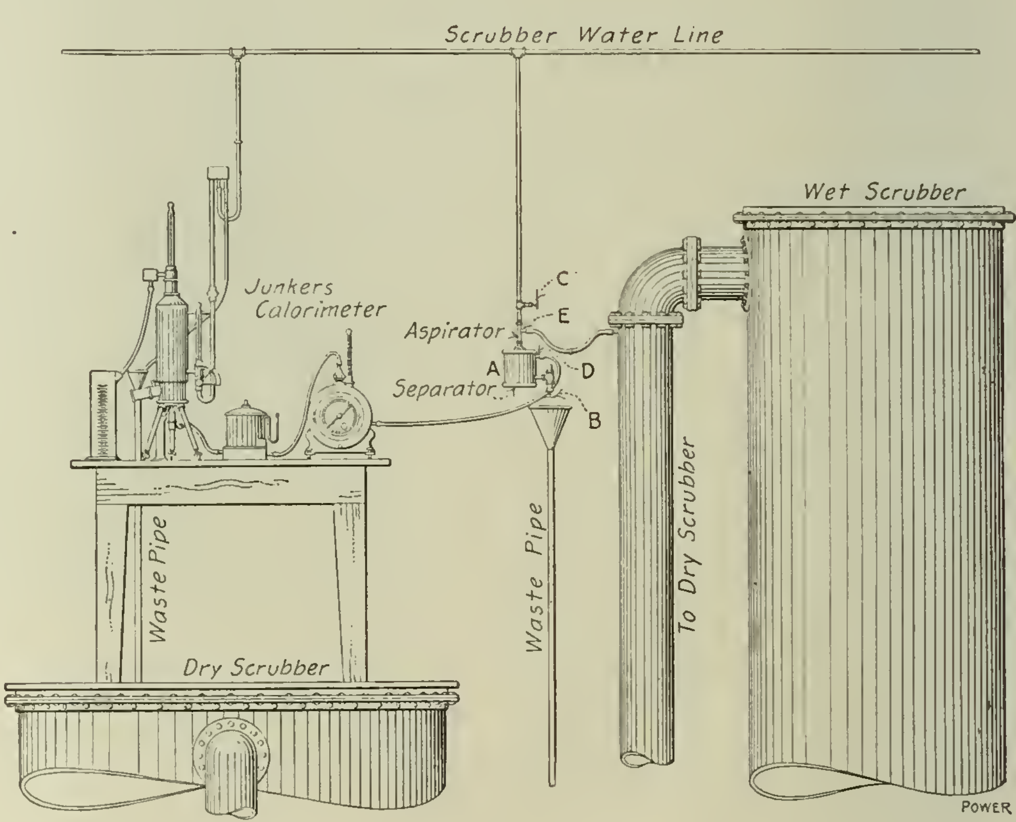


Fig. 2. Complete Equipment for Continuous Gas Sampling

successfully, the next task was to install it at the plant to be tested in a place where it would be readily accessible, be safe from damage and not interfere with the operation of the plant. As shown in Fig. 2, the wet and dry scrubbers were located side by side and it was decided to place the apparatus on the top of the dry scrubber and take the sample from the main connecting the two scrubbers. It was found to be necessary to provide a platform across the top of the scrubber so that the vibrations of the top of the scrubber due to the varying pressure within it would not affect the apparatus. As shown in the sketch, tees were inserted in the scrubber water line and the aspirator and separator were suspended temporarily by the pipe connecting them to this line. A sampling tube similar to that used with a steam calorimeter was inserted in the main and rubber tubing was used to make all connections. One-inch pipes carrying funnels in their open ends were used to carry away the water from the sampling apparatus and the calorimeter.

Due to the fact that the water used in this plant was supplied from a tank upon the roof of the building, the head upon the apparatus did not exceed 15 feet at any time during the tests and this was only sufficient to give a pressure of about two-tenths of an inch of water upon the gas at the meter, which was somewhat below that desired; but it was sufficient to operate the calorimeter successfully, though slowly. With the exception of one stop due to the clogging of the burner, the calorimeter was operated satisfactorily throughout three 24-hour tests.

Oil Engines for Ships

At the spring meeting in London of the Institution of Naval Architects, J. T. Milton contributed a paper on "Diesel Engines for Sea-going Vessels," in which he maintained that, apart from the relative cost and facilities for obtaining supplies of oil fuel and coal, an internal-combustion engine using oil possesses advantages for marine work over one using gas made from coal. The comparatively bulky gas producers and scrubbers are not required, there is no trouble with dust in the cylinders and there should be none with tar on the valve faces. Compared with coal, weight for weight, oil has at least 50 per cent. more heat value, occupies less space, can be carried in double bottoms and other spaces unsuitable for coal and cargo, requires no "trimming" and lessens the number of stokers. Moreover, it is more easily loaded and without the dust and labor of coaling.

In the employment of the Diesel engine the developed horsepower has to overcome the friction of the mechanism, to work the fuel pump and to compress the air necessary for injecting the fuel; in the two-stroke cycle engine it has also to work the scavenging pump. These, Mr. Milton points out, take up more of the gross power than do the accessories of a steam engine; consequently, a less proportion of the indicated power is transmitted to the shaft. For this reason, the power of a Diesel engine is more usually expressed in terms of brake horsepower. On the basis of 0.4 pound of oil consumed per brake horsepower-hour when the engine is working at full power, and assuming that with a modern steam engine and boiler the consumption of coal is 1.25 pounds per indicated horsepower per hour (which he says corresponds to about 1.47 pounds per brake horsepower-hour), the weight of fuel to be carried for the same voyage in a vessel fitted with Diesel engines will be only 28 per cent. of the weight of coal necessary with the steam power.

Mr. Milton cites as the more important auxiliaries in vessels fitted with Diesel propelling machinery: Steering gear; whistle; donkey pumps for bilge and fire service; electric-light machinery; distillers; steam-heating apparatus; water-ballast pump, winches and windlass; ventilating apparatus in passenger vessels. Alternatives proposed for the steering gear, whistle, distiller and heating appliances are: (1) A donkey boiler separately fired by oil fuel continuously at work at sea for all these purposes; (2) utilizing the heat of the exhaust gases by passing them through an auxiliary boiler and raising sufficient steam for the purpose; (3) working the steering gear and whistle by compressed air from the first stage of the compressor, which would be made larger for this purpose. The second alternative, the author says, has much to recommend it in view of the great quantity of heat which passes off with the exhaust gases.

Discussion of Mr. Milton's paper was opened by Doctor Diesel, who said the marine Diesel engine of the future will be of the two-stroke type. The air cooling of the cylinders must be accompanied by a back cooling of the oil itself in apparatus of the surface-condenser type. With regard to balancing in the Diesel engine, difficulties arise, particularly at low speeds, but by adding two scavenging pumps on both ends it is possible to completely balance the engine. In comparison with the whole output of Diesel engines the proportion of marine engines is comparatively small, the most important field being in the submarine, and the Diesel engine is now being nearly universally adopted for this class of ship by all countries except Great Britain and the United States.

It is a coincidence that before the Liverpool Engineering Society, in Lancashire, in a paper on "The Economics of Steamship Propulsion," Andrew Hamilton makes special reference to the use of oil fuel. He shows that, except for special purposes and in the navy, where cost is not so important, oil fuel under present conditions can be used in Great Britain only to a moderate extent. With regard to oil engines, he says it has recently been proposed to fit a vessel with engines of 150 to 180 total horsepower. Two engines speeded at 200 revolutions per minute would cost £2200, which, with the cost of settings, oil tanks, two sets of propeller shafts, etc., will be increased to £3000. The annual fixed charges at 15 per cent. on (say) £3000 will be £450. Compound steam engines of similar power will cost £900, which, with setting, etc., will be increased to £1280. Fifteen per cent. on (say) £1300 will be £195, showing a debit of £255 against the oil engines on capital account. Taking the consumption of oil at 0.8 pound per indicated horsepower-hour, 150 horsepower would require 120 pounds per hour, which at £1 15s. per ton would amount to 1s. 10½d. per hour; the fuel for 180 days will cost £405. The cost of coal for 150 indicated horsepower, taking 3 pounds per hour at 12s. per ton, will be about £518 for a similar period. Therefore, the capital charges and cost of fuel would be £855 for oil engines and £713 for steam; but in the case of the former, credits on account of extra cargo capacity and less labor (£230) reduce the total to £625, or £88 below the corresponding figures for steam power.

[Putting the oil consumption at ½ pound per brake horsepower-hour, which is much nearer to actual performance, the fuel expense for the Diesel engines would be £203 instead of £405 and the total operating expense £423 (instead of the author's £625) as against £713 for steam.—Editor.]

Gas and Oil Power in Phosphate Mining

The internal-combustion engine appears to be especially appreciated by the companies operating in the phosphate-mining district of southern Florida. The Prairie Pebble Phosphate Mining Company, at Mulberry, Fla., is operating eight Diesel engine units and expects to add eight more, each having a rating of 300 horsepower. The Pierce Phosphate Company has installed a 1200-horsepower Westinghouse producer and gas engine and contemplates installing another of the same capacity during the present year. The Pembroke Company is installing two Diesel engines of 300 horsepower each and one of 200 horsepower at its plant near Fort Meade, Fla.

The Diesel engines of the Prairie Pebble Phosphate Company have made a fine record during the time they have been in use and we shall publish shortly a detailed report of their performance.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Air Pump Valve Froze

I once had occasion to use a double-acting pump for mine purposes, using air at 90 pounds gage pressure. But I was continually bothered with the valves freezing, which stopped the pump.

Then it was the old story of burning a piece of oily waste to thaw them out and get the pump started again. This method, however, has often caused cracked and broken pumps, due to the unequal expansion.

I finally tried the scheme of tapping a 3/8-inch connection on the discharge pipe, near the pump, and leading the same around and over the air chest, branching off over each chest. Then I put in a 1/4-inch pet cock about 4 inches above each chest so as to get a small stream of warm mine water to flow over the top of each valve chest while the pump was working. This ended the trouble.

W. Cooke.

Chignecto, N. S.

A Puzzling Oil Trouble

I once had an unusual experience with an engine using the splash method of lubrication.

It ran with very satisfactory results for about six months.

The crank case holds about seven gallons of oil. It was my custom to empty all of the oil out of the crank case every three weeks and renew with new oil. The dirty oil was filtered and used on the other engines.

On one occasion I had changed the oil as usual and after running about three hours a bad pound developed on the crosshead pin. This became so bad that in about half an hour I had to shut down and key up the brasses.

I started again and in two hours the engine was pounding like a steam hammer. This time I took out the crosshead pin and boxes and found that while there was nothing hot and no apparent cutting, the oil grooves in the boxes had completely disappeared. I dressed up the boxes and the next day I had to stop three times. The third time I removed the pin and brasses and found that the oil grooves were gone again, and the pin so badly flattened that it had to be turned up. This trouble continued for some time. I changed oil again and again, but the pound still remained.

I was badly puzzled, and, while looking in the side door in the frame, I saw tiny particles of zinc floating on the oil.

I stopped the engine and keyed up again and after getting some oil from one of the other engine rooms started again, and, presto, the trouble was gone, and the engine ran nine weeks before the crosshead pin needed keying up again.

I then suspected the cause of my trouble and, procuring some barium chloride, made a test and found the oil strongly impregnated with sulphuric acid.

The crosshead boxes were of a composition containing about 90 per cent. zinc, for which sulphuric acid and water have a strong affinity.

On starting up with the new oil there was no water present and in consequence the contained acid remained inert. The metallic packing on the piston rod allowed a little water to escape and travel along the rod, whence it dropped down inside of the engine frame and mixed with the oil.

After a couple of hours sufficient water accumulated to form a corrosive mixture when combined with the acid, and this combination is what caused the brasses to waste away so rapidly.

I ran this engine for about 18 months after that, and never had a recurrence of the trouble, as I took the precaution to test each barrel of oil. I rejected two which I found contained traces of acid.

On taking up the matter with the chemist of the oil works which furnished this oil, he stated that through some error the acid had not been properly neutralized after the oil had been bleached.

The babbitted bearings of the engine did not show any ill effects and I do not think any such trouble would occur without this particular combination of zinc, acid and water, as this oil gave perfect satisfaction when used on Corliss engines with babbitted bearings.

C. A. Green.

Cleveland, O.

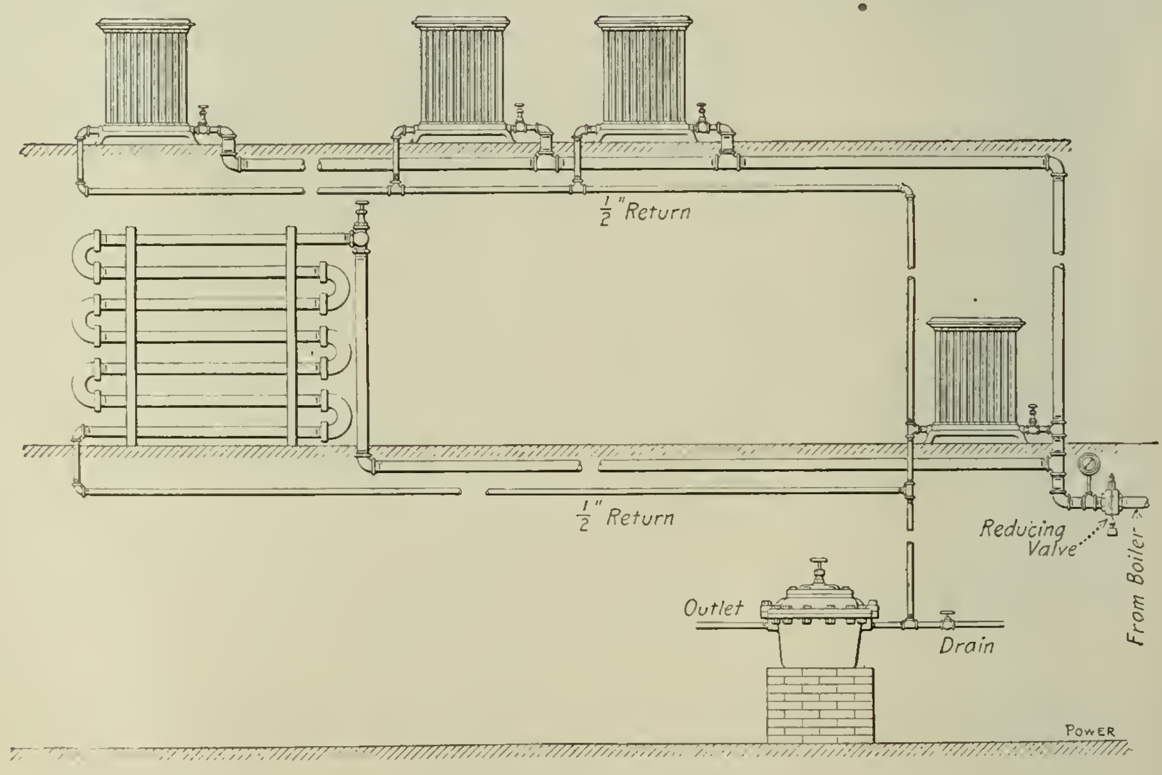
Radiators Give Trouble

The accompanying illustration is of a heating system with which I have been having trouble because three radiators on the second floor fill up with water.

When I open the drain from the trap the water drains out and the system works all right for from 8 to 15 hours before it will fill up again. The radiators on the first floor give no trouble. The 1-inch line from the boiler to the first radiator is 80 feet long. Can any reader of Power tell me how to remedy the trouble?

B. E. Thomas.

Seattle, Wash.



Radiators and Piping

Slovenly Pumping Plant

Shortly after my arrival in this country I got a position as fireman in a pumping station not far from Philadelphia.

The plant contained five water-tube boilers, two 5,000,000-gallon pumps, two centrifugal pumps and a 15-kilowatt generator direct coupled to a high-speed engine. The working force was divided into three shifts, each being made up of an engineer, fireman and a man to look after the filters. Only two boilers were under steam and it was a hard job to keep up the pressure.

After a while I began looking around and I found that the whole outfit was in very bad condition. The pumps were running with the drip cocks wide open, and the centrifugal pump made a noise like a triphammer. To keep the boxes cool and save oil, a ½-inch water hose was supplying a stream of water to them.

The engineer in charge paid absolutely no attention to the temperature of the feed water. The blowoff cocks leaked so badly that the water ran out of the blowoff pipe in a small stream.

I kept the job until the end of the season and then I left. A year later I passed by this same plant and, looking in, I saw the same chief sitting in the same rocking chair. No change was apparent in the conduct of the station, except that it was more dirty and noisy.

The chief did not propose to kill himself for $55 a month, working seven days a week.

LAISSEZ FAIRE.

Paterson, N. J.

What Causes the Pipe to Wear?

On a hydraulic dredge used for harbor work, the first 60 feet of the discharge pipe from the hydraulic pump consists of cast-iron pipe 25 inches in diameter. This pipe runs along one side of the dredge in a horizontal position and connects with the pipe leading to the scows into which the material is discharged.

The pipe was originally 1½ inches thick, but after being in use for about 18 months it began to leak at several points along the top. On examination the pipe was found to have been worn to a thickness of but ¼ inch along the top for its entire length; the bottom, however, showed no signs of wear.

The material pumped through the pipe is a combination of mud and sand and the pump discharges against a pressure of approximately 30 pounds.

The engineers would like to know why the wear comes on the top of the pipe instead of on the bottom.

S. KOLIN.

New York City.

Equalizing Pipe on Separator

Put a funnel into the neck of a bottle, as in Fig. 1, and pour water into it. The water will run freely into the bottle for

FIG. 1. ABSENCE OF AIR VENT PREVENTS WATER FROM FLOWING INTO BOTTLE

a time; but, if the joint at *A* is tight so that no air can escape, the air in the bottle will soon become compressed until its pressure equals the head of water in the funnel and then the flow will stop or

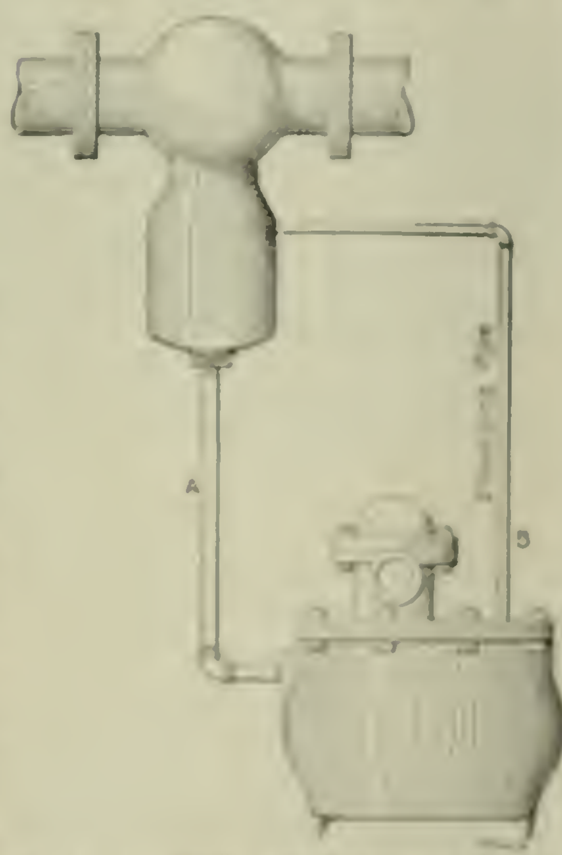


FIG. 2. SHOWING CONNECTIONS BETWEEN SEPARATOR AND TRAP

reduce to a dribble. If a sufficient vent is made at *A*, the flow will be as free as though the bottle were not there.

A similar condition is liable to arise in connecting a steam trap, as for instance in Fig. 2. When the flow of water is small the upper part of the trap is full of steam of the same pressure as that in the separator. If a slug of water comes over, the communication between the steam spaces of the trap and separator is shut off and the pipe *A* is like the neck of the funnel. Until the steam in the trap condenses (and it may have air in it which will not condense), the free flow of the water is impeded and the trap does not act as quickly as it should.

I have avoided trouble from this source in a number of instances by connecting the top of the trap to the steam space of the separator or whatever else is being trapped by an equalizing pipe *B*. This allows the water descending in *A* to push the steam or gaseous contents of the trap around through the pipe *B*, allowing the water to fall freely into the trap and the trap to work promptly and energetically to its full capacity. Furthermore, it takes care automatically of the venting of the trap, avoiding the necessity of getting down to it if it is in a pit, or of the trouble which may arise from neglecting it.

C. E. SQUIRES.

Cleveland, O.

Deterioration of Boilers

Boiler explosions continue to occur daily, and the reasons and excuses for them are numerous and varied. I have been an advocate of clean boilers and clean water since the time I was personally concerned in an explosion caused by foul water, and have every reason to believe that many explosions are due to this cause. My theory is that more explosions are caused by foul water than from any other cause, not excluding overheated plates which come from filthy boilers.

Not long since, a tube was removed from a vertical water-tube boiler. This tube was coated with a hard scale formation ½ inch thick. It is evident that the water-cooling effect was of little or no value to the tube. Crystallization will take place under just such conditions as this. The tube will lose its strength and will yield possibly under one-fourth of the pressure that it will when the flue has been kept in contact with the water.

In shearing boiler heads from some steel and iron boilers recently it was found that the lower half of the steel head was of good, tough character, especially on the water side. The other half, away from the water side and above the water line, which was subjected to the heat of the steam, was like tempered steel and would snap before it would bend. This indicates that a steel boiler in aging may become very brittle. The life of a boiler depends upon working conditions and the abuse it receives.

In one instance a water-tube boiler was fed with water that formed a hard scale. Some small leaks appeared around the rivet holes, due to small cracks. It was found necessary to remove the heads and upon examination it was discovered that the cracks reached out from the tube holes. In the tube a hard, flint-like scale was found from $\frac{5}{16}$ to $\frac{3}{8}$ inch thick on the interior of this tube and the header was also badly coated.

Pitting is another element of deterioration. In one instance the top of a boiler was covered with asbestos. Upon uncovering the boiler in order to reset it in a new battery, it was discovered that pitting had occurred on two of the top sheets. The dome connection was also in the same shape. The original thickness of the plate was $\frac{7}{16}$ inch and some of the pits were $\frac{1}{4}$ inch deep.

A coat of graphite will form a surface under the outer covering which will prevent the metal from being attacked in this way.

C. R. McGahey.

Baltimore, Md.

Furnace Questions

Why is it that more letters are not written regarding the CO_2 question? There have been many articles on the theoretical side. Now let us hear from the men who plug up holes and crevices in the boiler setting, and who crawl around in furnaces studying grate areas and fire arches. They should know something about the question. Talking of furnaces, how much can the air spaces in the dumping plates of Roney stokers be reduced without danger of burning?

How can I stop or reduce the leakage of air through the joints of the big doors at the rear of a Babcock & Wilcox boiler?

If a return-tubular boiler has an air space in the setting, does not air leak into the furnace from the air space? Has anyone tried filling up the air space, and what was the result?

William E. Dixon.

Malden, Mass.

Cleanliness in the Power Plant

One of the most important details about a power plant is cleanliness. The chief engineer of a plant has much to do in this regard, because others connected with the plant will follow the example set before them.

A young man starting in as an oiler is quick to acquire the habit of smoking a pipe and chewing tobacco if his engineer does. He will spit on the engine-room floor if he sees the engineer do so. He will acquire the habit of sitting around reading newspapers just because the example is before him in the person of the engineer. He will go around the bearings regulating the oil without the sign of a piece of waste. He will fill his oil cups without paying attention to wastefulness, forgetting to wipe the can before setting it down. The result is a general smear just because the fellow has seen his engineer do so and probably because he belongs to the class of men who are not naturally clean.

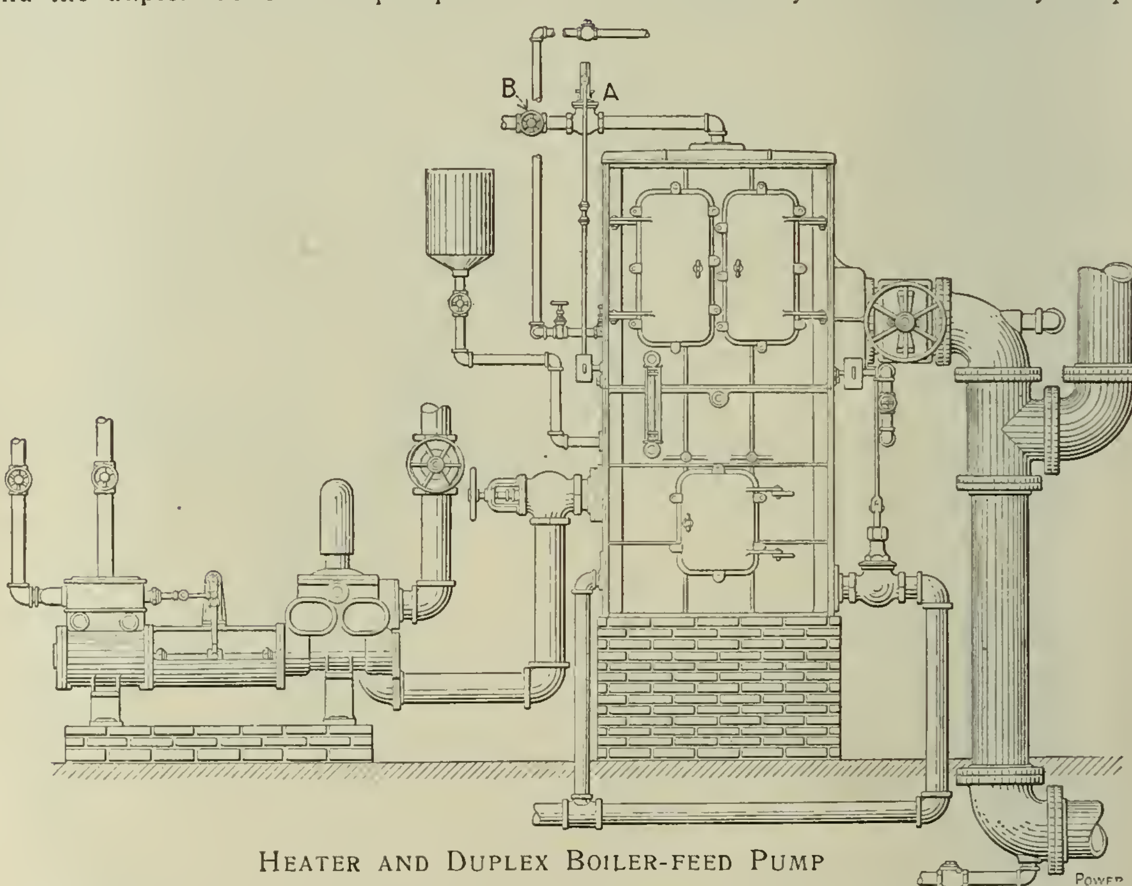
Some fellows learn by experience to keep clean, others do not. The slovenly have usually been brought up that way and never possessed any horse sense. No plant can be successfully operated without system, and the sooner the young engineer thoroughly comprehends its meaning and applies it to cleanliness, the better it will be for himself and all parties concerned.

Thomas M. Stirling.

Middlebranch, O.

Feed Water Regulation

In the power plant where I am employed there is a vacuum feed-water heater connected as shown in the accompanying illustration. The pump that supplies this heater also furnishes water for an outside line, on which it is necessary to carry as high as 80 pounds pressure per square inch. Since assuming charge of the plant, I have had some interesting experiences with the heater and the duplex boiler-feed pump.



Heater and Duplex Boiler-feed Pump

Originally, the heater was set so low in relation to the pump that there was not sufficient pressure to lift the intake valves. When the water was hot this condition caused steam pockets to form and the pump "kicked." The engineer or his assistant would have to step lively and close the throttle valve on the pump, and then admit some cold water to the heater to relieve the trouble. This was not pleasant for the fireman, for it kept him continually guessing as to the feed-water temperature and was also far from economical with the fuel supply. In addition to this the feed-water temperature fluctuated greatly as the demand of the boilers varied, this being due to the heavy rush of water into the heater as the regulator valve *A* opened, and the inability of the exhaust steam to properly heat this sudden supply of water.

Here were two difficulties to be overcome, but a third one appeared. Every time the regulating valve *A* was about to close or open it would chatter so fiercely that it could be heard some distance outside of the plant and also caused a commotion in the water pipes running to the office building some distance away. To remove the first difficulty, the heater was raised about 40 inches, and there has been no further trouble with the feed-water pump. In removing this trouble all complaints coming from the fireman were silenced and a saving in fuel was also made.

The 3-inch globe valve *B*, placed just beyond the regulating valve *A*, had always been kept wide open. This put the whole line pressure on the regulating valve and caused it to chatter, as mentioned. Then as the regulating valve opened there was such a rush of cold water into the heater that the temperature of the feed water to the boilers varied greatly.

This difficulty was removed by simply closing the 3-inch globe valve until it would admit only water enough to supply the heater with the regulating valve wide open. The globe valve had to be adjusted occasionally to meet the varying demand of the boilers, but this was very easily done. The chattering of the regulating valve is only a memory and it is now possible to maintain the feed-water temperature above 200 degrees Fahrenheit.

These were very simple remedies, but they may be of some service to the readers of Power in solving other difficulties that may arise.

C. D. Eldredge.

Fairport Harbor, O.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Prevented Water Hammer

Under the above heading, A. Stevens tells on page 573 of April 11 POWER how he drained the water from an exhaust pipe under vacuum. The apparatus he employs is very crude and must require considerable attention. The same thing can be done automatically by means of a return trap such as is used for boiler feeding.

A check valve should be provided in the drain from the exhaust main to the trap and a second check valve in the connection to the feed tank. The former valve should open toward the trap and the latter away from it. In operation the condensation comes down to the trap through the drain pipe, equilibrium being established through a vent pipe connecting the trap with the exhaust main.

When the trap is full, the float rises, operating a trip valve which closes the vent and admits live steam at boiler pressure to the interior of the trap. The check valve in the drain closes and the other opens, so that the water in the trap is forced out until the lowering of the float moves the trip valve in the opposite direction and reëstablishes connections with the exhaust main.

W. T. MEINZER.

Brooklyn, N. Y.

Graphite as a Scale Preventive

I agree with E. G. Trumbo, in his article of April 4, when he praises the use of graphite in boilers to keep the scale from sticking to the metal.

From personal experience and application I know that graphite will prevent scale from sticking to the shell so hard. This property of graphite in itself is a great help to engineers in keeping their boilers clean.

In a power plant of six Babcock & Wilcox boilers, four were run 24 hours daily while the other two were out being cleaned. After being thoroughly cleaned, 10 pounds of graphite were equally divided between the two drums of each boiler, the boilers were scaled, and put into service and two others cut out. When drained out and opened up, considerable scale was found in the mud drum, and when the cleaner was run through the tubes every vestige was removed. On examining the scale the graphite could be seen clinging to the under side, showing that it prevented the scale from sticking.

FRED L. WAGNER.

Chicago, Ill.

The Giddings Engine Valve

Regarding Mr. Stuck's engine valve, I have noted the remarks of several writers who have had some experience with the Giddings balanced valve, and C. A. Cahill's letter in the May 2 number is quite clear, but there is no reason for the abrupt notch in the compression line.

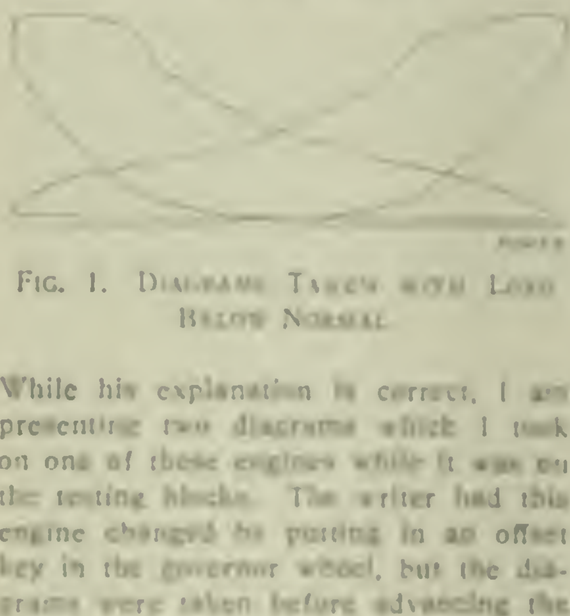


FIG. 1. DIAGRAMS TAKEN WITH LOAD BELOW NORMAL

While his explanation is correct, I am presenting two diagrams which I took on one of these engines while it was on the testing blocks. The writer had this engine changed by putting in an offset key in the governor wheel, but the diagrams were taken before advancing the eccentric. This change made the admission much sharper and better. In the diagrams the compression lines are good and also the release. The balancing of this valve was a difficult job, and the successful running of the valve depended upon this.

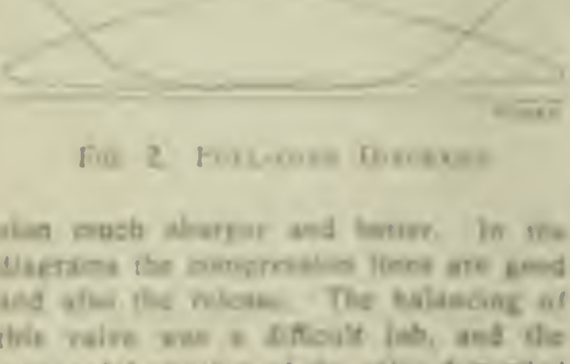


FIG. 2. FULL-LOAD DIAGRAMS

Mr. Stuck's suggestion of having a by-pass pipe for stopping and starting is good. I always found the new engines going out with this arrangement. For successful running, both springs in the governor must have the same tension. This can be determined by striking the springs with a light hammer and listening to the sound; the tighter spring will give a higher tone.

C. R. MCGAHEY.

Baltimore, Md.

Asleep on the Job

The foreword in the March 14 issue regarding the engineers who fall asleep on their job hits the nail squarely on the head. How many would-be engineers are dozing? Then when caught by their employers or other persons on the watch, they will put the blame on someone else.

The time has passed when an engineer can afford to fall asleep on his job. The Edison or central-station interests are not to blame if some day the sleeper wakes up and finds them on his job.

Organizations and knocking are not the things needed. Employers are entitled to facts, figures and results. Work therefore should be done so that it will command as much respect as the work of professional men. It may be asked why do employers look at it in this way now any more than formerly? Well, because the general operating expenses are on the increase. Supply bills and wages are higher. The outside man is giving this as an argument. It is a catchy one. He makes it appear as if all trouble ends with the putting in of outside service. It sounds well when told by him, and, mind you, he has his piece well learned and can tell it. Then the "boss" comes after he has been posted and wants to know how much coal is burned per kilowatt-hour; how many B.t.u. are in the coal; perhaps, something of the CO_2, or how many pounds of water are evaporated per pound of coal used? What do you do? Have you any reports showing daily results, anything to fall back on? Can you produce facts which may send your "boss" back to his outside friend and shut him up for good? I am afraid not.

If you want to better your job, you should keep daily records. In this way you may be able to hold the coal man in plain and know just what you are doing. You will have a check on your firing and plant conditions.

The isolated plant is all right. But the isolated-plant engineer must keep awake.

This is an age of [illegible] tion. You must [illegible] abreast with the lead[illegible]

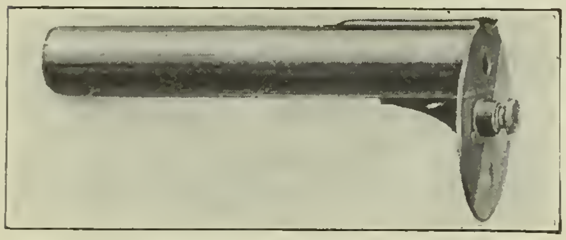
[illegible]

Binghamton, N. Y.

Measurement of Smoke Density

The construction of the smoke tintometer, as mentioned in the April 25 issue of POWER, is essentially the same as that of the smoke meter described by the writer in the London *Engineer* of January 31, 1908. I believe, however, that my instrument has superior qualities, one of which is that its simplicity permits it to be more readily made by anyone who may wish to possess a smoke meter.

As shown in the cut, the Kunze smoke meter consists of a metal tube 6 inches long and 1 inch in diameter, at the end of which is a disk similar to that of the smoke tintometer. I made the first disk of glass, but finding this expensive and easily broken, I used transparent celluloid. Only four tints were employed as the grades "clear" and "black," corresponding respectively to 0 and 5 of the Ringelmann chart, were unnecessary to operation. The grades 3 and 4 are most vital, as they constitute a violation of city ordinances as usually drafted. If the smoke appears darker than grade 4, it may be recorded as 5, and if no smoke is seen the record 0 may be used.



THE KUNZE SMOKE METER

At first I tinted my disks by painting them, but I found it difficult to get a flat tint without streaks or spots. A better way is to tint the disks by photography. The four segments of a large circle drawn on a sheet of bristol board are tinted corresponding to the grades 1, 2, 3 and 4 of the Ringelmann chart; this is then photographed and printed on a sensitized celluloid disk. By using an arc light for printing, one can time the exposure so accurately as to secure uniform grades of tints for any number of prints, and the tints after being fixed are not easily destroyed through use. Should it be desired to further protect the tinted surface, it can be done by having the celluloid disk turned out, leaving a small rim around the edge and, after sensitizing and printing the inner surface, covering it with a glass disk, in this way protecting the glass from breakage by the celluloid. In calibrating the different tints with the Ringelmann chart the instrument is used in its usual manner.

In employing any of the methods of tint comparison, including that in which the Lowdon instrument is used, a difficulty arises in that so many conditions may change the appearance of the smoke: the condition of the background, the color of the sky, the time of day, the position of the sun and many other conditions which will widely alter the effect of the observation. This trouble is mostly due to the fact that the eyes of the observer are not concentrated upon the smoke and the tint with which it is being compared, but are influenced by foreign conditions such as those named. This objection was overcome in the Kunze smoke meter through the use of small holes in the center of the tints as presented in front of the tube. In using the instrument the observer looks through the tube with one eye, and closes the other. The smoke will be seen by the naked eye through the small hole in the center of the tint and as all background is cut off there will be no disturbing influences and an exact comparison can be made. The disk is turned around its axis until the shade of smoke proper corresponds to the tint on the disk, or most nearly to it. If the smoke is darker than the surrounding tint, a dark spot will appear in the center. If the smoke is lighter, the spot will appear to be quite light in comparison. The contrast is great until the shades correspond to one another, at which time the contrast suddenly ceases to exist and the tint at the end of the tube is unbroken.

The use of this instrument need not be confined to smoke observations but may be used to compare color tints as readily as it does shades of grayness.

EDWARD J. KUNZE.

East Lansing, Mich.

Standpipe on Heating System

With reference to Alexander Dolphin's letter under the above title in the May 9 number, I do not think that the standpipe would give satisfaction. I think that the system would always be filled with water and that there would be violent water hammer. There could not be good circulation and the service would be poor. If it would be convenient to get below the return line a water seal in the shape of a U-bend would make a good form of trap. I have used a U-bend for a trap on low-pressure lines with success. It is bound to drain all the water out of the line, and it will not permit any steam to escape. There would be an objection to this trap for Mr. Dolphin's system which carries as high as eight pounds pressure, in that it would be necessary to extend the bend down about 18 feet below the return line in order to prevent the steam pressure from overcoming the weight of the water in the trap and thus allow steam to escape.

WILLIAM SWOPE.

Tiffin, O.

In the May 9 number of POWER Alexander Dolphin seeks information concerning a standpipe on a heating system. There is this objection to a standpipe. If he has a single-pipe system, every time the steam pressure goes off, the water in the standpipe will run into the radiators below the level of the water in the standpipe, and when the steam comes on again it will blow the remaining water out of the standpipe and cause severe pounding in the radiators. Then the water in the radiators must be removed, and this is no easy matter.

If he has a double-pipe system the steam pressure will clear the radiators of water but will cause much pounding and if there are any pockets he will find that the radiators behind the pockets will be flooded.

Then, too, with either system of piping, he will have a job to keep the proper head of water to balance the steam pressure. Five pounds on the steam mains will require 11.5 feet of water in the standpipe, measured above the lowest point in the steam mains; eight pounds will require 18.4 feet of water.

If the end of the pipe were in plain view it would be possible to put on a valve and throttle it, using it as a bleeder. Another way would be to use a water seal which can be made by taking two ¾-inch pipes about 20 feet long, laying them parallel and connecting them at one end with two elbows and a short nipple. Then place them upright and connect one end of the U-bend to the return main and let the other end discharge to the tank. This trap will keep the radiators clear of water and will prevent steam from blowing through.

ROY V. HOWARD.

Tacoma, Wash.

To Engineers Who Write

Much advice and exhortation have been devoted to those engineers who do not write. Just a word to those who do.

Many hesitate to write because they fail to see that what seems commonplace to them is just what some other fellow is aching to know. Others hesitate on account of lack of confidence. Then, too, a proposition reduced to black and white usually loses much of the force and luster it had while it was only an unexpressed thought. All these and more may account for the fact that some writers of letters stop right in the midst of their story.

For example, take the letter of C. B. Smith on page 646, April 25 number, on "Reduced Compression and Lead Saves Coal." Now, I happen to know the two engines of which he speaks. It also happens that I am running three engines of the same make. Naturally I am interested. Mr. Smith found it possible to save 3000 pounds of coal per day. If we could turn the same trick here, it would give us great pleasure. But here is the hitch. I know how my valves are set; but Mr. Smith has failed to show how his were set, either before or after adjustments. Possibly my compression is the same as his after adjusting, or my lead may be the same as his before adjusting. I do not know; he has left me in the dark.

A set of cards taken as the engines were originally and another set as they were when saving 1½ tons of coal per day would be relevant, or measurements of lap and lead and compression might be given. With such information the letter might be made very valuable to the many who are operating Rice & Sargent engines. Without it, all we know is that one man used a wrench and saved coal.

I have taken Mr. Smith's letter, not to cast any doubt or reflection upon it, but because it is easier to make one's meaning plain by using a concrete example. His fault is quite common. Let every writer try to put himself in the place of the "other fellow" for whom he is writing.

The admonition "Be brief," frequently given to writers, may be the reason for some of these letters which contain only half the story. We readers do not like to wade through a lot of verbiage to get at an idea. We want the ideas clearly set forth; but we want all of them. It may not be possible to do that and be brief; so I say, be concise. Get all the essential facts—and then prune.

WILLIAM E. DIXON.

Malden, Mass.

Coal Defined

In my letter under the above heading which appeared in the May 30 number I neglected to cross out the words "noncombustible elements" in the last equation of Table 2. The equation should read:

Pure Coal = Combustible Elements.

WILLIAM KENT.

New York City.

Benefit of Organization

Under the above caption in POWER of April 11, there appeared an article signed by C. C. Harris, of Springfield, Mass., calling attention to an organization of firemen, oilers and engineers to be known as the Brotherhood of Power Workers. I assume it is a local benefit association organized for the purpose of caring for the sick and burying the dead. How this will benefit the power-plant worker as a worker I fail to see.

For some little time there has been a movement to organize the Institute of Operating Engineers. This organization is to be composed of all men associated with the power plant. Assuming that all power-plant employees from coal passer up will eventually become engineers, it is therefore an engineers' organization.

The purpose of the Institute of Operating Engineers has been explained at length in POWER and is the kind of organization the engineer sadly needs.

Through its system of lectures, grades and certificates, the apprentice may become in time an operating engineer and in turn receive his certificate of master operating engineer.

The present standing of the average engineer is due, in part at least, to his isolation and his short-sightedness. He has been left out of the general distribution of rewards and is therefore compelled to accept a lower wage than some of those over whom he has supervision.

When the standards set by the Institute of Operating Engineers are established, there will be a recognized distinction between the engineer in charge of a 25-horsepower plant and the chief of a large central station.

The man who will be able to obtain a certificate of master operating engineer, will have in his possession a paper of value and his services will be in demand. His compensation will be in accordance with his ability.

J. P. FLEMING.

Chicago, Ill.

The Accident at Amoskeag Mills

In reading over the account in the April 11 issue of POWER of the accident at the Amoskeag mills, and the resulting death of three men, it seemed almost incredible that the two men on the engine-room floor were unable to get out of the building before being enveloped by the escaping steam. A little figuring, however, leads one to wonder how anyone was able to escape.

The only measurement given is the length of the basement, 151 feet. If the drawing is to scale, the width is 80 feet. The basement is probably not over 10 feet high and the engine room about 40 feet. These assumptions are sufficiently close for the information desired. This gives 600,000 cubic feet as the total cubical contents.

About one-fourth of the flange blew out, so that the area of the opening was 78.5 square inches. Using Napier's formula, the quantity of steam flowing through this opening in one minute, with a boiler pressure of 170 pounds, would be

$$\frac{185 \times 78.5 \times 60}{70} = 12{,}450 \text{ pounds}$$

One pound of steam at atmospheric pressure is equal to 26.8 cubic feet, so that in one minute 333,000 cubic feet of steam at atmospheric pressure would be blown into the basement and engine room. This would mean that in less than two minutes the entire building would be full of steam at a temperature of 212 degrees Fahrenheit, high enough to kill a man in a few seconds. Actually the engine room must have filled with steam to a hight of 10 or 15 feet inside of 15 seconds, and the men, unable to see, must have been caught before they could grope their way out.

W. L. DURAND.

Washington, D. C.

Triplex Pump Problem

In Mr. Potter's triplex-pump problem in the March 28 number, let us assume two different positions of the cranks as in Figs. 1 and 2. Let the connecting rod be four times the length of the crank, then when one of the cranks is on the bottom center the end of the plunger will be five crank lengths from the center of the crank shaft. The stroke of a plunger will equal two crank lengths and if for the sake of argument we call a crank length one volume, the stroke will equal two volumes.

The cranks, the connecting rods and the center lines of Figs. 1 and 2 will form a number of triangles. If the length of the center line forming one side of the triangles in Fig. 1 is determined and this distance measured from the center of the crank shaft, it may be determined how far up the end of the plunger has moved. By the use of the sine tables and the rule that the sides of any triangle are proportional to the sines of the opposite angles, I find that in Fig. 1 two plungers have displaced 0.5955 volume each, while the other plunger, being at the end of the stroke, has displaced two volumes, the sum of the three being 3.1909.

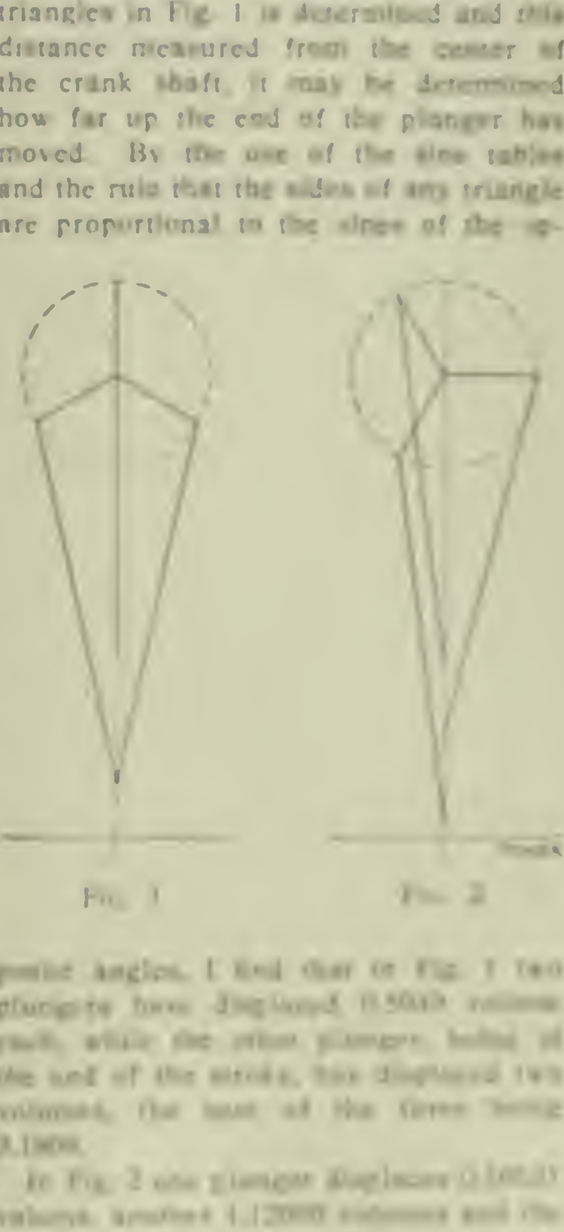


FIG. 1 FIG. 2

In Fig. 2 one plunger displaces 0.16033 volume, another 1.12000 volumes and the other 1.90545 volumes. The sum in this position is 3.15072. The shorter the connecting rod the greater becomes the effect of the angularity. With a connecting rod twice the length of the crank, I obtained 3.525 volumes for Fig. 1 and 4.32303 volumes for Fig. 2. While the difference in volume for the two positions is not large, when the cylinders are filled with water I think that something would have to be so.

LESTER PYLE.

West Fitchburg, Mass.

Value of CO_2 Recorder

In the issue of May 9, H. S. Vassar presents diagrammatically the results of a number of boiler tests for the purpose of confirming his disbelief in the value of flue-gas analyses in general, and automatic CO_2 recorders in particular. He starts out by placing these instruments in a class with pies and puddings—which are unnecessary, if not indeed harmful, luxuries—and clinches his arguments by citing a fable which represents all those who are spending time, effort and vocabulary in an earnest endeavor to show the true relation between CO_2 and efficient combustion, and to convince the power producer of the economic value of a continuous automatic record of CO_2, as "strangers glib of tongue" who are enticing the foolish managers of power plants into ordering these instruments "at a fabulous price" and all those who for many years have been spending time, money and patient, toilsome effort to perfect such instruments as "weavers of airy nothingness from nothing."

Mr. Vassar's presentation of experimental data is not without value.

First, because it shows how easy it is to draw false conclusions from insufficient data.

Second, it gives an opportunity to discuss the subject of CO_2 from a new viewpoint.

Third, and most important, it sets those who are, or should be, interested to thinking.

Valid conclusions cannot be drawn from the meager data presented. It is necessary to know the draft, rate of combustion, feed-water temperature, steam pressure, the percentage of superheat or moisture in the steam and, above all, the temperature of the flue gas and the percentage of coal left in the ash and clinker.

It is absurd to condemn the value of an automatic CO_2 recorder from the results of a series of tests in connection with which no such records were made. An average sample may be quite misleading because it cannot reveal what has happened during the sampling period. In an average sample showing 11 per cent. of CO_2 the flue gas may have varied between 5 and 17, 8 and 13 or 10 and 12 per cent., and unless these variations are known, valid conclusions cannot be drawn as to the economic value of CO_2.

Furthermore, the ordinary method of sampling by drawing the gas into a bottle filled with water and allowing the water to drain off gradually does not give a true average sample. The flow of gas varies inversely with the draft, and directly with the loss of head in the bottle, causing the flow to become less and less rapid as the bottle empties. Until Mr. Vassar gives assurance to the contrary, there is justification in doubting that he obtained true average samples.

Mr. Vassar says nothing about the temperature of the flue gas and, since the loss of heat up the chimney varies directly with the temperature of the escaping gas, no valid conclusion can be drawn without this knowledge.

The loss of coal through the grate bars is another factor which may vary between 1 and 5 per cent. and must therefore be taken into account. Without a knowledge of these factors it is absurd to draw a general conclusion. There are certain fundamental principles and natural laws with which experimental results must harmonize, and if they do not so harmonize, there is something wrong with the results or the manner in which they have been obtained.

To burn 1 pound of carbon to CO_2 requires 11.6 pounds of air, forming 12.6 pounds of combustion product composed of 21 per cent. CO_2 and 79 of nitrogen by volume. If 50 per cent. excess air is supplied the products of combustion will weigh 18.4 pounds and contain 14 per cent. of CO_2. With 100 per cent. excess air the products of combustion will contain 10½ per cent. CO_2 and weigh 24.4 pounds. With 200 per cent. excess there will be 7 per cent. CO_2 and 35.8 pounds of flue gas; and with 300 per cent. air, 5.25 per cent. CO_2 and 47.4 pounds of flue gas. Thus the weight of the flue gas increases as the percentage of CO_2 decreases.

In burning 1 pound of carbon 14,500 B.t.u. are liberated, and this quantity of heat remains the same whether the coal is burned to CO_2 with the theoretical minimum weight of air required or with an excess of 300 per cent. or more. There is therefore a definite quantity of heat available from every pound of carbon burned, irrespective of the excess of air supplied.

To raise 1 pound of dry flue gas 1 degree, requires 0.24 B.t.u. If the temperature of the escaping flue gas is assumed to be 500 degrees above atmospheric temperature, 1 pound of flue gas will carry away

$$0.24 \times 500 = 120 \text{ B.t.u.}$$

Therefore there must be loss of heat up the chimney. The following gives the losses for various percentages of CO_2 in the flue gas and also the percentage of these losses to the total heat produced:

CO_2, 21.0%	$12.6 \times 120 = 1512$ B.t.u.	or 10.4%
CO_2, 14.0%	$18.4 \times 120 = 2208$ B.t.u.	or 15.2%
CO_2, 10.5%	$24.4 \times 120 = 2928$ B.t.u.	or 20.0%
CO_2, 7.0%	$35.8 \times 120 = 4296$ B.t.u.	or 29.6%
CO_2, 5.25%	$47.4 \times 120 = 5688$ B.t.u.	or 39.2%

These are minimum figures for the stack temperature assumed, and can be reduced only by reducing the stack temperature.

The loss up the chimney may be and generally is greater than shown in the table, due to various causes: First, higher stack temperature; second, unconsumed combustible gases, and, third, water vapor.

Abnormally high stack temperature may be due to dirty and insufficient heating surfaces and excessive driving. With a properly constructed furnace and intelligent firing, appreciable quantities of unconsumed gases will not occur when 40 to 50 per cent. of excess air is used. Water vapor is always present, due to moisture in the coal and the air and to the combustion of hydrogen.

In all cases high or low CO_2 means high or low efficiency, and when, as some of the tests in Mr. Vassar's diagrams indicate, 5.25 per cent. CO_2 gives a higher efficiency than 8 per cent. (Fig. 1) and 8 per cent. is more efficient than 12½ (Fig. 2), there is something wrong either with the percentage of CO_2 given or the determination or computation of the other data.

While it would be preposterous to say that a CO_2 recorder is a sure cure for all sources of loss in the boiler room, it is none the less true that it is the most available and most reliable, and hence the best, guide to efficient firing, and in combination with a recording pyrometer gives a correct measure of the loss of sensible heat up the chimney. When it is considered that this constitutes from 60 to 90 per cent. of the total waste in generating steam, its importance must become evident to all concerned in boiler-house economy.

EDWARD A. UEHLING,
President Uehling Instrument Company.
Passaic, N. J.

The Line Shaft Breaks

In the issue of May 2, A. Rathman writes that the shafts break in the hub of the sheaves. That is the weakest place, as the keyseat is cut there.

An uptodate factory which had been installed but a short time was operated by a rope drive. The generator was driven by a Corliss engine of 1500 horsepower.

One night during a rain storm the wheel pit was flooded and the rope got wet and began to shrink. It was then slacked off all that was possible on the tightener. The stress was so great that a coupling on the generator shaft was sprung, cracking one bearing, and the rope drive had to be cut out to keep it from pulling the generator off its base.

Mr. Rathman does not say whether the plant was run 10 hours or 24 hours, but I infer that it is operated in the daytime. At night the drive is apt to get damp and contract, causing a heavy strain or even springing the shaft. The remedy I suggest is to keep the drive as dry as possible. A good belt dressing might be a help to prevent moisture, if applied when running slowly just before shutting down.

O. L. SHERMAN.

Duluth, Minn.

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POWER

The National Electric Light Convention

Some of the features of the "electric light" convention recently held in New York City might be profitably adopted by the other national engineering bodies. The committee system is probably the most important of these. Of about thirty items on the program relating to engineering or closely allied branches of central-station work, nineteen consisted of committee reports and most of these were far and away more valuable than any of the papers constituting the remaining eleven "events." Just why this is so we do not presume to say in detail; it is sufficient that it is true, which is indubitable. Those of the reports that are of high merit are the results of a year's almost continuous effort by the several committees making them; this is a very obvious and excellent general reason why they are of more value than the average paper. Of course, there are other reasons and anyone interested can easily discover most of them.

The committee reports this year were of a much higher order of merit than those previously returned; this is but the natural result of continuing good, earnest workers on the committees from year to year instead of disorganizing things and handicapping the work by annual upheavals. The reports on meters, power, overhead line construction, underground construction and the preservation of poles and crossarms, for example, were masterly compilations of practical information, each worth its weight in gold to any central station within the class to which it applies.

It is by no means intended to intimate that the papers read at the convention were not meritorious. On the contrary, most of them were unusually so and this fact serves only to emphasize the demonstration which this year's program makes, that a committee report can be made of more practical value to the station operator or manager than a good individual paper.

However, the fact must not be ignored that some subjects cannot be treated as well in a committee report as in an individual paper. Hence, there will always be excellent work to be done in the way of preparing papers. No hard and fast line can be drawn, but in general it would seem that the best plan of apportionment is to have principles treated in individual papers and practice reflected and guided by committee reports—not forgetting that specialization pays in committee work as well as other kinds. This policy was reflected to a large extent in the convention under discussion, with the conspicuously beneficial results to which we have referred.

Progress or Something New?

As a people the Americans attempt to be progressive to a degree not reached by any other, but all of this progress is not in the right direction. Much of it is merely change which does not represent real progress.

When an idea is developed it is frequently adopted without sufficient investigation. New processes and methods of doing work and new products are daily creations which are adopted almost as a matter of course on the assumption that that which is new must be better than that which is old.

In the test of practical operation failure is more than often the ultimate result which investigation or even logical mental analysis would have predicted.

Some years ago improvements in rolling-mill practice made the rolling of large sheets possible. Immediately two-sheet boilers were put on the market with multitudinous unsupported statements of the advantages of a boiler construction devoid of circumferential seams. Short terms of service demonstrated the fallacy of the claims in a much more costly manner than would a reasonable amount of analytical research.

Concrete, both plain and reinforced, now supplants iron, wood, brick and stone in countless forms of construction, with little regard for its fitness in many instances. It is used in buildings, beams and bridges, in pavements, fences and conduits, aqueducts and for foundations and retaining walls, but careful engineers, while recognizing its many advantages for various purposes, are advising its employment only where it is manifestly advantageous.

In power-plant equipment the piping is a factor of prime importance and the necessity for reliability has led to the design of many types of pipe joints, among which the welded flange is not the least noticeable. Though it may be possible that a pipe line in which the flanges are integral with the pipe length is better than one with separate flanges, it is of paramount importance that the construction be safe beyond the possibility of suspicion.

When two pieces of iron or steel are to be welded together the surface must be clean so that the pasty metal may be rolled or hammered into perfect contact, and when the slag is not entirely removed from both surfaces this is impossible. There is always more or less difficulty in welding when one of the members is much thicker than the other, and this is aggravated when the surfaces to be joined are comparatively broad or long.

Between the pipe and the flange there is a considerable difference in thickness and the form of the joint is such that the removal of all of the slag and oxide is problematical. A joint of this kind though to all appearances perfect outwardly and may withstand a mild hydrostatic test, may be so imperfectly joined within that the stresses and flexures of even a short service will pull it apart.

The strength of a perfect weld may be approximately calculated, but the uncertainty of the continuity of the union between the pipe and the flange in a welded joint has led conservative engineers to discourage the use of the welded pipe flange, not because of the lack of strength and rigidity when sound, but because of the uncertainty of the nature of the union between the pipe and the flange.

Ignition in Gas Engines

It has been universally true ever since the early days of electrical engineering that electrical auxiliaries used with machines not themselves electrical are responsible for most of the troubles experienced in the operation of the machines, until the makers of them "wake up" and put the proper quality in their electrical auxiliaries. The gas engine is no exception to the rule—in fact, it is a shining example of its truth. It has been stated that more than two-thirds of gas-engine troubles are due directly to the ignition equipment; it is our opinion that the proportion is much nearer ninety per cent.

The remedy in all cases where the engine is small is to equip it with the best quality of ignition apparatus *and wiring* that money can buy. Large engines, however, suffer the unavoidable handicap of relatively slow complete ignition, no matter how good the equipment, because of the distance through which the flame must travel and the very small quantity of mixture in contact with the spark made by the igniter.

The Diesel engine has been perfected mechanically to such an extent, we are told, that it is operated in Europe by unskilled labor. Does anyone suppose this would be possible if the engine had to depend for ignition on the kind of apparatus commonly applied to gas engines? The fact that the air in the cylinder is hot enough to ignite the oil as it is injected undoubtedly accounts for the conspicuous operating success of the Diesel type of engine, now that the rubbing surfaces, crank shaft and nozzle have been made practically fool-proof.

Builders of gas engines will do well to take this lesson to heart. Ignition by means of a minute spark at one or even two points on the circumference of a large cylinder is inefficient, and attempted ignition, at one or forty points in any cylinder, by means of cheap apparatus is an insuperable obstacle to satisfactory operation.

Gathering Them In

"Twenty-nine steam plants in one town; twenty-seven of them are shut down and the other two are on the run." This is the substance of what the chief engineer of a central station in a prosperous Massachusetts manufacturing town told a Power representative recently.

Why have the owners of these twenty-seven steam plants found it to their advantage to close them, unless it is because electrical energy is sold to them at a lower cost than the steam plants can produce the same power?

This is not a proof that the isolated plant cannot produce power cheaper than it can be bought from the central station, but it indicates that some engineers are so operating their plants that they cannot compete with central-station rates.

There is not enough attention given by private-plant engineers to the undeniable fact that their positions are in peril. They do not seem to realize that their employers are going to get power where it will cost the least. There is no sentiment in business. The owner of a steam plant sees no poetry in the roaring furnace and revolving flywheel, and just as soon as it is determined that the central-station rate is cheaper than isolated-plant operation, out goes the small plant and with it the engineer.

When the operating conditions of some isolated steam plants are noted it is a wonder that they have not been superseded by the central station long ago. Some engineers are woefully ignorant about the machinery in their plants. Recently the man in charge of a four-valve engine could not tell his visitor the maker's name until he had looked at the nameplate. In another steam plant the engineer was operating a cross-compound engine. Each cylinder was provided with two exhaust valves and each steam valve was fitted with a riding cutoff valve. The engineer stated that each cylinder had but four valves.

With such men in the small steam plant it is no wonder that the central station is putting them out of business. An isolated plant, in order to withstand the competition of the central station, must be operated by an intelligent engineer.

Two steam plants in operation out of twenty-nine is a commendable record for the central station, but what a mighty poor showing on the part of the twenty-seven engineers! A fact worth noting is that the engineers of the two live steam plants are readers of power-plant journals.

Is it not about time to wake up?

High Voltage Transmission

At a meeting of the power-transmission section of the National Electric Light Association during the recent convention the question was raised as to what is the maximum voltage that can be carried economically on transmission lines. Although there were a number of prominent electrical engineers present and the question evoked considerable discussion, there appeared to be no definite opinions upon the subject.

At one time it was believed by many that distance was a factor dependent only upon the voltage; that is, power could be transmitted almost any distance providing a sufficiently high voltage could be employed to avoid excessive copper losses. The chief difficulty then lay in obtaining insulators which would withstand the high tension; but this now seems to have been overcome and with the introduction of the suspension type of insulator it is probable that this phase of the problem will be met for any voltages likely to be used. Another factor to contend with, however, is the breaking down of the dielectric strength of the air, resulting in objectionable leakage from wire to wire through the intervening air.

In Colorado, transmission lines carrying current at one hundred and ten thousand volts are in successful operation at altitudes of ten thousand feet above sea level, and a one hundred and forty thousand-volt line is being constructed in Michigan. This represents an increase in voltage about tenfold during the past fifteen years. What then appeared to be unsurmountable difficulties have been successfully overcome and it is probable that like progress will be made in the future. Nevertheless, definite data upon the subject of leakage through the air would be of great value to engineers engaged in power-transmission work.

It is expected that in twenty or thirty years all of the water power in Bavaria will have been developed. There is a total of some three million horsepower, about one-half of which is owned by the government. One of the first large projects to be undertaken under government auspices is that at Lake Walchensee.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Feed Water Entrance to Manning Boilers.

Why does not the feed water enter the water leg of a Manning boiler as in most vertical boilers?

M. B. H.

The feed water enters the Manning boiler as it should all vertical boilers, well up toward the top of the water, in order to give the contained air a short pass to the steam space. If the water enters the boiler anywhere in the comparatively cool water leg, the oxygen in the air leaves the water slowly and collects on the staybolts and sheets and injures them by corrosion; while if set free in the hot water near the top, it goes directly into the steam space and thence to the engine, where it can do no harm.

Soda Ash and Soda Crystals

What are the comparative values of soda ash and soda crystals for water softening?

F. W. S.

Soda ash and soda crystals are on the market in such degrees of impurity that a definite answer to your question is impossible.

Soda ash runs from 40 to 60 per cent. alkali, and soda crystals may contain anywhere from 20 to 30 per cent. of water. Ordinarily, the largest per cent. of alkali is obtained for the money when 48 per cent. soda ash is bought.

Sulphur for Hot Bearings

How is sulphur used for cooling hot bearings, and is it suitable for all sizes?

C. H. P.

Pulverized sulphur, commonly called flowers of sulphur, is mixed with a heavy oil, preferably cylinder oil, in proportions by measure of about 1 of sulphur to 6 of oil. The mixture is applied liberally and is suitable for all sized bearings.

Horsepower of an Engine

What would be the horsepower of an engine: mean effective pressure, 40 pounds; length of stroke, 12 inches; diameter of the cylinder, 14 inches; number of revolutions, 90?

W. G.

The horsepower of a steam engine is found by multiplying together the speed of the piston in feet per minute, the area of the piston in square inches and the mean effective pressure per square inch and dividing the product by 33,000.

Expressed as a formula the rule is:

$$Horsepower = \frac{PLAS}{33000}$$

Substituting the values given it becomes:

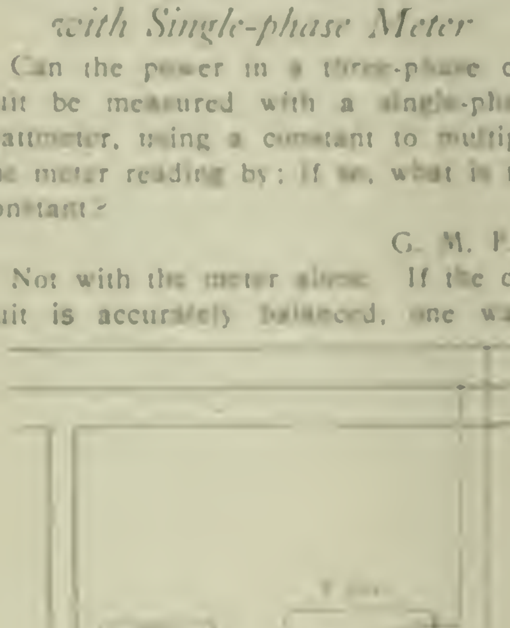
$$\frac{40 \times 153.94 \times 180}{33000} = 33.58 \text{ horsepower}$$

Measuring three-phase Power with Single-phase Meter

Can the power in a three-phase circuit be measured with a single-phase wattmeter, using a constant to multiply the meter reading by; if so, what is the constant?

G. M. F.

Not with the meter alone. If the circuit is accurately balanced, one wattmeter and a Y-box, connected as shown in the diagram, may be used. The wattmeter will indicate one-third of the total power in the circuit—that is, it measures the power in one phase only. The use of the Y-box is for the purpose of giving the potential coil of the wattmeter the true voltage between the main wire and the neutral point of the system. The resistance of each branch of the Y-box conductor must equal that of the potential coil.



MEASURING THREE-PHASE POWER WITH A SINGLE-PHASE WATTMETER

Alternating-current Frequency

What determines the number of cycles per second in an alternating-current circuit?

H. E.

The number of cycles per second is equal to the number of field-magnet poles on the alternator which supplies the circuit multiplied by one-half the number of revolutions per second. For example, a machine with eight poles running at 15 revolutions per second (900 revolutions per minute) will deliver current of 60 cycles per second, because

8 poles × 7½ r.p.s. = 60 cycles.

Same Speed at No Load and Full Load

A shunt-wound direct-current motor continues running at the same speed after the load is cut off that it showed with full load; what is probably the reason?

F. C. G.

It is probable that the brushes have a forward lead to such an extent that the armature reaction at full load weakens the field enough to keep the speed up to the no-load speed, but this would ordinarily cause bad sparking. Another possibility is that the field winding is differential instead of simple shunt. Examine the coils closely.

Removing Scale from Engine Jackets

How can I remove the scale from the water jacket of a gas engine that is so small that a scraper cannot be used in the jacket space effectively?

F. C. H.

Fill the jacket with a strong solution of washing soda and run the engine until the water becomes hot; empty the jacket and refill with pure water, not too cold, and run the engine until the water begins to evaporate (not boil vigorously); empty the jacket and refill again with pure water and run the engine as before. Repeat this until the water comes out reasonably clean. If it is rusty and dirty after the third or fourth dose of pure water, put a solution of washing soda through again and follow with the fillings of pure water as in the first effort.

Reversing a Direct-current Dynamo

What changes in connections are necessary when a direct-current dynamo is driven in the direction opposite to that for which it was built?

H. F.

Transpose the connections of the two cables leading to the brush holders and reset the brushes for the reversed direction of rotation.

Refrigeration Department

Principles and operation of ice making and refrigerating plant and machinery

The Westinghouse-Leblanc Water Refrigerating Machine*

This machine rests on the principle of producing cold by evaporation of an aqueous solution in a vacuum. But it differs essentially from the old machines of Leslie and Carré and from the vacuum machines now employed in America in that the water evaporated, instead of being absorbed by concentrated sulphuric acid, is removed by mechanically drawing off. This leads to a great simplification since there is no longer any need to trouble with reconcentrating by dilute sulphuric acid. If this expedient had not hitherto been devised, it was because it seemed impossible, practically, by mechanical means, to remove the enormous volumes of water vapor evaporated at low temperature (since the boiling point of water at atmospheric pressure is 212 degrees Fahrenheit, is much higher than that of other liquefied gases used in compression machines, viz., 14 degrees Fahrenheit for sulphurous acid, — 13 degrees for methyl chloride, — 31 degrees for ammonia, and — 108 degrees for carbonic acid). This was, in fact, quite impossible with piston pumps and could not be accomplished except by recourse to entirely different apparatus, such as ejectors, which, by reason of the enormous velocities attained by the liquid in them, allow a considerable flow of steam. Yet it has been necessary, in order to obtain the requisite high vacuum or low absolute pressure of 0.12 of an inch of mercury to get a refrigeration to 23 degrees Fahrenheit and less than 0.039 inch to reach 28 degrees, generally to combine with a steam ejector a special water ejector fed by a sort of reversed turbine. These two appliances, which separately would be insufficient, give the desired result when they are coupled in series.

The Westinghouse-Leblanc refrigerating machine permits the refrigerant to be employed more simply than in compression machines. While in the latter apparatus the evaporated refrigerant liquid, such as ammonia, cannot generally be employed directly and serves only to cool a brine, in the Leblanc machine it is the brine which is directly cooled and constitutes the refrigerant liquid. At the same time it is concentrated by the natural action of the vacuum machine. This peculiarity avoids the need of concentrating by heating the brine, which becomes quickly hydrated by contact with the moisture of the air and the substances that are being cooled. Here, on the contrary, it is always necessary to add a certain quantity of water to the heated brine before sending it to be cooled.

When the Leblanc machines were first built, the water vapor removed from the brine was condensed in the water ejector itself. This arrangement was applied only in one installation, in the Gillet Chemical Works, at Lyons, to cool a dye-works product to 46 degrees Fahrenheit only. In all subsequent installations the water vapor removed from the brine has been condensed in a separate mixing or surface condenser, the vacuum pump of which is formed by a liquid ejector. This new arrangement has rendered easily possible the design of powerful refrigerating machines for low temperatures, which would not have been practicable with the simple ejecto-condenser applicable only to small installations for quite high temperatures.

The accompanying illustration is a diagrammatic sketch of a Leblanc refrigerating machine, with a mixing countercurrent condenser, such as that installed at the Bethune mines. All the other installations are of nearly the same type, except that the condenser may be of the surface type. The heated brine coming out of the refrigerator *R* passes to a dilution tank *S D*, where a cock with a float brings fresh water when the level in the tank falls below a certain point. The brine, suitably diluted, is thence drawn up through the pipe *S C* to the top of the evaporator *A*, by reason of the vacuum existing therein. This evaporator is formed of a cylindrical body *B*, carrying at the top a finely perforated plate, through which the heated brine falls in slender jets. Under the influence of the vacuum which prevails in the evaporator, this brine in falling liberates water vapor, which escapes by the annular jacket surrounding the cylindrical body *B* and rises to pass through the short pipe *A E*. At the same time the brine, cooled by con-

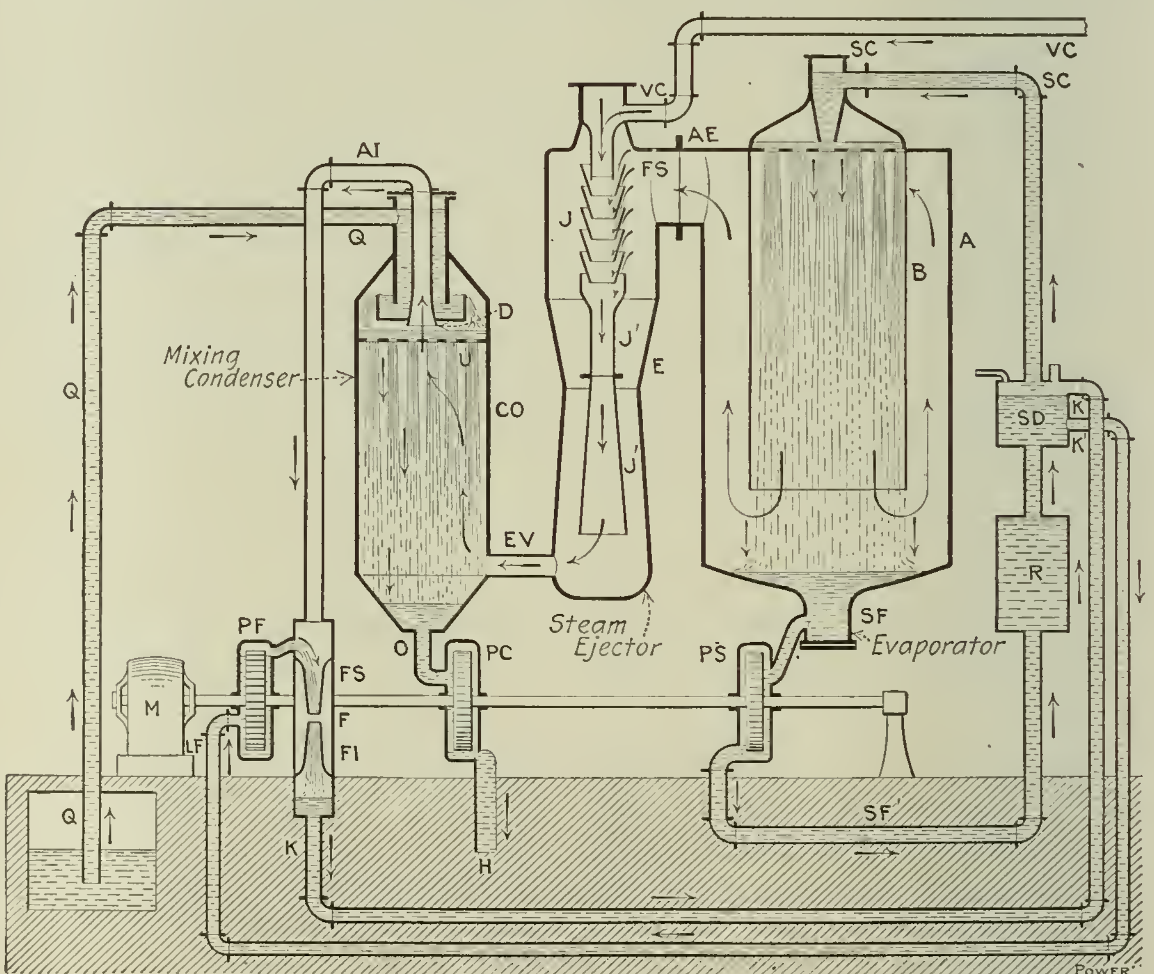


Diagram of Westinghouse-Leblanc Water Refrigerating System

*Translated from an article by Ch. Jacquin in *La Technique Moderne*.

centration, falls to the lower part *S F* of the evaporator *A*, where a centrifugal pump *P S* sends it to the refrigerator *K*.

The air and water vapor removed from the brine, at low pressure, enter at *A E* the periphery of the steam ejector *E*, which contains a series of nozzles *J* followed by a converging and diverging cone *J* into which comes a flow of hot steam from the pipe *V C*, which can be at atmospheric pressure only. The hot steam jet enters the nozzles *J* and draws along with it into the cone *J* the air and cold vapor coming from the brine. The mixture passes out at the lower part *E V* of the steam ejector and into the lower part of the condenser *C O*, where it is drawn upward by the vacuum exerted in the pipe *A I*. In rising, it meets slender jets of cold water coming from the tube *Q* and spraying through a finely perforated plate *U*. In contact with this water, the water vapor of the mixture condenses and falls with the sprayed water to the bottom *O* of the condenser, where the two combined waters are discharged at *H* by a centrifugal pump *P C*. The air which was contained in the rising gaseous mixture, with the water vapor from the brine, is sucked through the upper central orifice *D* into the pipe *A I*.

The suction is produced in *A I*, at the top of the condenser, by a water ejector *F*, containing a converging cone *F S*, into which is injected a liquid, generally water, at very high velocity, forced by the turbine pump *P F*. The liquid injected into *F S* carries with it, into the diverging cone *F I*, the air sucked from the condenser and falls into *K*.

In the ejecto-condenser machines (corresponding in the figure to a direct communication of the base *E V* of the steam ejector *E* with the top *A I* of the liquid ejector *F*) the ejecto-condenser is fed at *L F* by the water sucked from a well or tank, but it is then necessary to prime it with water under pressure. In the machines with a separate condenser, such as that shown, the turbine pump *P F* is fed with the brine itself coming through *K L F* from the dilution tank *S D*, and returning there at *K* whenever the level in this brine tank *S D* is to be raised. There is nothing further to consider but the priming of the liquid ejector, which starts work when the pipe *K* is open. Likewise there is no need of special water for the operation of this ejector, whose speed of circulation is such, and which requires so little liquid that it causes no trouble in the brine tank *S D*.

The liquid ejector *F* gives a constant vacuum, equal to the tension of the water vapor at the temperature of the liquid of condensation, some 15 to 20 millimeters. The steam ejectors *E* have their piping calculated to bring about the vacuum begun by the liquid ejector *F*, so as to obtain in the evaporator *A* a final absolute pressure, variable according to the temperature to which the brine should be cooled; for example, 0.12 inch of mercury when it is desired to reach 23 degrees Fahrenheit, and ¼ inch of mercury when 41 degrees suffices.

The three pumps, *P S* for circulating the brine, *P C* for discharging the condenser and *P F* the pump of the water ejector, all being of centrifugal type, are driven by a single small electric or steam motor *M*.

The Leblanc machine has the advantage of being built only of strong parts, with no valves, etc., subject to rapid wear. The absence of noise is also in certain cases a valuable quality; for example, on the "Suffren," and on the seven large warships of the "Danton" type now in construction, where there is an interesting application of this refrigerating machine for cooling ammunition magazines. The brine cooled in the refrigerating machine serves for cooling to a temperature of a few degrees above 32 degrees Fahrenheit, the air entering an air cooler and circulating in the magazine, thus preventing such rise of temperature of the powder as to cause an explosion.

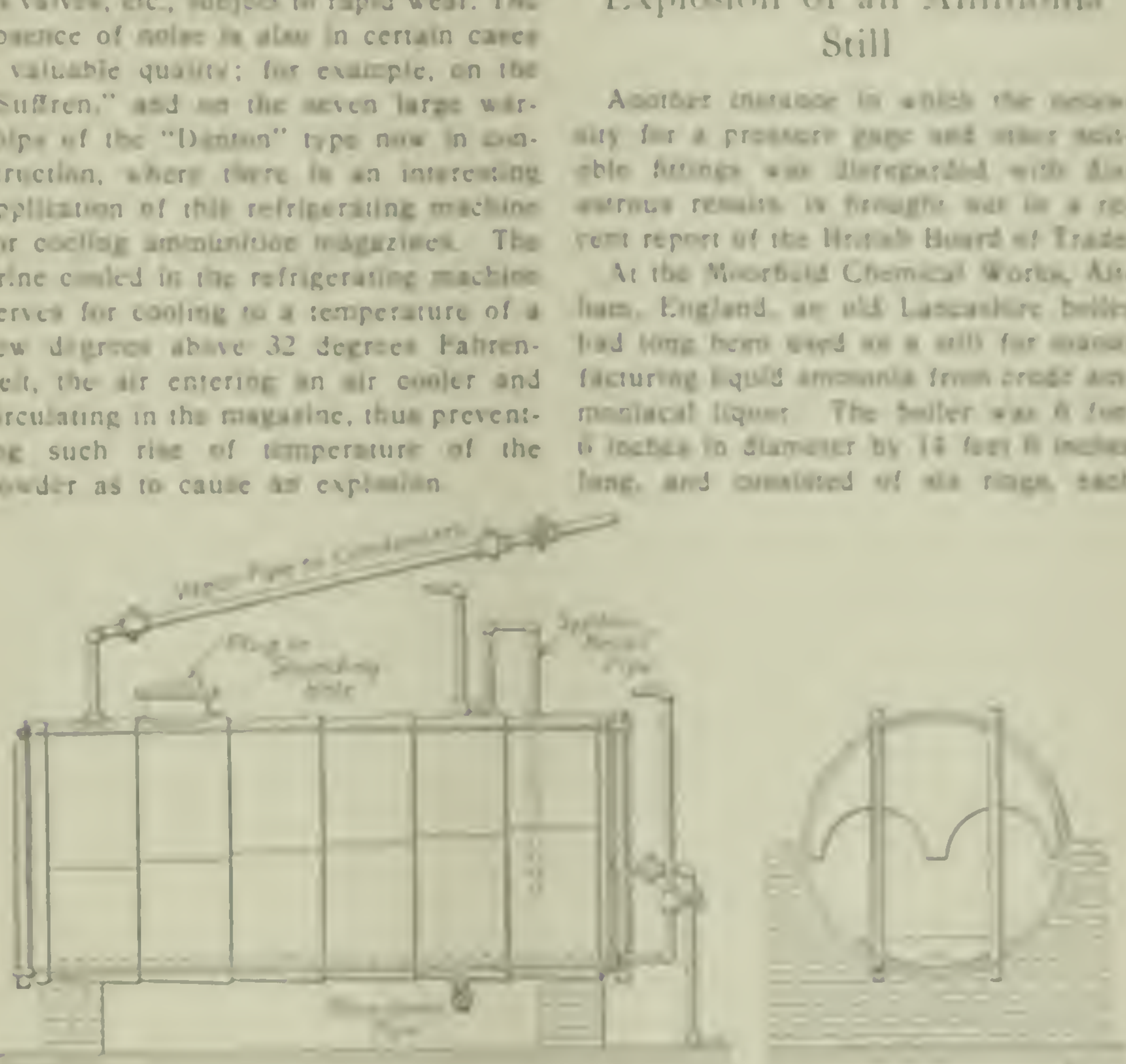
The Westinghouse-Leblanc machine is well adapted to chemical industries where there is no need to cool below the freezing point, its efficiency then being excellent, while for very low temperatures its power and efficiency notably decrease because of the extremely weak tensions which the water vapor then shows. It has recently been applied in the Nanterre factory of the French Glue and Gelatine Company to cool the air used to hasten the viscosity of the gelatine. In this installation, since the brine does not require to be cooled to a low temperature, the evaporation of the water does not need a high vacuum, and a steam ejector alone suffices to produce the vacuum required in the mixing condenser; the liquid ejector and its turbine pump are then unnecessary.

The Leblanc vacuum machine consumes in its condensers a little more water than compression machines require for their cooling, but, when the temperature of refrigeration is not very low, it takes, as motive power employed for driving its pumps, and as steam necessary for its ejectors, a total energy rather less than the mechanical power required for driving a compression machine; and this power is produced economically when the steam of the ejectors, which constitutes the greater part of it, may be derived from the exhaust of steam engines, as is often the case in large works.

Explosion of an Ammonia Still

Another instance in which the necessity for a pressure gage and other suitable fittings was disregarded with disastrous results is brought out in a recent report of the British Board of Trade.

At the Moorfield Chemical Works, Altham, England, an old Lancashire boiler had long been used as a still for manufacturing liquid ammonia from crude ammoniacal liquor. The boiler was 6 feet 6 inches in diameter by 14 feet 8 inches long, and consisted of six rings, each composed of two ¼-inch plates. The heads were ⅝ inch thick and were secured to the shell by means of internal angle irons. Double angle irons were also riveted to the front head and a pair of girders were placed vertically across the outside of each head, their ends being clamped to tie-rods running the entire length of the boiler, as shown in the illustration.



OLD BOILER USED AS AN AMMONIA STILL

A 1½-inch wrought-iron pipe for charging the boiler with ammoniacal liquor and milk of lime, entered the front head as did also a similar pipe for supplying the heating steam. A valve was fitted on each of these pipes and a 1½-inch vapor pipe led from the crown to two condensers. There was a siphon relief pipe, 1½ inches in diameter, which passed through the boiler crown and was connected to an internal pipe, the open end of the siphon being about 3 feet above the top of the boiler and the length of the internal pipe 4½ feet.

A blow-down cock was fitted to the bottom of the boiler and a manhole was provided at the top, through the cover of which was drilled a ¾-inch hole for sounding purposes; the latter was closed by a wooden plug. The vapor pipe also contained a ¼-inch hole for ascertaining the strength of the gas, and, like the other, this was closed by a wooden plug. No pressure gage or other mountings were fitted.

The method of working the distilling apparatus was as follows: When the boiler was to be charged, the cocks on both branches of the vapor pipe were closed. The ammoniacal liquor was then run in from the settling tank, up to within 3 feet of the top of the boiler, and then about 4 to 6 inches of milk of lime was introduced by means of an injector. The charging cock was then closed and the steam valve opened, admitting steam into the boiler and boiling the liquor.

The gas evolved was led to the condensers, where it was condensed to liquid ammonia. There were two condensers, it being the usual practice to pass the gas to one condenser for 20 hours, one cock being open and the other shut. The cocks were then changed and the gas led to the other condenser, which, after working for another 20 hours, exhausted the charge in the boiler. The spent liquor remaining in the boiler was run off by means of the cock at the bottom of the boiler, after which recharging took place. It required about one hour to run off the spent liquor, and another hour to charge the boiler. It was customary to open one of the outlet cocks on the vapor pipe at the same time as the steam was turned on to the boiler.

At about midnight on the night before the explosion the boiler was due for recharging and, according to custom, the man on duty should have opened the steam valve and the vapor cock, the latter of which he apparently neglected to do. For, about two hours later, a violent explosion occurred, blowing out the front head, the rivets connecting it with the angle-iron ring having been completely sheared off and the tie-rods ruptured. The rear head was also torn at its connection to the shell for about four-fifths of its circumference, and the boiler was projected backward about 2½ feet. The attendant was so severely injured that he died a few hours later.

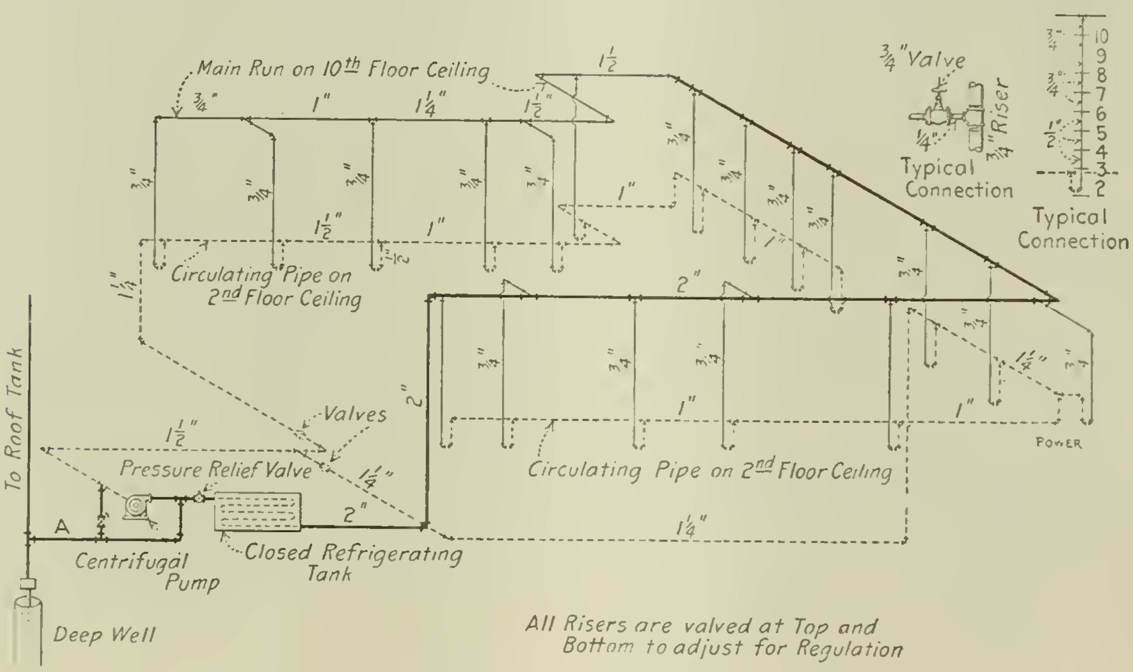
An investigation after the accident showed the relief pipe to be completely choked and as there was no pressure gage nor safety valve attached, an explosion was inevitable.

Air in Ice Water System

By Charles J. Johnson

I inclose herewith a blueprint of an ice-water system that is giving considerable trouble by mixing air with the water, causing it to become milky. As very few people know the real cause of this color, I am troubled with constant complaints.

I have thought out a remedy for this in the following manner. Put an air trap on the supply pipe A, or disconnect the line at this point and put in a direct line from the tank. Either one or both can be done, if necessary, but would like to hear from Power readers first.



Piping Diagram of System

Purging the Absorption System

By H. Westergaard

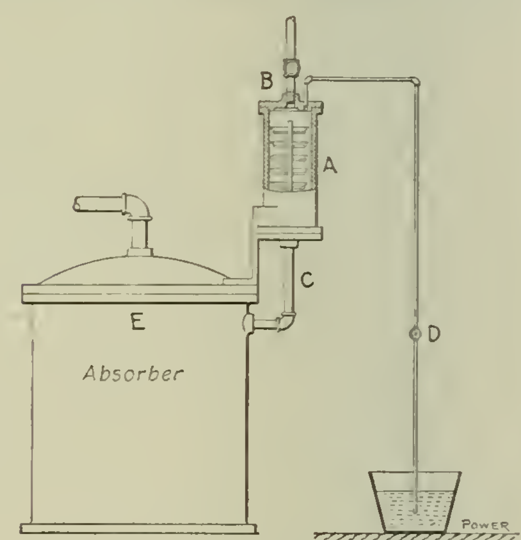
To get the best possible results from an ammonia-absorption system, the foul or permanent gases collecting in the top of the absorber must be drawn off at regular intervals. A purge connection with a shut-off valve is provided at the top of the absorber for this purpose in all installations of this kind, and the usual way to proceed when purging is to submerge the open end of this connection in a pail full of water. Then the purge valve is opened slightly and the gases are allowed to escape through the water.

The permanent gases will rise through the water and escape into the atmosphere, as they are not absorbed by the water. Most of the ammonia vapor which is mixed with these gases is absorbed by the water. This water is generally thrown away and the ammonia absorbed in it lost.

To avoid this loss of ammonia the writer employs the apparatus illustrated herewith.

The poor liquor from the exchanger enters an upright cylinder A at B and runs down over a number of perforated pans suspended at equal distance through the length of the cylinder. The lower end is connected with the top of the absorber by a pipe C. The purge pipe is connected to the top of the cylinder and is provided with a valve. The gases collecting in the space E of the absorber flow through pipe C and in the cylinder come in contact with weak and cool aqua ammonia, which presents a large surface and rapidly absorbs the ammonia gas present. The foul gases being insoluble under the existent pressure flow to the top of the cylinder and may be removed through the purge pipe.

The apparatus above described has so far proved successful, and it is my belief that it will not only save ammonia but will furnish a lower absorber pressure than would be possible without it. Whether I am right the operation of the plant this summer will show.



Scheme to Avoid Loss of Ammonia

One of the few points of advantage of the absorption system over the other refrigerating systems is that it is better adapted to maintain low temperatures, but it can only accomplish this result if the absorber and other parts of the system are kept free from permanent gases.

Analyses have shown that the foul and permanent gases purged from an absorption system contain besides air some gases which have been formed by the decomposition of ammonia, and practical experience seems to indicate that this decomposition increases with the temperature in the generator or still. It is, therefore, of great importance to provide that part of the plant with an abundance of heating surface, properly distributed so that the temperature of the liquor in the generator can be maintained at a fairly low point when the machine is operating at its maximum capacity.

Spring Meeting Mechanical Engineers

It has been 27 years since the American Society of Mechanical Engineers last met at Pittsburg before the spring meeting of this year, which was held there from May 30 to June 2. The extensive mechanical interests attaching to Pittsburg and the large membership of the society in and about that city justified expectations of an especially profitable gathering which were fulfilled by the event. The attendance was large and the program replete with interest, excellently arranged and admirably carried out.

Those who arrived on Tuesday had an opportunity to inspect the Foundry and Machine Company exhibit installed in connection with the convention of the National Foundrymen's Association, which had taken place the previous week. In the evening an informal reception was held at the Hotel Schenley, during which President E. D. Meier was presented with an engrossed testimonial in commemoration of his seventieth birthday, the presentation being made by J. H. Woodbury, as follows:

"The flight of time is so noiseless that it requires anniversaries to mark its progress, and at a meeting of engineers in Boston a few weeks ago, it was remarked that you would have a notable anniversary on this occasion which ought to be recognized in a manner similar to that of the seventieth birthday of several of your associates and predecessors, and the matter was placed in the hands of a committee of your fellow members from various parts of this country.

"Your career has been indeed a notable one in its facility of doing many things and doing them well.

"In the service of your country in both cavalry and artillery, you became a part of movements of national history. In the reorganization of the militia of your State, you became a force in the maintenance of law and order.

"It is, however, in the greater victories of peace that we have come more closely in touch with your career as an engineer.

"You have been connected with the great cotton industry in making improvements in baling the raw material, in mill construction, and also that of the textile machinery which produces the finished product.

"In the great problems of transportation you have been connected with locomotive practice and railway management.

"The functions of the engineer as an economist have been wrought by yourself in the generation of steam and in the more radical innovations of the internal-combustion engine.

"But this recital of deeds well done is trite in comparison with that of the respectful tribute which we give to your sterling manhood which has endeared yourself to those with whom you have been associated.

"Accept, then, this engrossed testimonial briefly stating our felicitations; and this will be followed in due time by a folio containing the names of those taking part in this testimonial, and we ask you to give sittings to an artist whose portraiture will, I trust, be worthy of the subject."

The sessions were held in the auditorium of the Carnegie Institute, that of Wednesday morning being devoted to the subject of cement.

The Committee on Standardization of the society working in conjunction with a similar committee of the National Association of Master Steam and Hot Water Fitters, presented a schedule of standard-weight flanged fittings and extra-heavy flanged fittings. This schedule will be presented in an early issue.

In the afternoon the visitors were taken to the works of the Universal Portland Cement Company at Universal, and returning a visit was paid to the Westinghouse shops at East Pittsburg.

On Wednesday evening the session at Carnegie Institute was devoted to the machine shop, while the gas-power section held a simultaneous session in one of the halls of the Carnegie Technical Schools. The meeting took the form of a discussion of "Large Gas Power Plants," introduced by descriptions of their plants and relations of their experiences with them by F. A. Maccomb, superintendent of furnaces of the Edgar Thomson Steel Works; R. H. Stevens, mechanical engineer, Homestead Steel Works; A. N. Diehl, superintendent of furnaces, Duquesne Steel Works, and A. L. Hoerr, steam and hydraulic engineer, National Tube Works. Most of the speakers thought that a pause, if not a reaction, had been reached in the rapid development of the large gas engine, and that, even in industries where gas is available as a byproduct, its economic application will be found more limited than has been thought, although H. K. J. Freyn ardently championed the internal-combustion motor and maintained that its present superiority would be emphasized by the increasing cost of fuel. The proceedings of the gas-power section and the discussion will appear in detail in an early issue.

There was also presented at this session a paper describing some of the recent work of the Bureau of Mines, by S. B. Flagg and C. D. Smith. This was illustrated by lantern slides, and described the experiments made with a long combustion chamber having a Murphy stoker at one end, and from which gases are withdrawn each 5 feet of its length for analysis. This furnace and the experiments upon it have been made the subject of a recent bulletin by the Bureau of Mines and will be treated further in an early issue. Reference was also made to experiments now in progress wherein a producer is run at such a high temperature that its capacity is very much increased and by the use of proper fluxes the ash and clinker are melted and drawn off continuously as slag. The temperatures necessary for the formation of liquid slag are very favorable for the production of producer gas and in the tests already made the CO has generally been above 30 per cent. while the CO_2 has been well under 2 per cent. These percentages were obtained, however, with air alone, no steam being used. Frequently 2000 to 2500 cubic feet of gas per square foot of fuel bed have been produced per hour having a heat value of about 115 B.t.u. per cubic foot, thus giving an output of approximately 25 horsepower per square foot of fuel-bed area, and no attempt has been made to operate the producer at its maximum rate.

The local committee had prepared a special pamphlet dealing with the important large gas-engine installations in the vicinity and containing illustrations of those at Carrie Furnaces, the Edgar Thomson Steel Works, the Duquesne Works, the Mesta Manufacturing Company, the Cambria Steel Works at Johnstown, and the National Tube Works, opportunities to visit which were open to the visitors.

The first paper considered Thursday morning was that of Prof. Reid T. Stewart upon "Stresses in Tubes." The author gave the results of some investigations tending to show that the stresses in the wall of a tube exposed to external fluid pressure are of the same character as those in a column having ends fixed in direction.

Using the experimental results obtained in some previous tests upon the collapsing pressures of commercial steel tubing, he derived equivalent column formulas upon the assumption that the circumferential stress in a tubular annulus subjected to external fluid pressure is theoretically the same as that in a straight column with fixed ends, whose length is one-half the mean circumference of the tubular annulus. These formulas are

$$[illegible] \quad (1)$$

$$[illegible] \quad (2)$$

where S is the axial load on the column in pounds per square inch, l the length of the column, and r the least radius of gyration of the section. Formula (1) is applicable only to cases where the ratio $\frac{l}{r}$ is less than 221 and formula (2) to cases where this ratio is greater than 221.

Next came "The Purchase of Coal," by D. T. Randall. This paper is presented in the columns following this report.

"Energy and Pressure Drop in Compound Steam Turbines," by Prof. F. E. Cardullo gives a graphic method of taking into account the transfer of heat which occurs from the higher to the lower stages by friction, eddy, etc., causing a departure from the condition of constant entropy ordinarily assumed. Professor Peabody submitted a table for the same purpose.

In the "Pressure-Temperature Relations of Saturated Steam," Prof. Lionel S. Marks explains the recent work of Holborn and Bauman and deduces a modification of the Van der Waal formula which expresses the pressure-temperature relations very satisfactorily from 32 degrees to the critical temperature. The values of the pressures derived from this equation have a maximum difference from the best experimental values of about one-tenth of 1 per cent. in the range from 212 to the critical temperature (706.1 degrees Fahrenheit). Below 212 degrees the maximum difference is 0.196 per cent. at 50 degrees corresponding to a pressure of 0.00035 pounds per square inch.

The formula is

$$\log. p = 10.515354 - 4873.71\ T^{-1} - 0.00405096\ T + 0.000001392964\ T^2.$$

"A Pressure Recording Indicator for Punching Machinery" was a description by Prof. G. C. Anthony, of the application of the steam-engine indicator to the punch, obtaining diagrams showing the variation of pressure during the stroke, the maximum pressure for which punches should be designed, the point of maximum stress in the punching of plates, the advantage to be derived from the use of shearing punches, the effect of clearance between punch and die, etc. The lower die rests upon a piston, the pressure of which is communicated to that of the indicator hydraulically. One of the discutants thought that the stress could be taken upon a spring beam which would weigh it more directly.

On Thursday afternoon a portion of the members visited the National Tube Company's works at McKeesport, while the rest were taken by boat up the Monongahela river, calling at McKeesport on the return trip for the others. This excursion proved to be a grateful interim in a rather strenuous program, affording at the same time an opportunity for physical rest and social intercourse.

On Thursday evening a reception and dance was given by the local members in the new ball room of the Hotel Schenley which was hurried to completion for this occasion.

The session of Friday morning, although designated upon the program as a "steel works session," developed considerable interest from the power standpoint through a debate upon the comparative merits of gas engines and turbines for blowing purposes which occurred in the discussion of R. H. Rice's paper upon the "Commercial Application of the Turbo-Compressor, and Reciprocating Blast Furnace Blowing Engines," by Professor W. Trinks. We shall have more to say of this in a subsequent issue. Mr. Rice's paper is presented in this issue.

The concluding paper of the meeting was by Bathold Gerdan, of Düsseldorf, Germany, and George Mesta, and was presented by Herr Gerdan in person. It dealt with steam-hydraulic forging presses of which he is the inventor and which are manufactured in America by the Mesta Machine Works.

On Friday afternoon the visitors had the option of a visit to the Duquesne works of the Carnegie Steel Company or a trip to the Mesta Machine Company's works at West Homestead, both of which excursions were well attended.

A new feature in an American Society of Mechanical Engineers' program was a smoker, given in honor of the visiting societies by the Engineers Society of Western Pennsylvania in the Union Club. George H. Neilson, the orator of the evening, found no difficulty in making light of the rather heavy subject of crucible steel, and numerous speakers, including a local monologuist, together with an excellent quartet, brought out the funny side of engineers and engineering, and wrought the audience up to a condition of good fellowship which made an effective closure of the week's program.

Too much cannot be said of the work of the local committee. Every facility was placed at the command of the visitors for access to the many industrial and engineering attractions of which Pittsburg is the center, and every attention paid to their comfort and convenience. The ladies were kept busy with special receptions, luncheons, drives and visits, and for each of the principal trips an illustrated pamphlet had been prepared with details of the program for that event and descriptions of the principal things to be seen.

Although the selection requires conformation by the council, the expression in favor of Cleveland as the place for the next spring meeting was so unanimous that it is practically certain that the next year's meeting will be held in the "Forest City."

The total output of all the air-compressor plants employed on the Panama Canal work during the year ending June 30, 1910, was 7,227,203,513 cubic feet of free air and the average cost was 4.03 cents per 1000 cubic feet.

The Purchase of Coal*

By D. T. Randall

Large savings may be made in the boiler room along two distinct lines: First, by burning the fuel at the highest practicable efficiency; and, second, by choosing fuel of a character suited to the plant conditions.

The coals of the United States vary widely in character, some being high in fixed carbon and low in moisture, volatile matter and ash, while others are low in fixed carbon and high in other constituents. An analysis reported "as received" represents the composition of the coal just as it is delivered at the laboratory. An analysis reported on the "dry basis" represents the composition of the coal after having been dried for one hour at 105 degrees Centigrade in a special oven. Moisture is an inherent constituent of the coal and an increase in its percentage decreases the heating capacity of a given coal proportionately. This constituent is weighed and paid for on an equal basis with the combustible portion of the coal, and therefore its determination is of importance in ascertaining the value of coal.

The ash in coal is, like moisture, an inert constituent. It may be distributed in small particles in such a way as to make separation from the coal impossible, or some of it may be present in larger pieces, owing to carelessness in mining and preparation. An increased percentage of ash decreases the heating value proportionately and causes additional expense and loss in efficiency due to extra labor required to handle it. The fusibility of the ash governs the amount of clinker that will be formed and consequently some attention should be given to this feature.

The B.t.u. or heating value of coal determines its value as a fuel. When coals of the same character are under consideration the heating value may be taken into account as a correct measure of the value of the coal, but when coals of different character are to be compared, the character of the coal as well as the heating value must be considered.

There is often considerable variation in the quality of coals from the same district; this is due principally to impurities. On account of economy in mining and in marketing coal, it is common practice for one company to operate a number of mines and to ship coal from all of these mines to its customers. It is only rarely that coal is equally good in all the mines and, therefore, the customer will receive some good coal and some inferior coal.

The influence of volatile matter upon the efficiency depends on the design of the furnace. With a poor furnace and indifferent firing, coals containing about

*Abstract of paper read before the American Society of Mechanical Engineers.

18 per cent. volatile matter may give results 10 or 12 per cent. higher than coals containing 30 per cent. or more volatile matter. With furnaces adapted to the kind of coal burned, however, there is little loss of combustible gas.

The size of coal is important in many cases. If it does not coke and is fine, there may be considerable leakage through the grates when burned on stokers with inclined grates or on hand-fired grates at rates that require frequent breaking up of the fuel bed. The size of the coal also affects the economy with which it may be fired. If the coal is too large, more air is admitted than is necessary, and if the fuel bed cannot be increased in thickness to overcome this difficulty, there will be a loss of heat. If the coal is fine and the draft is very strong, some of it will be carried off the grate before it is completely burned. Fine coal which cakes and forms a porous coke may be burned with good efficiency. If the coal does not coke but packs closely on the fuel bed, it is difficult, if not impossible, to secure a uniform air supply at all parts of the bed and the combustion is poor, owing to an excess of air at some points and a lack of air at others.

Fuels considered without reference to any particular equipment may be valued on the basis of their available heating value. It has been found possible to design furnaces to burn almost any fuel with reasonably good efficiency when based upon the available heat of the fuel. This has been accomplished with tan bark, sawdust, lignite and low-grade coals. As a rule, inferior coals can be bought much more cheaply on their heating value than the higher grades of coal and it is to the interest of every consumer to select the coal which will give the greatest amount of heat for a unit cost, provided it can be burned successfully. In many cases it will be profitable to change the equipment so as to burn slack or coals which are below the average quality. It is fully as important to take into account the size and character of coal when automatic stokers are used as when the coal is hand fired.

The methods employed in burning coal are of equal importance with the quality and should be given careful attention. The coal dealer should not be held responsible for results in boiler plants except as influenced by changes in the quality of the coal delivered.

The manner in which a sample of coal is obtained is fully as important as the manner in which it shall be analyzed. It is only fair to both parties concerned that the sample should be obtained in the manner which will secure a small portion which is thoroughly representative of the entire lot.*

Selection of Coal

The problem of purchasing a supply of fuel for any given plant, so as to obtain coal that is suitable for the equipment in use and one that will deliver the greatest amount of heat to the boiler for each dollar expended, is one which requires experience and an intimate knowledge of the various kinds of equipment for burning coal, and also of the different characteristics of the coals available at reasonable freight rates. The following information should be considered by the engineer in deciding on the best coal for a plant:

a Kind and size of boilers and furnaces;

b Load conditions, average and maximum loads;

c Draft available and how controlled;

d Character of the coals offered or available;

- (1) Moisture and its effect on the weight of combustible matter delivered;
- (2) Volatile matter and its relation to kind of furnace;
- (3) The amount of ash, its fusibility and tendency to clinker;
- (4) The amount of sulphur and how combined;
- (5) Heating value in B.t.u.;
- (6) Coking qualities of the coal;

e Size of the coal;

- (1) Relation of the size of coal to the equipment.

Specifications for Coal

After it has been decided what kind of coals may be burned successfully in any given plant, it is important that the specifications be so drawn that it will be to the interest of the dealer to deliver the kind of coal which has been established as standard in his proposal and prevent the substitution of lower grades which might be difficult to burn with good results. It is evident that specifications based on the heating value alone will not do this and that there should be some clause making it possible to reject the coal, or to burn it and pay for it at a reduced price if the coal should fall below the requirements.

There has been much said for and against purchasing coal on a guaranteed analysis and, as is often the case, both sides are right but they are really discussing different things. A properly drawn specification protects the dealer who is prepared to furnish good coal in competition with dealers handling inferior coals at the same price. Where these specifications require the coal contractor to state the analysis of his coal which on acceptance of the bid becomes the standard for the contract, there need be but little variation in the price if the dealer is familiar with the analyses of the coal offered, and if the standard is based on average values the premiums and penalties for the year should practically balance each other. Many dealers have bid on impossible analyses and then blamed the specification plan for their losses.

A properly drawn specification providing for premiums for better coal than that specified, encourages the coal operators to exercise greater care in mining and in picking the coal before shipping, and enables them to secure a return on the cost of such preparation. Most consumers have found that it is not profitable to pay freight on an unnecessary amount of slate and ash in the coal.

The important items in a specification are as follows:

- *a* The amount and character of the coal desired;
- *b* Conditions for delivering the coal;
- *c* A statement regarding the disposition which will be made of the coal if it is outside the limits specified;
- *d* The corrections in price for variations in heating value, ash and sulphur, provided it is advisable to limit the percentages of ash and sulphur in the coal to be delivered;
- *e* A blank form on which the dealer may submit the price and the kind and quality of coal which he proposes to furnish.

This method of purchasing coal has already been adopted by many of the larger and more progressive consumers of coal. Its advantages are so clearly demonstrated to engineers thoroughly experienced in power-house practice that few who are in a position to purchase large quantities of coal are willing to do so without a guarantee as to the quality. With information as to the coal bed, the district and the mine from which the coal will be furnished and the guaranteed analysis, an experienced engineer can make a suitable selection of coal.

A contract based on a guaranteed analysis provides for a definite procedure in settling for variations in the quality of the coal delivered and avoids the necessity of devoting much time to personal arguments and correspondence regarding poor coal. If both the consumer and the seller are familiar with the technical points involved in the sale of coal on a guaranteed analysis, it will prove a fair method by which the purchaser pays according to the value of the coal delivered to him, and the dealer is reimbursed for any expense due to better preparation of the coal.

Th' other day I took a walk out near th' dynamo room an' knocked a bottle of belt dressin' offen th' gallery. It must have hit my pipe but I didn't notice it then. When I got back t' th' engine room I could smell it [illegible] all over th' place, but I couldn't find it an' began t' get scared. [illegible] got up [illegible] an' I knew [illegible] what th' trouble was.

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*Mr. Randall cited a method of obtaining a sample identical with that published in the May 23 issue of Power.

Commercial Application of the Turbine Turbo-Compressor*

By Richard H. Rice

The General Electric Company recently put in operation at the Oxford Furnace, N. J., plant of the Empire Iron and Steel Company, a turbine-driven air compressor for blowing the blast furnace.

The unit consists of a six-stage compressor operating at a normal speed of 1650 revolutions per minute and driven by a direct-connected four-stage Curtis steam turbine. The design is such that this normal speed produces a blast pressure of 15 pounds per square inch. The unit, however, is designed to regulate the volume of air delivered per minute so as to keep the rate of discharge constant at any value, determined by the furnace superintendent, within its capacity. The construction of this unit, as well as the method of regulation, was given attention in a description of the plant which appeared in the March 7, 1911, issue of Power so that the operation of the unit will be considered only.

Both turbine and compressor attain their best efficiency under similar conditions as regards rotating speed, making the combination a logical and efficient one. Under conditions usually met with in blast-furnace operation involving pressures of blast of 10 to 20 pounds per square inch, the efficiency remains sensibly the same. A curve of efficiency at varying volumes is shown in Fig. 1 and above this has been drawn a curve of speeds and pressures which, taken in connection with the first named curve, shows the variations of efficiency with pressure, at rated volume.

This latter curve shows graphically the variation of pressure with change of speed, which follows the law of squares; that is, doubling the speed gives four times the pressure, etc., from which it will be seen that only moderate changes in speed are necessary to give considerable changes in pressure. It is these changes in speed, increasing or decreasing the blast pressure, which are utilized to maintain a constant rate of flow of air into the furnace, against the varying resistances set up in the tuyeres and furnace by varying furnace conditions; as, for instance, clogging of tuyeres and changes in the size and composition of the charge, temperatures, etc.

The means by which these changes of speed are produced in the manner necessary to keep up a constant rate of influx of air per minute was fully described in the previous article.

At the time this blowing unit was put in operation, it was not expected that the volume of air required by the furnace would be at such a low figure as turned out to be the case, the machine having been designed for a normal volume of 22,500 cubic feet per minute. On putting the machine on the furnace, it was found the volume required was only about 15,000 cubic feet per minute and the pressure corresponding to this volume under furnace conditions ranged from 10 to 12 pounds. Under these conditions, it was found that pulsations were met with in the pressure

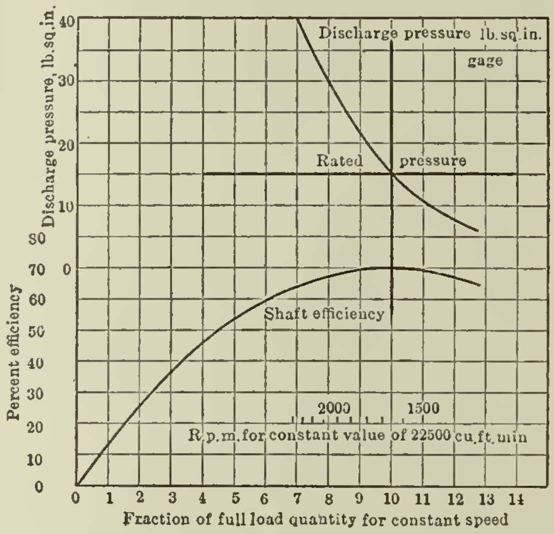


Fig. 1. Efficiency and Pressure Curve with Constant-volume Governor

line, this pressure fluctuating about 2 pounds, and in order to overcome this pulsation it was found necessary to throttle the inlet opening. Since this time, a convenient butterfly valve-throttling mechanism has been designed and applied, which is found to eliminate these pulsations without appreciable loss of efficiency.

The pulsations in pressure above noted are an inherent characteristic of all centrifugal blowing apparatus of similar construction, and they occur when the apparatus is operated at loads and pressures widely differing from those for which the apparatus is designed; that is, from normal full volume and pressure. At any given volume they occur at a certain critical pressure and at all higher pressures, but do not occur at lower pressures than the critical. As volume is increased, critical pressure increases also. The critical pressure is slightly affected by the density and the humidity of the air.

Fig. 2 gives the characteristic critical pressure-volume curve of this compressor.

Fig. 3 is the curve of pressure and volumes for this compressor at constant speed.

At the time this was written the blast pressure at Oxford Furnace varied from 10 to 14 pounds during the day with volume constant at 16,000 cubic feet per minute. The speed varied from 1500 to 1600 revolutions per minute. The average steam pressure was 135 pounds.

The figures in Table 1 are taken from a typical station log, showing the variation of pressure and volume during the 24-hour period of operation.

The apparatus used for blowing the furnace before putting this machine into operation consisted of two vertical reciprocating blowing engines built by the I. P. Morris Company, each of the following dimensions: Steam-cylinder diameter, 54 inches; blowing-cylinder diameter, 72 inches; stroke, 72 inches. Blowing-cylinder displacement, 339 cubic feet per revolution each. Maximum speed rating, 30 revolutions per minute each, giving 20,300 cubic feet per minute total displacement. Actual maximum speed, 23 revolutions per minute each, giving 15,000 cubic feet per minute total displacement. The average blast pressure was 8 pounds.

Judging from the revolutions of this engine, it was thought that the volume used was about 14,500 cubic feet. On putting the centrifugal compressor into action, an immediate increase in the

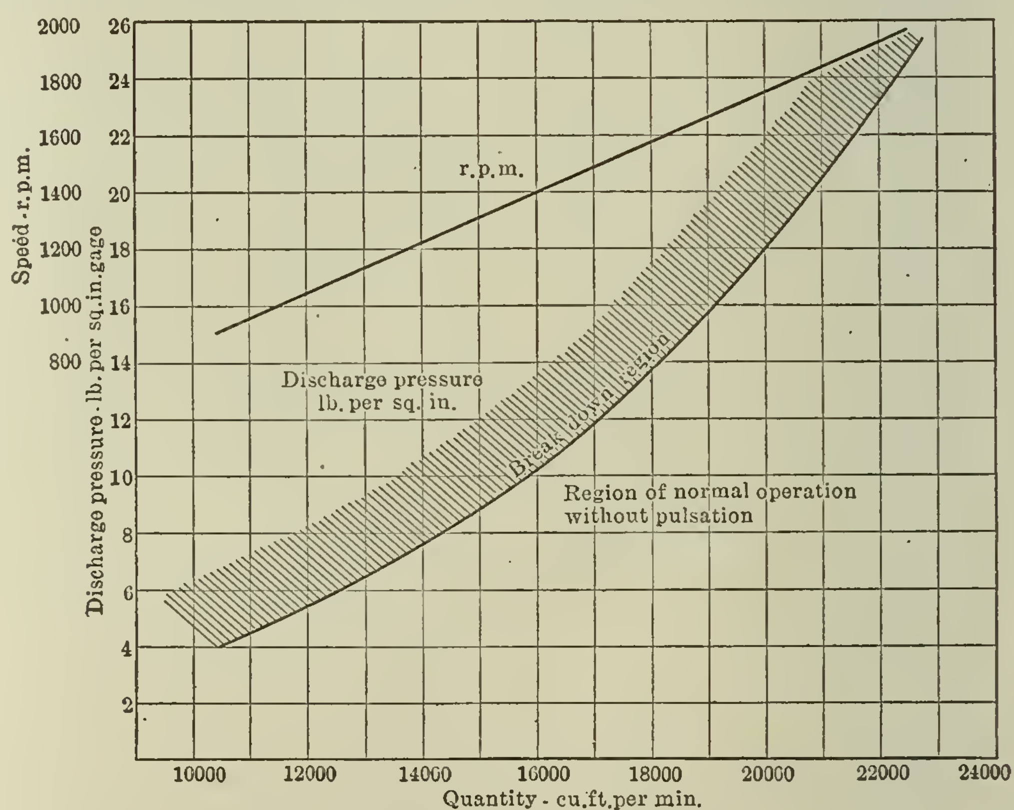


Fig. 2. Curve of Breakdown Points from Factory Tests

*Abstract of paper presented before the American Society of Mechanical Engineers.

amount of iron melted by the furnace was experienced. The output went up from an average of 139 tons per 24 hours in February, 1910, to 176 tons in April, 1910, and the iron was found to be of a more uniform character and the operation of the furnace was improved. A gradual increase in the amount of air has since taken place and the corresponding increase in pressure required to force the air through the furnace has been necessary as was to be expected. This increase of air has resulted in an increase in the production of the furnace from 176 tons on starting to the present average of about 190 tons. The machine is now operating with 16,000 cubic feet of air and the production of ore is 185 tons per 24 hours average. It is proposed to continue this increase to 200 tons per 24 hours, the limit of the charging apparatus.

The dimensions of the furnace are as follows: Diameter at bosh, 17 feet 6 inches; at hearth, 11 feet; at top throat, 12 feet; hight from hearth to dumping ring, 80 feet.

The condensing apparatus is of the barometric type. This was described, however, in the March 7 number.

TABLE 1. ENGINE ROOM REPORT, MARCH 17, 1910

Empire Iron & Steel Company, Oxford Furnace, N. J.

Time	Volume, Cu. Ft.	Blast Pressure, Lb.	R.p.m.	Steam Pressure, Lb.	Vacuum, In.
a.m.					
1	15,750	13	1,840	140	24
2	15,750	12.5	1,430	155	24
3	15,750	14.5	1,800	145	24
4	15,750	12	1,810	140	24
5	15,750	13.5	1,350	150	24
6	15,750	13	1,806	150	24
7	15,750	12.5	1,806	150	24
8	15,750	12	1,490	150	[illegible]
9	15,750	11.5	1,549	150	[illegible]
10	15,750	13.5	1,960	160	26
11	15,750	12.5	1,820	145	25
12	15,750	12.5	1,480	150	26
p.m.					
1	15,750	13	1,550	145	26
2	15,750	12	1,480	150	26
3	15,750	14	1,480	150	26
4	15,750	15	1,860	150	26
5	15,750	11	1,182	140	26
6	15,750	11.5	1,450	150	26
7	15,500	11	1,490	145	26
8	15,750	12	1,770	150	26
9	15,750	12.5	1,560	150	25.5
10	15,250	11	1,560	140	25
11	15,750	11.5	1,840	140	25.5
12	15,750	11.5	1,440	145	25

Made [illegible] tons of iron in 24 hours.

Owing to the fact that the condensing apparatus is of the barometric type, the further fact that the machine is operating far below its designed capacity and the difficulties involved in making an accurate boiler test to determine the amount of feed water under present conditions, no tests have been made to determine the actual efficiency of the machine. It is, however, furnishing considerably more air than the old machines, as is evidenced by the greatly increased product of the furnace, and is at the same time operating with fewer boilers. Also these boilers are more easily worked than when operating with the engine.

There is great difficulty in making comparisons of the performance of this type of blowing unit with reciprocating types, either steam or gas driven, owing to the absence of actual test figures, since none have been published which permit of accurate and satisfactory comparison. With the results which have been obtained from all sources as to the actual performance of such machines and from actual experience with this machine and its sister machine installed at the Northern Iron Company, in line with tests which have been made in the factory, it seems that the following conclusions are correct in reference to this apparatus as compared with reciprocating engines for blowing blast furnaces:

That the output of the furnace is increased on account of the greater steadiness of operation and more uniform conditions obtaining in the furnace.

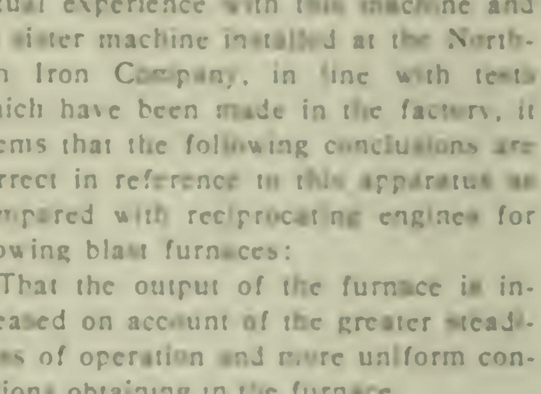


Fig. 3. Factory Test, Showing Pressure Plotted against Quantity of Air

That the quality of the product is improved.

That the steam consumption is equal to, or less than, that of the best compound engines blowing similar furnaces.

That the engine-room space occupied is only a fraction of that needed by reciprocating engines, either steam or gas.

Considering all factors, including consumption of fuel; cost of operation, including oil and supplies, attendance, etc.; cost of buildings and foundations, interest on the investment, and cost of maintenance of plant; that the centrifugal compressor is a blowing apparatus which can be operated for a lower net cost than any other means of blowing furnaces.

A power-transmission plant is being erected at Lauchhammer, Germany, designed to generate current for transmission at a pressure of 110,000 volts, which is stated to be the highest voltage used for power transmission in Europe. The current transmitted is three-phase; the generator pressure is 5000 volts, which is transformed up to the transmission voltage by four transformers, each of 5000 kilowatts capacity.

Milwaukee's License Law

That persistent agitation on the part of progressive engineers in all parts of the country for the enactment of license laws and ordinances is not fruitless is proved by the action of the Common Council of Milwaukee, Wis., which recently passed an ordinance making it unlawful for an unlicensed person to have charge of any portion of any steam-power plant exceeding 10 horsepower except locomotives, engines and boilers in the civil service of the city, State or Federal Government and boilers used for heating in which the pressure is less than 15 pounds per square inch.

It is provided that the mayor shall appoint a chief examiner who may select an assistant, the two constituting a board of examiners all of the time of which shall be spent in examining applicants for license, inspecting boilers and engines and in discharge of such other duties as may be prescribed by the ordinance.

To be eligible for examination an applicant must be 21 years of age; of good moral character; temperate habits; be vouched for in writing by two citizens of Milwaukee and have had not less than two years' experience as a machinist, oiler or fireman in the construction or operation of steam engines or boilers.

Licenses are of three grades and are based on a rating of 12 square feet of heating surface per boiler horsepower. First-class licenses are unlimited as to horsepower; second-class licenses permit the operation of plants up to a capacity of 300 horsepower, while the holder of a third-class license is limited to the operation of 75 horsepower. But one engineer may act as assistant to another holding the next higher grade of license. Special licenses without examination may be issued to engineers operating the plants in which they are employed provided that they have been in charge for the six months next prior to the passing of the ordinance. Transfers of special licenses from one plant to another may be made at the discretion of the board.

All engines, boilers and auxiliary apparatus are directly under the jurisdiction of the board, are subject to periodical inspection, whether insured or not, and all engineers are required to notify the board of any defect in any and every detail. Appeal may be taken from any decision made by the board to a board of arbitration [illegible] whose shall consist of three practical engineers of at least 10 years' experience.

Provision is made for the operation of steam plants by unlicensed men in cases of emergency and many details are left to the discretion of the board of examiners. When not engaged in the actual work of inspection, the board will hold daily sessions from 8 a.m. to 10 a.m. for the purpose of examining applicants for license.

It was the intention of the Common Council to give the city a rational license and inspection ordinance which, administered in the spirit if not in the exact letter, will benefit the engineer, the owner and the public by eliminating the incompetent engine runner and the unsafe boiler.

In one particular the board of examiners is allowed no discretion. It is mandatory that the board see that each and every boiler plant in the city is at all times during its operation in charge of a duly licensed engineer.

Ohio Board of Boiler Rules

Following the example set by Massachusetts the legislature of Ohio has passed a bill creating a Board of Boiler Rules, consisting of the chief examiner of steam engineers, as chairman, and four members appointed by the governor. Of these four it is intended that one shall be an employee of the boiler-using interests, one from the boilermaking interests, one from the boiler-insurance interests and one an operating engineer, but the governor may at his discretion make these four appointments from any class of citizens.

With the exception of boilers of railroad locomotives, portable boilers used in pumping, heating, steaming and drilling in the open field, for water, gas and oil, and portable boilers used for agricultural purposes, and in construction of and repairs to public roads, railroads and bridges, boilers on automobiles, boilers of steam fire engines brought into the State for temporary use in time of emergency, boilers carrying pressures of less than 15 pounds per square inch, which are equipped with safety devices approved by the Board of Boiler Rules and boilers under the jurisdiction of the United States, all boilers in operation in the State must be inspected at intervals not exceeding one year.

Rules for the construction, installation, inspection and operation of boilers, for ascertaining the safe working pressure, for the construction and sizes of safety valves, locations for fusible plugs, and other appurtenances are to be formulated by the board.

Public hearings on complaints, recommendations and for the examinations of inspectors will be held quarterly and at such other times as may be necessary. Changes in the rules may be made after any hearing, such changes being subject to a further hearing which shall have been duly advertised. All changes in the rules which affect the construction of boilers become operative six months after being approved by the governor.

Boilers of special design may be installed by permission of the board if after an examination of the drawings and specifications such boilers are deemed safe. The chief examiner of steam engineers is *ex-officio* chief inspector of steam boilers and is authorized to appoint, with the approval of the governor, an assistant inspector and ten general inspectors for service in the different districts into which the State is divided. He may also appoint as special inspectors employees of any company authorized to conduct boiler insurance and inspection business in the State, provided such employees have passed the examination required by the Board of Boiler Rules.

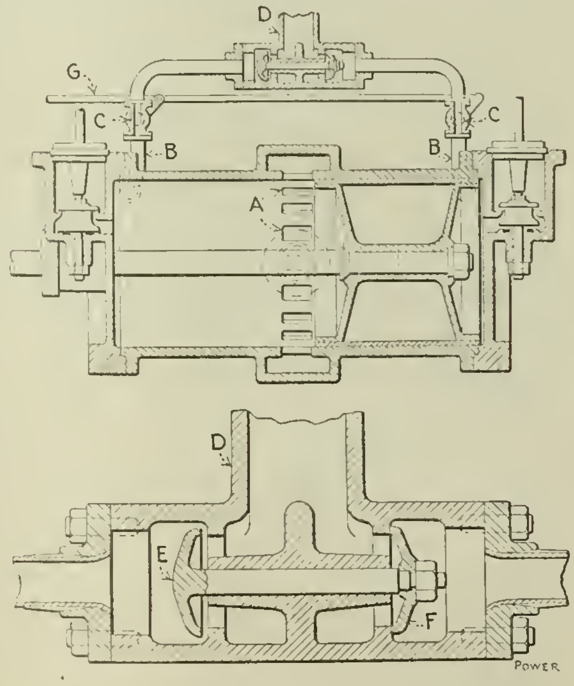
By a system of fees for boiler inspections and for the examinations of applicants for certificates of general boiler inspectors the department will be partially self-supporting.

Punishment by fine or imprisonment or both for the violation of any of the rules of the board by the owner, user or operator of boilers is provided for in the bill which makes the rules of the board operative on January 1, 1912.

In creating the Board of Boiler Rules the legislature of Ohio has closely followed the Massachusetts precedent and it is confidently expected that the same salutary effects will result that have obtained in the latter State in the elevation of the standard in boilermaking.

Stumpf Auxiliary Exhaust Port

In the operation of the uni-directional-flow steam engine of Prof. Johann Stumpf it has been found that the compression at starting and during overload periods is sometimes excessive and to remedy the effect of which an auxiliary exhaust valve has been designed.



Stumpf Auxiliary Exhaust Valve

To each end of the cylinder there is attached a pipe *B* leading to the valve box *D* and controlled by a cock *C*. In the valve box there are two valves, *E* and *F*, mounted on a common spindle.

Under ordinary working conditions the cocks *C C* are closed, but if for any reason it is desired to reduce the compression they may be opened by means of the rod *G*.

With the cocks open and the piston traveling toward the left, steam will be admitted to the valve box and the pressure will close the valve *F* and open *E*. This allows the steam to escape until the compression is high enough to close it or until admission takes place and it is closed by the pressure of steam from the boiler. When the other valve opens the process is repeated at the other end.

PERSONAL

H. J. K. Freyn has resigned his position with the Illinois Steel Company to take charge of the gas-engine department of the Allis-Chalmers Company.

Tom Oakes, who has been identified with the valve interests for the past thirty years, is now connected with the New York office of the Nelson Valve Company.

Reinhard Kunz, who is well and favorably known among the engineers of Wisconsin, has been appointed by the mayor as chief of the board of examiners of engineers for the city of Milwaukee.

SOCIETY NOTES

The Engineers Blue Club of Jersey City will hold its annual outing at Eitners park, Staten Island, on July 9.

On May 26, the American Institute of Steam Boiler Inspectors held a meeting at the United Engineering Societies building in New York City. The major part of the evening was devoted to mechanical topics. J. S. Lane, of the Engineer Company, read a paper on "Combustion and Balanced Draft," which was followed by a lively discussion. F. L. Johnson spoke forcibly on the value of thorough inspections to the engineer in particular and to the public generally. James Winters read a paper on the physical and mental qualifications required to make a successful inspector and pointed out that this field was no place for weaklings. The next meeting of the society will be held at the same place on the last Friday of September, when the regular monthly meetings will begin and be continued throughout the season.

That there is considerable water power in Iceland is denoted by the following announcement: Two English experts have recently visited Iceland in order to survey the large Dettifoss fall, on the river Iökulsa, which is calculated to have a capacity of 60,000 horsepower. Another less known fall, the Vigaberg fall, is estimated to have a capacity of 50,000 horsepower.

New Jersey State N. A. S. E. Convention

The twentieth annual convention of the New Jersey State Association of the National Association of Stationary Engineers took place at Newark, May 2, 3 and 4. There was an exceptionally large attendance of delegates, and at the many sessions considerable important business was transacted. The meetings were all held in the new auditorium.

On Friday at twelve o'clock the exhibition hall in the new auditorium was opened with a short address by Mayor Jacob Haussling. He welcomed the engineers and their guests to Newark and congratulated the convention upon the splendid exhibit of the supplymen. More than seventy booths occupied the main hall, which was neatly decorated, and the display was by far the largest in the history of the New Jersey State Association.

The first session of the delegates was called to order on Friday afternoon, at half past two, by Past State President J. C. Savage, who welcomed the delegates and their friends to the city. Mr. Savage then introduced Harry D. Cozens, one of the organizers of the national association and its first national president, who spoke interestingly of his past experience in the National Association of Stationary Engineers, and concluded his remarks by congratulating the New Jersey State Association upon its progress. It was in the engine room of Mr. Cozens, in the court house at Providence, R. I., in the year 1879, that the National Association of Stationary Engineers was organized. He is now chief engineer of the court house at Newark, N. J. After the appointment of the necessary committees, the several reports were read and adopted, the secretary's report showing the organization to be in a healthy financial condition.

Exhibit Hall at New Jersey State Convention

On Friday evening a most enjoyable entertainment was given in the exhibition hall, in which the "Bunch" participated. The program was arranged by Frank Martin.

On Saturday evening a banquet was given at the Continental hotel, which was largely attended by the ladies. F. L. Johnson officiated as toastmaster and introduced the following gentlemen, who made brief and instructive addresses: John H. Donnelly, president of the common council; W. J. Reynolds, past national president; Edward H. Kearney, national vice-president; E. W. Sears, State president; Assemblyman Michael J. McGowan; Joseph F. Carney, past national president; A. L. Case, State deputy; John J. Callahan, past State president. The speeches were interspersed with vocal and instrumental music.

At the Sunday morning session the delegates listened to an able address by National Vice-President Edward H. Kearney, after which the officers for the ensuing year were elected as follows: Edward W. Sears, Newark No. 3, past president; William Krouse, Passaic No. 11, president; Martin J. Hickey, Jersey No. 1, vice-president; Charles Sievers, Hoboken No. 5, treasurer; Thomas A. Brown, Newark No. 3, secretary; Thomas J. MacMeran, Paterson No. 2, doorkeeper; Thomas Heath, Elizabeth No. 14, conductor; A. L. Case, Plainfield No. 12, chairman of license committee.

The New Jersey Delegation to the State Convention

Newark was again chosen as the place for holding the next annual meeting.

The following firms had exhibits:

Acheson Graphite Company, American Steam Gauge and Valve Manufacturing Company, V. D. Anderson Company, Ashton Valve Company, Cling-Surface Company, Couse & Bolten, Crandall Packing Company, James W. Crane, Crane Company, Cryer Return Line System Company, M. T. Davidson Company, Dearborn Drug and Chemical Works, R. & J. Dick, Dixon Cascade Pump Company, Engineers Blue Club of Jersey City, Garlock Packing Company; Greene, Tweed & Co., Greenpoint Fire Brick Manufacturing Company, Griscom-Spencer Company, Hampson & Marks (American Engine Company), Harrison Safety Boiler Works, Hewes & Phillips Iron Works, Home Rubber Company, Homestead Valve Manufacturing Company, Iron Works Company, Jefferson Union Company, Jenkins Brothers, The Henry Johnson Company, E. Keeler Company, Kennedy Valve Manufacturing Company, Keystone Lubricating Company, Lagonda Manufacturing Company, Jacob Levi Company, Lippincott Steam Specialty and Supply Company, Ludlow & Squier, Lunkenheimer Company, McLeod & Henry Company, W. B. McVicker Company, Macknet & Doremus Company, Morehead Manufacturing Company, Mutual Supply Company, Nathan Manufacturing Company, National Oil and Supply Company, Nelson Valve Company, Newark Brush and Scraper Company, New York Lubricating Oil Company, New York Belting and Packing Company, Norben Oil and Supply Company, Ohio Blower Company, Otis Elevator Company, Peerless Rubber Manufacturing Company, Philadelphia Grease Manufacturing Company, William S. Pitts Company, William Powell Company, POWER, Clement Restein Company, John A. Roebling's Sons Company, David C. Seymour, W. S. Sheppard, Simmons Pipe Bending Works, Millard F. Smith, C. E. Squires Company, Standard Oil Company, Standard Regulator Company, Strong, Carlisle & Hammond Company, Under-Feed Stoker Company of America, H. B. Underwood & Co., C. Yingling & Son.

Kentucky State N. A. S. E. Convention

After opening the ninth annual convention of the Kentucky State National Association of Stationary Engineers with prayer by the Rev. J. H. Young, C. E. Fertig, chairman of the convention committee, introduced Mayor W. O. Head, of Louisville, who delivered a warm address of welcome. Frederick L. Ray, State president, followed with the president's annual address, after which R. W. Brown, secretary of the Louisville Convention and Publicity League, spoke, his subject being "Our City." He enlarged upon the beauties and advantages of Louisville as a commercial, residence and convention center and greatly impressed the visitors with the hospitable words of welcome so characteristic of the native Kentuckian. Response was made by Osborn Monnett, of POWER.

F. W. Raven, national secretary, then spoke on "Our Order," outlining its aims and purposes and explaining to the mayor and visitors the high ideals which actuate the association in all its affairs. At the close of the morning session, W. L. Osborne, of Chicago, formally opened the exhibit with a few words of greeting to the delegates.

GROUP OF KENTUCKY ENGINEERS AT THE N. A. S. E. STATE CONVENTION

Owensboro was chosen as the place of next meeting, the new officers being as follows: John H. Oelze, of Owensboro, president; J. L. Shrode, of Hopkinsville, vice-president; J. L. Harpole, of Hopkinsville, secretary; Edward Kockenrath, of Louisville, treasurer; C. Carroll, of Louisville, conductor, and William Cummings, of Henderson, doorkeeper.

A smoker, tendered by the Central States Exhibitors' Association, was a social feature of the meeting, while on Saturday afternoon, after lunch at the Willard hotel, as guests of the Louisville Convention and Publicity League, the delegates and visitors were taken for an automobile ride, visiting the Louisville Lighting Company, the Louisville Railway Company power house and Cherokee park, this also being through the courtesy of the public-spirited citizens.

The meeting came to a close with the annual moonlight excursion on the Ohio river, given by Louisville National Association of Stationary Engineers association No. 1, a special invitation being extended to the visitors.

Exhibitors at the convention were as follows: Ahrens & Ott, Louisville, Ky.; V. D. Anderson & Co., Cleveland, O.; Andrew Cowan & Co., Louisville, Ky.; James Clark, Jr., Electric Company, Louisville, Ky.; Crandall Packing Company, Palmyra, N. Y.; Dearborn Drug and Chemical Works, Chicago, Ill.; Garlock Packing Company, Palmyra, N. Y.; United States Graphite Company, Saginaw, Mich.; Greene, Tweed & Co., New York City; Hawk-Eye Compound Company, Chicago, Ill.; Hills-McCanna Company, Chicago, Ill.; Home Rubber Company, Trenton, N. J.; Jenkins Brothers, New York City; H. W. Johns-Manville Company, Milwaukee, Wis.; Kentucky Consumer's Oil Company, Louisville, Ky.; Laile Company, Louisville, Ky.; Lunkenheimer Company, Cincinnati, O.; Lyons Boiler Works, De Pere, Wis.; Moran Flexible Steam Joint Company, Louisville, Ky.; E. D. Morton & Co., Louisville, Ky.; *National Engineer*, Chicago, Ill.; National Smoke Prevention Company, Louisville, Ky.; W. H. Neil Company, Louisville, Ky.; Osborne High-Pressure Joint and Valve Company, Chicago, Ill.; William Powell Company, Cincinnati, O.; POWER, New York City; *Practical Engineer*, Chicago, Ill.; J. J. Reilly Manufacturing Company, Louisville, Ky.; Standard Oil Company, Louisville, Ky.; Sterling Boiler Compound Company, Louisville, Ky.; Charles C. Stoll Oil Company, Louisville, Ky.; Henry Vogt Machine Company, Louisville, Ky.; Wickes Boiler Company, Saginaw, Mich.

The installation of a large electric-power station at Vemark, in the province of Telemarken, Norway, was started during the early part of May, the Rjukanfos, or Foaming, falls supplying the power for the machinery. This fall, which is one of the magnificent sights of Norway, has been changed so that now there is a straight drop of about 400 feet, where previously the drop was 800 feet. By this means 145,000 horsepower was made available.

POWER

Vol. 33 NEW YORK, JUNE 20, 1911 No. 25

THE engineer is prone to think that after he has once established an operating routine in his plant nothing special remains to be done in the way of increasing economy. That if he keeps his plant in good commercial shape and the bills run along about on an average it is evident the original economy is being maintained. Record keeping is irksome and as long as the plant expenses are about the same, month in and month out, he is satisfied.

But if he would dig deeper into his local conditions, know more about factors which surround him, he would probably find that there are circumstances in connection with his case of which advantage could be taken for obtaining an increase in efficiency.

Perhaps two engines are carrying the load when one will do the work more efficiently; an air leak in the setting may offset all efforts toward economical combustion; scale may coat the boilers sufficiently to prevent rapid transmission of heat, and there may be several other possibilities reducing the over-all efficiency of the plant—but why continue?

Record keeping will show up the fifty-seven varieties of little wastes, will absolve the furnaces from the sin of gluttony, and allow them to enjoy a normal, healthy, coal appetite—in fact, it will show how much money is being saved and what improvements or changes in the arrangement of the plant have been responsible.

It is in making a detailed study of the operating conditions that the greatest advantage of complete operating data is seen. Without them, if a change is made, how can it be known except in a general way what the effect has been?

Knowing things in a general way in this day and age does not get a man much in the engineering line. He must have specific information to show what he is doing and with records available, advantageous changes are frequently indicated which otherwise would remain in obscurity.

In other columns of this number is told the story of how a large saving was made by the simple expedient of shutting down the air compressor which controlled the thermostatic valves on the radiators of an office building.

This was not in a new plant where the routine was just being arranged, but in a plant which had operated for years at excellent economy and where a system of record keeping is in vogue that for completeness of detail probably cannot be surpassed in this country.

The saving realized here came about through the desire to take advantage of every opportunity for decreasing the coal bill.

Naturally, the light-load period is the time when energy costs most per kilowatt-hour and concentration of thought on the light-load period proved most productive, while with the operating records available it was possible to show just what the conditions were before, just what they were afterward, and just how much money could be placed on the credit side of the ledger.

This is a sample of the keen commercial instinct, the reducing of technical affairs to the dollar and cents standpoint, which mark the difference between the stopper and starter and the real engineer.

Pennsylvania Terminal Service Plant

By A. D. Blake

A plant of over 2500 boiler horsepower supplying the new Pennsylvania railroad terminal in New York city with light, power, compressed air, refrigeration and heat through an indirect system. During periods of no heating demand, electricity is taken from the Long Island power house.

One of the most important problems connected with the layout of the new Pennsylvania terminal station in New York City, was that of supplying service power, light, heat, etc.

The main power plant for the entire system is located at Long Island City, where the facilities for handling coal and the abundant supply of condensing water make it possible to generate electricity at a minimum cost.

While it would have been feasible to have supplied the passenger station with power and light from this source, there were other factors which had to be considered. Refrigeration was required in connection with the restaurant service; compressed air was necessary for the switching equipment and for the ejection of sewage; a high-pressure water system for fire protection was desirable; and most important of all, was the necessity of providing an adequate heating system. These, together with several other features, proved to be governing factors; hence it was decided to build and equip a service plant to meet the needs of the great terminal. The building also contains one of the railway substations supplying motive power to the trains.

According to the general scheme adopted, electricity for service light and power is generated during the winter months by noncondensing turbo-generators, the exhaust from which, together with that from the air compressors, pumps and other auxiliaries, is used for heating the station. During the summer months, however, when there is no heating demand, or at times when the exhaust from the compressors and pumps is sufficient to meet the demand, the turbines are shut down and electricity is taken from one of the 60-cycle machines at the Long Island power house. This arrangement also serves to guard against the terminal being without light and power should anything happen to the machines at either plant.

The service plant is located on Thirty-first street, opposite the station, with which it is connected by underground passages. The building is of steel and brick, faced at the front with granite to match the exterior of the station. It extends four floors above the street and three below. The street level is occupied by the boilers, the railway rotary converters and transformers and the various switchboards. The first level below the street contains the pump room and the direct-current switches; the second level the turbo-generators, air compressors, hydraulic-elevator pumps, ice machine and ash conveyer; and in the basement are located the sewage ejectors, ventilating fans for the service plant, part of the coal-handling apparatus, the storage battery and the refuse destructor. There is also an intermediate gallery containing part of the switch and bus structure. The floors above the street level are occupied by the economizers, the coal-storage bin, offices and store rooms.

Fig. 1. Service Switchboard, Alarm Switchboard and Exciters

Fig. 3. Exterior View of Service Plant

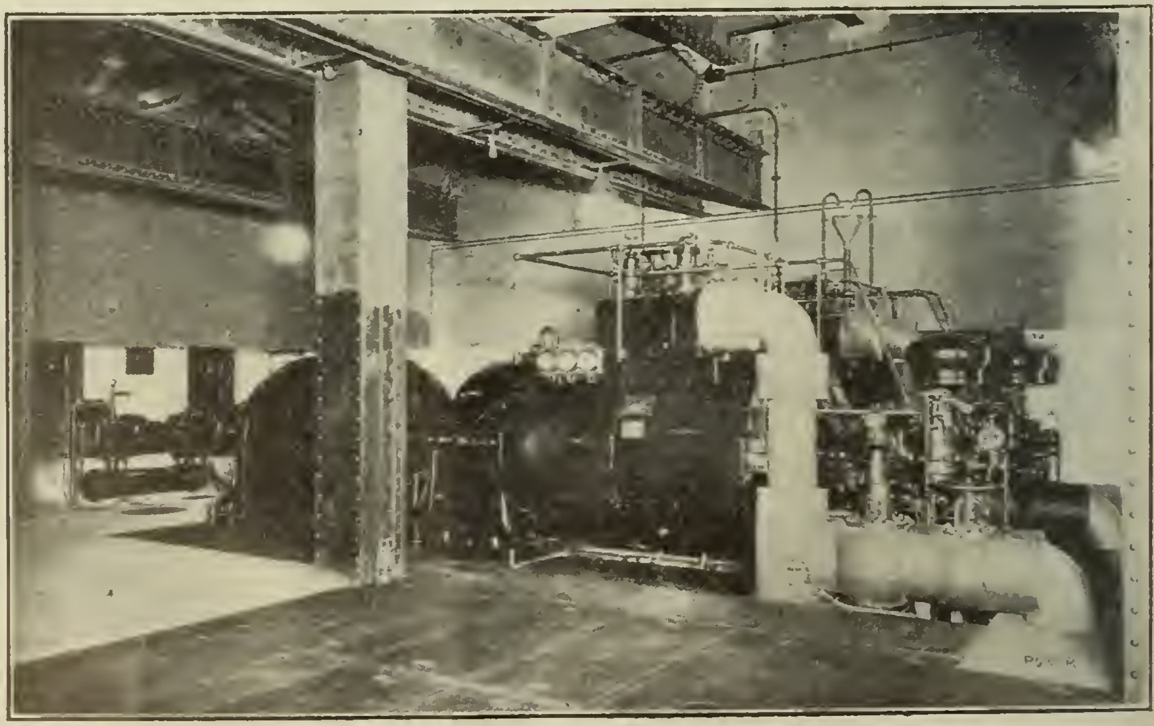


Fig. 2. Turbogenerators

Fig. 4 Direct-current Switchboard

Fig. 5. Main Heating and Circulating Pumps

Boiler Plant

Steam is furnished by five 525-horsepower Babcock & Wilcox boilers equipped with shaking grates and designed to carry a steam pressure of 200 pounds, although they are usually run at about 160 pounds. Space is provided for five additional boilers of the same size to be installed as the demand for steam increases. Owing to the plant being in the heart of the city and therefore subject to the smoke ordinance, it was found inexpedient to burn bituminous coal; hence No. 1 buckwheat coal was selected and hand firing employed.

A radial-brick stack, carried on steel framing, rises 50 feet above the roof and the supports were made strong enough to carry an additional 50 feet of stack should the erection of adjoining buildings make this necessary. At present the top of the stack is 127 feet above the grates and the natural draft is supplemented with forced draft furnished

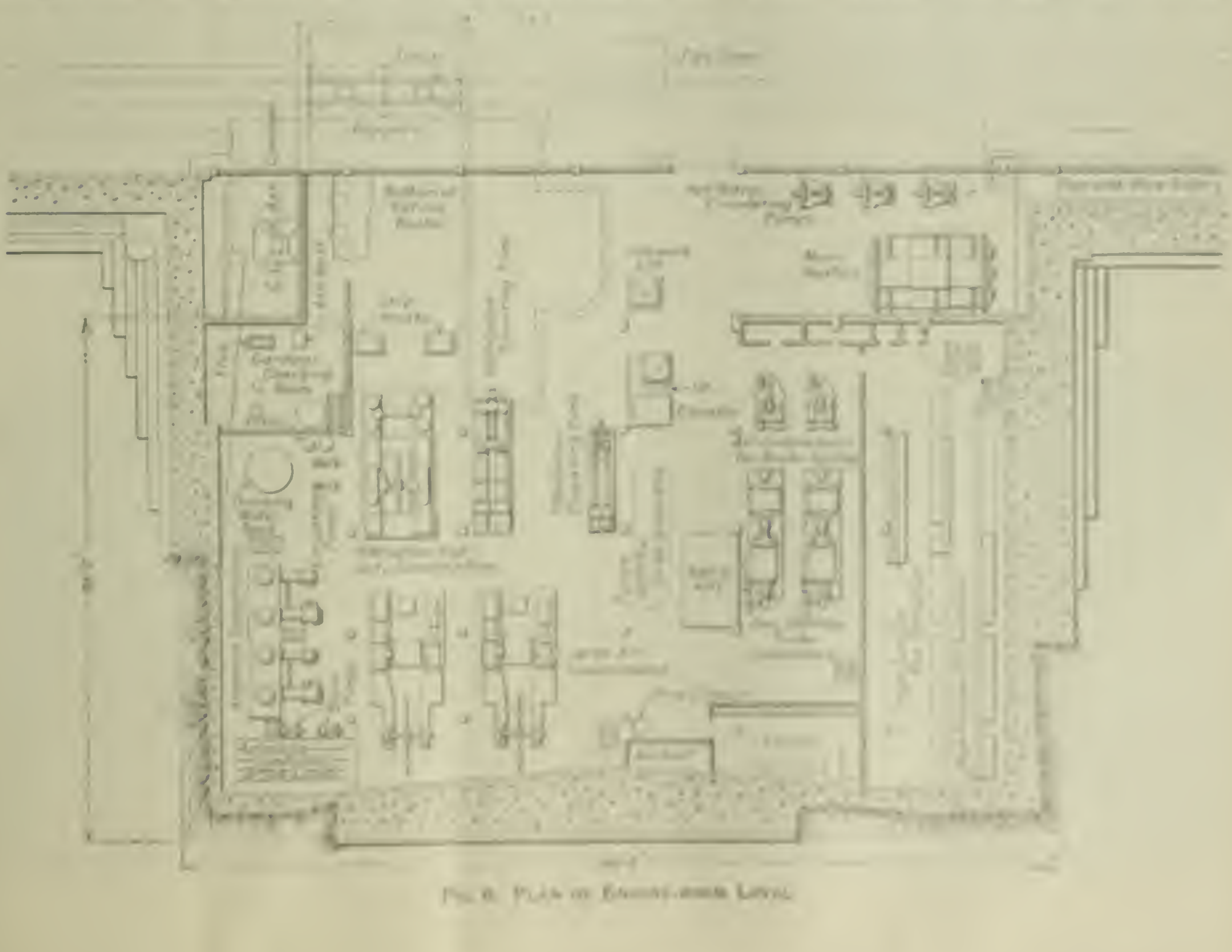


Fig. 6. Plan of Engine-room Level

by two Sirocco blowers direct connected to high-speed engines and capable of maintaining a pressure of 2½ inches of water in the ashpits.

The gases before reaching the stack pass through Green economizers, of which there are two, each containing 32 sections of 10 tubes.

The feed water is pumped from the hotwell to a feed-water storage tank of about 25,000 gallons capacity; from whence it is taken by the boiler-feed pumps and delivered to the feed-water heater, thence to the economizers where its temperature is raised to over 200 degrees Fahrenheit.

The heater is of the induction type and is located on a branch of the 18-inch line into which the auxiliaries exhaust.

The Holly system is employed to return the drips to the boilers.

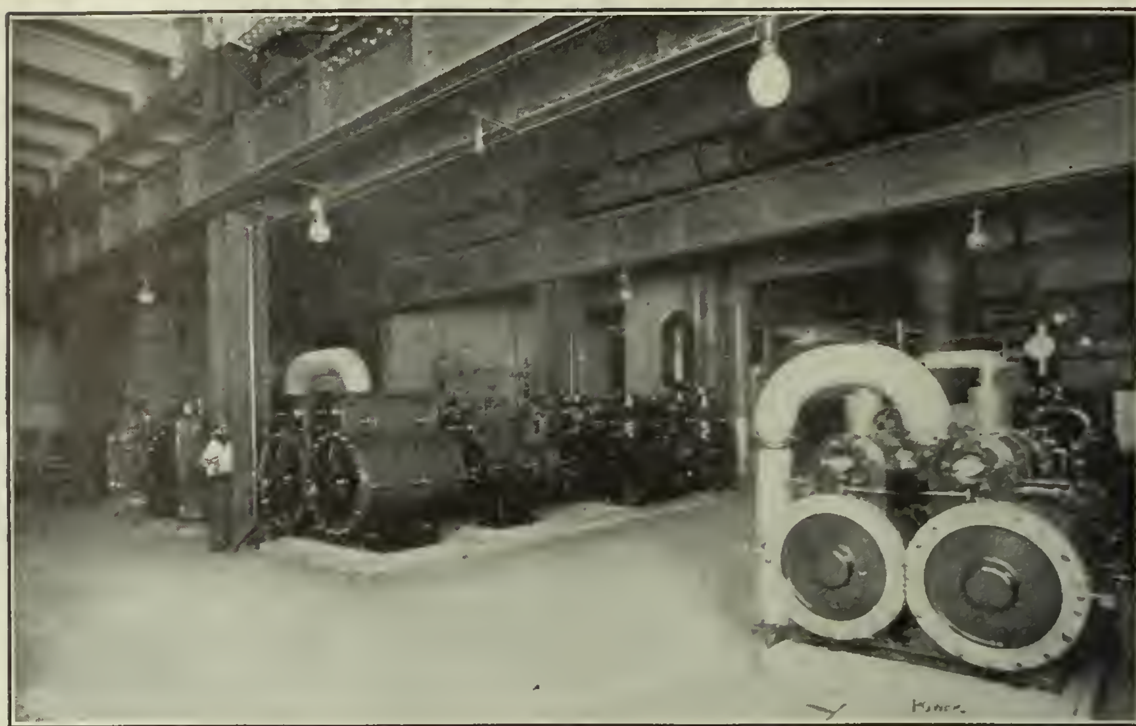


Fig. 7. Hydraulic Elevator Pumps

Coal and Ash Handling

Coal is brought to the service plant in cars over the Pennsylvania railroad and dumped from the track level, which is one level above the basement, into a hopper from which it is carried by a belt conveyer to two skip hoists. These lift the coal to the top of the building and discharge onto a motor-driven belt conveyer which distributes it along a storage bin of 1000 tons capacity located over the boilers. From here the coal is delivered through hoppers and automatic weighing scales to the floor in front of the boilers. A significant feature of the coal-handling apparatus is that, from the

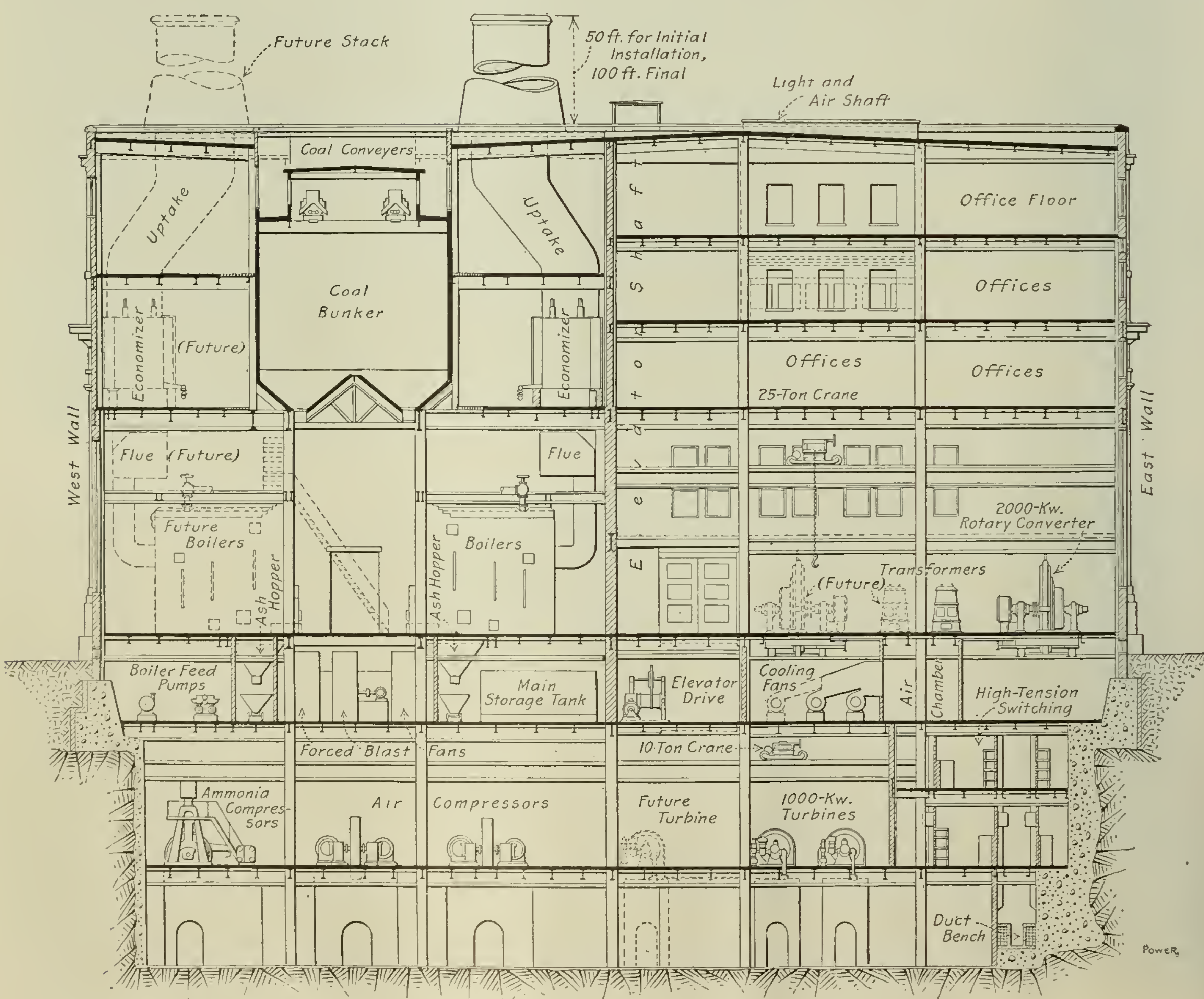


Fig. 8. Sectional Elevation Looking toward Front of Service Plant

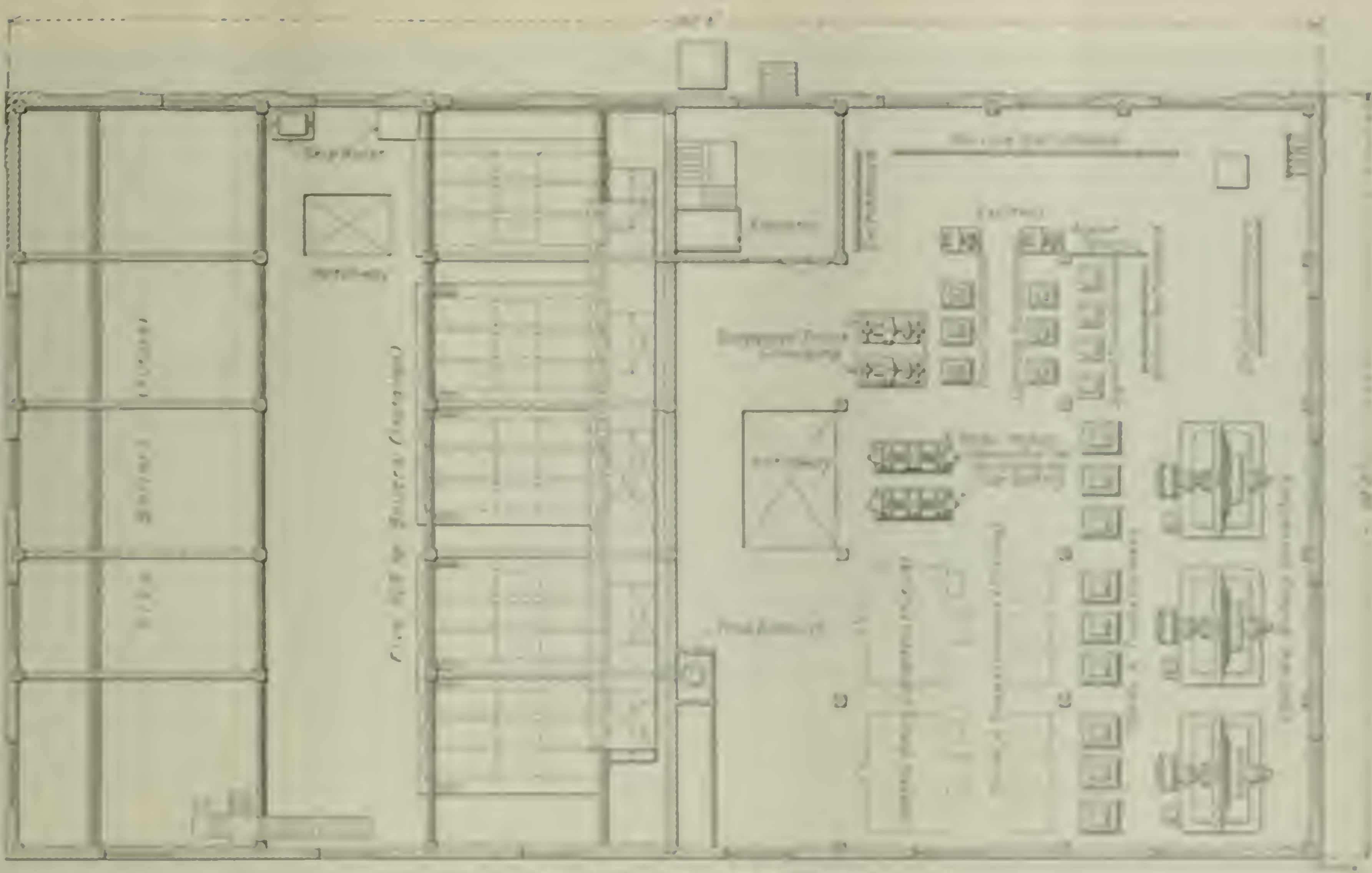


Fig. 11. Plan of Street Level

time the coal leaves the cars till it is in the bin, it is under the control of one man.

Under each ashpit there is a hopper through which the ashes are discharged into hand cars and wheeled out over a large reinforced-concrete storage hopper located under the sidewalk. This empties onto a belt conveyer which, in turn, discharges into gondola cars and the ashes are carried away over the same tracks upon which the coal is brought in.

Light and Power

Electricity for light and power in the passenger station, as well as the service plant itself (when not supplied from the Long Island power house) is furnished by two 1000-kilowatt Westinghouse-Parsons turbo-generators running at 1800 revolutions per minute and generating three-phase currents at 240 volts. The leads from these generators are carried to solenoid-operated switches, thence direct to the 240-volt busbars on the service switchboard. These connect with the lighting panels of the switchboard from which three-conductor cables lead to a number of subswitchboards located in various sections of the terminal. These, in turn, supply numerous panel boards from which the circuits are so arranged as to balance the load between the three phases. With the exception of a few tungsten lamps in the main waiting room and office hallways, the light is furnished by Nernst lamps. As a matter of general interest, it may be stated that there are over 100 miles of electrical conduit in the passenger station alone.

Power for the various motor circuits is at 420 volts. This is supplied through two banks of transformers (see Fig. 13). The circuit leads from the 240-volt busbars to one of the transformer panels, through a disconnecting switch to the primary side of one bank of transformers where the voltage is stepped up to 11,-

Fig. 9. Barriers of High-tension Switch Structure

Fig. 10. Coal Conveyer

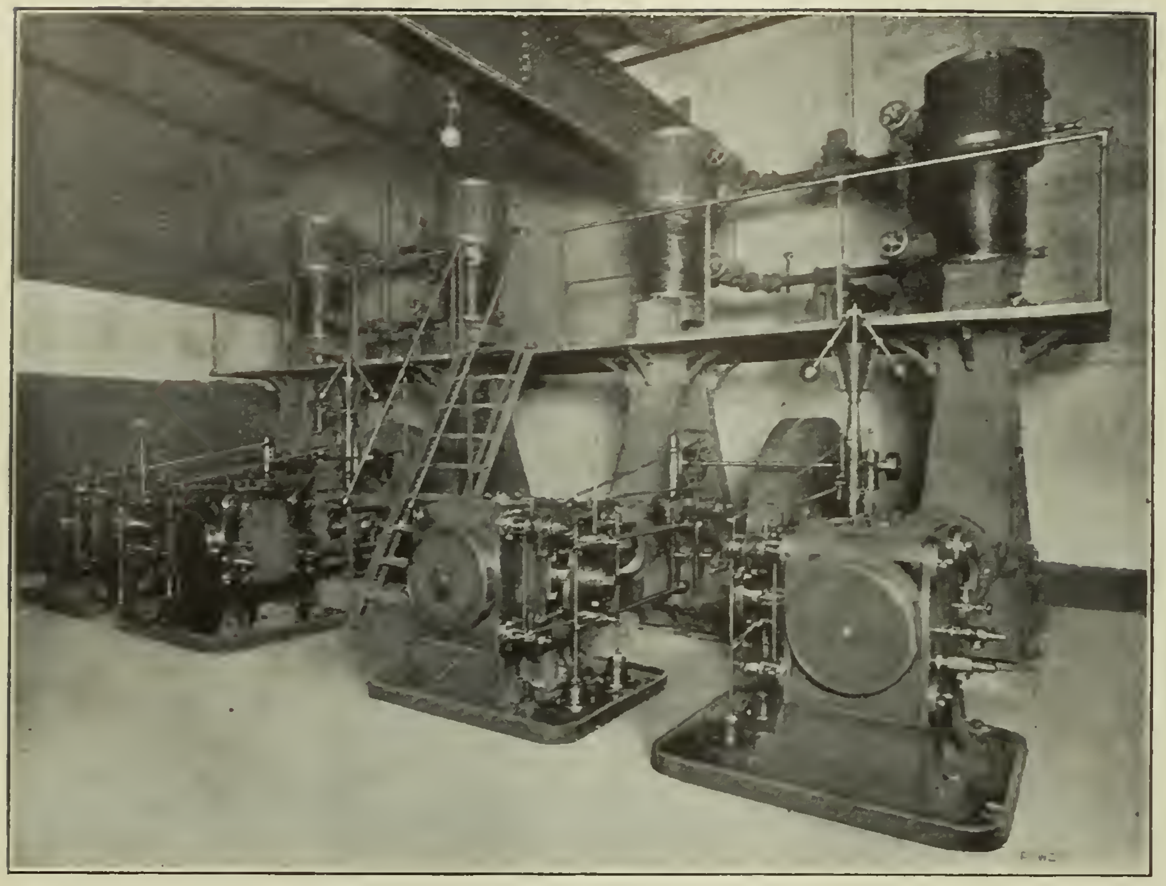


Fig. 12. Refrigerating Machines

000. It then passes over to the other bank of transformers where it is stepped down to 420 volts, and from here passes through another disconnecting switch to the 420-volt busbars; these supply the power circuits.

Although this arrangement may at first seem cumbersome, its flexibility becomes apparent when it is considered that during part of the year current is taken from the Long Island power house. This is brought over at 11,000 volts and after passing through the high-tension switching structure, the circuit ties in between the two banks of transformers; here it divides, part being stepped down to 240 volts for lighting and the remainder to 420 volts for power.

There are two motor-generator sets for furnishing excitation to the generators. A 60-cell 400-ampere-hour storage battery supplies excitation when starting the turbo-generators and also supplies emergency lighting circuits around the plant as well as the fire-alarm circuits.

Direct current for charging the motor-driven baggage trucks and automobiles is supplied by two motor-generator sets. The electric elevators and dumbwaiters are operated with direct current at 650 volts, taken from the rotary converters supplying the train motive power.

Air Compressors

There are three principal uses for compressed air about the terminal: the electropneumatic switching and signal system, sewage ejection and brake testing. Compressed air for the first two services is supplied by two cross-compound, two-stage Nordberg compressors, each having a capacity of 2000 cubic feet of free air per minute and compressing up to 90 pounds per square inch. There is an intercooler between the air cylinders and an atmospheric aftercooler located on the roof.

For testing the brakes on cars, however, a higher pressure is required and for this purpose two motor-driven compressors are provided. These have a capacity of 100 cubic feet of free air per minute and compress to 125 pounds per square inch. Their operation is entirely automatic;

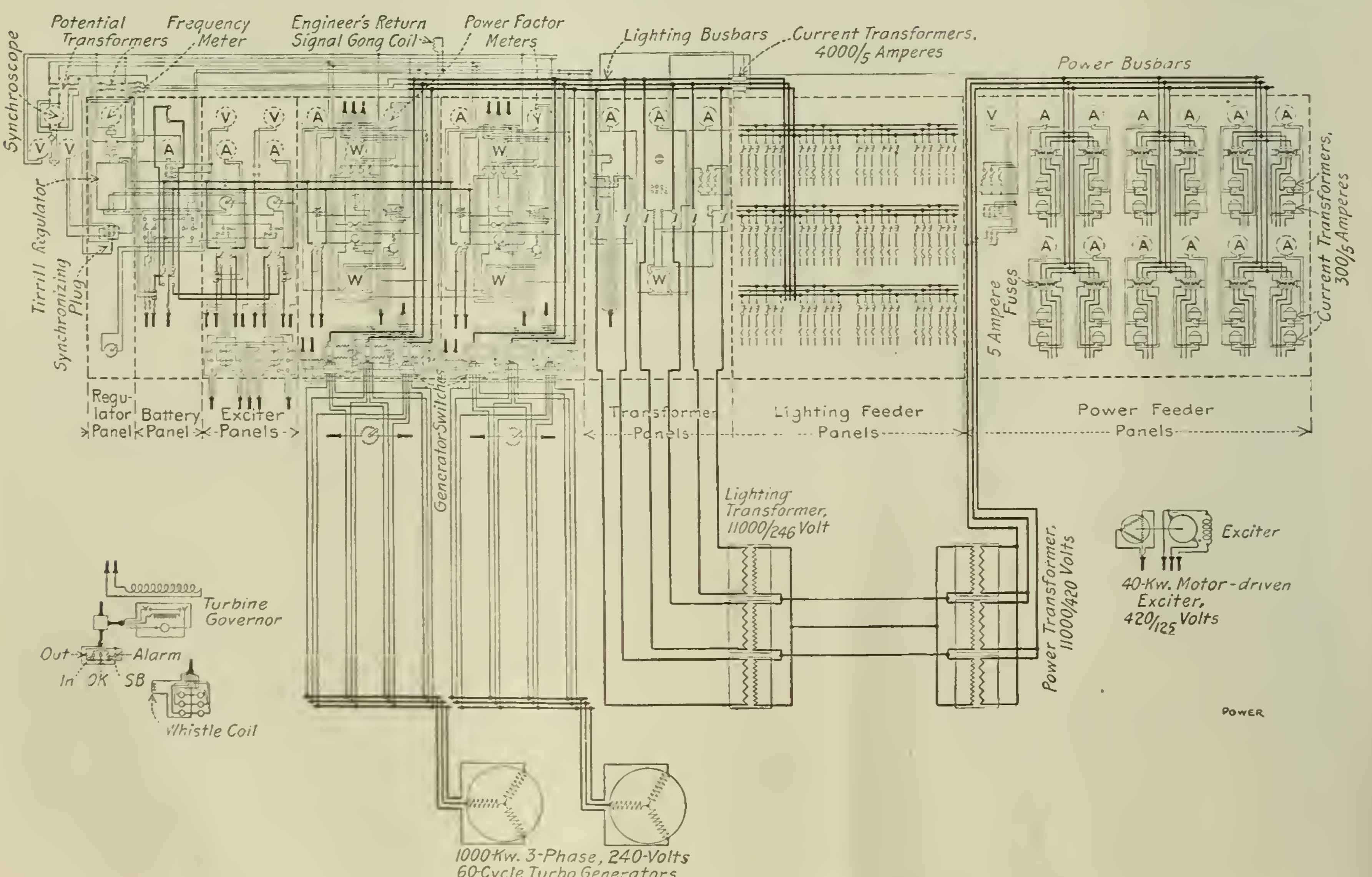


Fig. 13. Wiring Diagram of Service Switchboard

FIG. 14. MAIN AIR COMPRESSORS

If this compressor is unable to supply enough air to maintain the required pressure, the other is automatically started and continues until the upper limit of pressure is reached.

Air for the hydraulic elevator tanks is taken from the Nordberg compressors at 90 pounds and stepped up to 300 pounds by two railway air-brake compressors mounted on the wall just behind the large compressors.

HYDRAULIC ELEVATOR SERVICE

All the baggage lifts, twenty-one in number, and eleven of the passenger elevators are of the direct-acting plunger type, working at a water pressure of 300 pounds per square inch. These are supplied by three compound steam pumps, one a Heisler high-duty flywheel pumping engine having a capacity of 1500 gallons per minute; the second is a direct-acting pump of 1500 gallons capacity, and the third is of similar design but having a capacity of only 800 gallons per minute. The maximum load can be handled by operating one of the large pumps in connection with the small one. A 3000-gallon pressure tank, a 3000-gallon suction tank and a 5000-gallon surge tank form part of the hydraulic-elevator system.

REFRIGERATING SYSTEM

The refrigerating plant consists of two eighty-ton vertical single-acting York ammonia compressors, each having two ammonia cylinders and direct connected to a horizontal cross-compound Corliss engine. Calcium brine is circulated by centrifugal pumps through the cooling boxes in the kitchens of the station. The temperatures required in these boxes vary from 10 to 28 degrees Fahrenheit according to their contents.

Drinking water for the station is filtered and cooled in the service plant, before being circulated through the system.

HEATING SYSTEM

The station is heated by an indirect system. The exhaust steam from the compressor engines, elevator pumps, fire pumps, etc., is delivered through an 18-inch main to three closed tubular heaters having a total heating surface of about 17,500 square feet. A 30-inch exhaust-steam main also leads from the turbines to the heaters and provision is made for using live steam when the supply of exhaust steam is inadequate. The condensed steam from the heaters flows to the hotwell.

The heating water after passing through the heaters is circulated by motor-driven centrifugal pumps through a closed system of heating coils in the passenger station, over which fresh air is drawn by fans and circulated through the various rooms. The heating is regulated by varying the supply of steam to the main heaters, and any temperature of water up to 200 degrees may be obtained. The maximum air temperature obtainable is about 130 degrees.

In addition to the station heating considerable live steam is required for heating the switch cabins and the cars while they are in the station yard.

The total steam required during the month of March, 1911, was over twenty million pounds.

Every room in the terminal is ventilated by mechanically exhausting the air from it, there being in all 21 ventilating fans.

WATER SUPPLY

Water for fire protection is furnished by two steam-driven pumps, each having a capacity of 1200 gallons per minute. They are automatically controlled, taking water from the city mains and discharging at 150 pounds pressure. In order that they shall at all times be ready for service, they are kept running continuously at a slow rate, a small quantity of water being utilized for other purposes from the fire mains.

The water used in the kitchens of the restaurant is taken direct from the city mains while that supplying the drinking fountains throughout the station is first filtered and cooled in the service plant and then forced through the system by motor-driven centrifugal pumps. Water from the cooling jackets and coils of the air compressors and the refrigerating system is used for flushing the toilets.

A storage tank of 50,000 gallons capacity in the service plant is kept constantly filled to furnish an emergency supply, should the city supply fail.

All sewage is led to ejector tanks located in the basement and in the pipe tunnels; these are automatically emptied by means of compressed air into the street sewers.

All drainage in the service plant below the sewer level and the drips are led to a sump in the basement. This is periodically emptied by automatic float-controlled motor-driven pumps. Similar

FIG. 15. ROTARY CONVERTERS AND TRANSFORMERS

sumps are located in the pipe tunnels under the station and yard.

Substation

The substation, which is located in the service-plant building, furnishes motive power to that section of the electrified system which is within the vicinity of the terminal. Twenty-five-cycle, three-phase currents at 11,000 volts are generated at the Long Island power house; these are stepped down at the substation, converted to direct current at 650 volts and delivered to the third rail. Sixty-cycle, three-phase currents at 11,000 volts are also supplied and are stepped down to 420 and 240 volts for (alternative) service power and lighting and to 2300 volts for the primary circuit of the signal system. The substation equipment consists of nine single-phase 750-kilovolt-ampere air-cooled transformers, delta connected and supplying three 2000-kilowatt rotary converters. The latter are started by induction motors mounted on the same shaft with the rotor. These starting motors are supplied with power through a set of three transformers connected to the 11,000-volt line.

There are also three 11,000-2300-volt transformers which supply current for the train-signal system.

The high-tension switch and bus structure is of selected buff brick with soapstone barriers and cement slabs. All the oil switches are solenoid operated and are controlled from two switchboards on the main floor. There are two sets of busbars and the arrangement of switches is such that any feeder or section may be cut out for repairs without interfering with the rest of the equipment or interrupting the service.

The direct-current switches for the train feeders are all motor-operated and are located on the floor below the converters, although they are controlled from the same switchboard as are the high-tension oil switches.

In all, there are five switchboards, but these are arranged so that one operator can attend to them all.

At present the load is such that only two rotary converters are required to be in service at a time, the third being used as a spare; but space has been provided for three additional machines.

The entire plant was designed, built and equipped by Westinghouse, Church, Kerr & Co., of New York.

Analysis of Industrial Power Costs

By M. Oswald Jenkins *

The items chargeable to the cost of producing power in an isolated plant from the central-station viewpoint.

*New York Edison Company.

The cost of producing a unit quantity of power from small steam plants, such as are usually found in city manufacturing buildings, ranging from 100 to 400 horsepower in capacity, presents a subject which, although by no means new, is ever interesting owing principally to the widely varying results which may be obtained for a given case, depending largely upon the object for which the calculation is being made, and also upon the skill of the investigator.

If the unit cost of producing a given quantity of power is being sought for the purpose of making a direct comparison with the cost of purchasing the same amount of power, as a finished product, from an outside source, such as a central station, the character of the investigation and the cost items concerned would be quite different than if comparison were being made with similar power-producing plants.

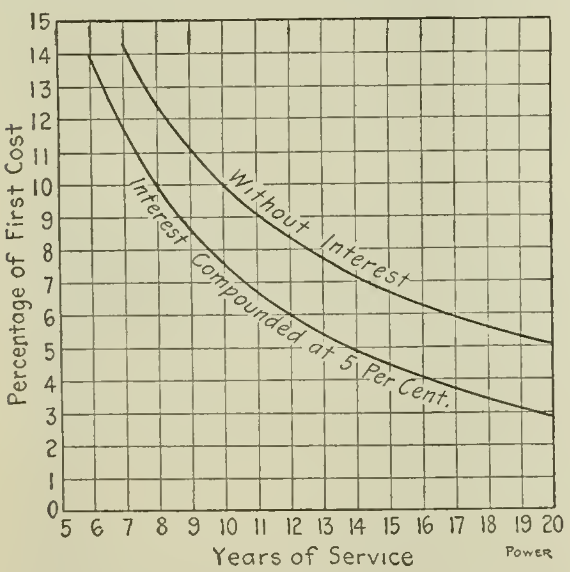


Fig. 1. Per Cent. to Be Set Aside as a Sinking Fund

Operating and designing engineers associated with power-plant work in general, and those identified with the smaller plants in particular, are interested in the efficiency of operation, and consequently in the cost of operating a power plant only as affected by its inherent efficiency, which includes only the actual cost of operation, such as fuel, labor, water and repairs. These constitute what might be termed factory costs as distinguished from total-production costs and the selling price of the manufactured article. They are quite sufficient for purposes of comparison with similar plants, revealing as they do the exact and complete results from the viewpoint of economy in design and operation. They are also sufficient for determining the selling price of power where the purchaser is a tenant in the building and as such is obliged to pay his *pro rata* share of the plant investment and other fixed expenses in the form of rent, irrespective of the power requirements.

Such an indirect power charge is usually of necessity in proportion to the floor space occupied by the purchaser, rather than in proportion to the demand on the power plant; the latter being a more just method of fixing the price. Thus, the cost of power as expressed in terms of cents per horsepower-hour or kilowatt-hour, or dollars per horsepower per year, and considered to be the total cost of producing power, may represent only that portion of the total cost known as operating expenses of the plant, and may be misleading. The total power cost includes other items of expense to which particular attention is herein directed.

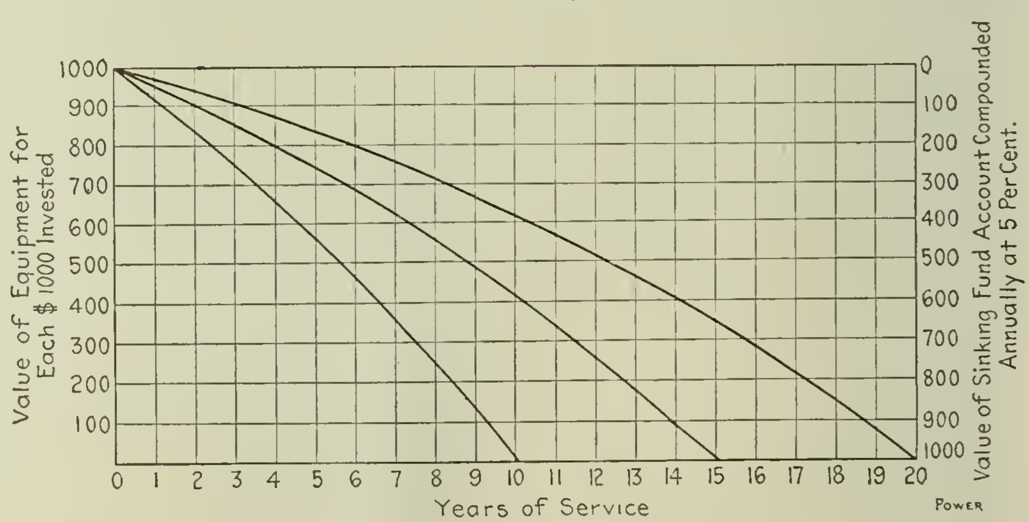


Fig. 2. Chart Showing Present Value of Plant

Since the general introduction of electric power from a public supply for manufacturing purposes, comparison between the cost of purchasing electric power delivered to the premises, and of producing power by a steam plant on the premises, requires a more comprehensive view of the plant costs and a better understanding of a correct and proper method of determining them; failure to do so often leads to erroneous conclusions, with results likely to be unfair to both producer and consumer of the public supply.

The power-costs account should rightly include every item pertaining to the plant presence and operation. Both items and accounts are to be determined on the basis that the power-plant operation is an entirely independent business than that primarily engaged in by the owner, and as such is to be dealt with accordingly. As any essential department of a well organized business (which a power plant is not if public power is available) must be able to stand on its own account, so should a power plant, and even more so, for it must provide adequately for power requirements for the entire factory, including any and all emergencies. It must continue to do efficient service for as many years as the factory will require, and above all must show a return on the capital invested in it equal to that of the average manufacturing business, where money invested is not free from risk, say, 15 per cent. over and above all other items of expense.

In order to arrive properly at the various costs generally known as fixed charges on a plant, some method of accounting must be employed. In every case where money is invested in manufacturing a commodity which is incidental to the general business, and which may be purchased from a public supply, the important thing is to be able to quickly determine the ability or inability of the manufacturing costs to compete with the cost of the public supply, and the method of accounting that will best show which is the one to employ. The principle is to buy whatever can be purchased cheaper than it can be manufactured, it being presumed that those who make a specialty are better equipped to turn it out cheaply than one would be who turns it out simply as a byproduct.

The original cost of a power plant may be represented by two accounts at all times; namely, the present value, and the value of the sinking-fund reserve established for depreciation. The sum of these two accounts should at all times be equal to the original investment. Each of these may again be divided as in the following schedule. The amount indicating the plant value would consist of two items, the salvage or market value, and that chargeable to obsolescence, the latter being the difference between the present and the salvage values:

Original cost	Depreciation and amortization sinking fund.	Increment, compounded. Portions of plant outstanding.
	Present value	Salvage value. Loss owing to obsolescence.

TABLE 1. STEAM-POWER COST REPORT

Including Lighting and Heating for Plant of

Name .... Address ....

Industry .... Plant in operation .... Years useful life ....

Power-plant Equipment	First Cost
Boilers, engines, pumps, piping and foundations	
Dynamo, switchboard and wiring	
Belting and shafting	
Motors and wiring	
Total for complete plant	
Present plant value, based on .... years of useful life	
Amount credited to sinking-fund account	
Salvage value of entire plant	
Obsolescence chargeable to new investment	

Annual Cost of Steam Power

	Items Chargeable to Investments Account	Cost
1	Interest on investment of $ ...... @ ...... per cent	
2	Depreciation of equipment, value $ ...... Useful life ...... years ...... @ ...... per cent	
3	Taxes on value of plant ...... @ ...... per cent	
4	Insurance, owing to operation of plant ...... @ ...... per cent	
5	Value of space ...... square feet @ $ ...... per square foot	
6	Superintendence and profit on investment, over and above heating plant cost of $ ...... @ ...... per cent	
	Items Chargeable to Operating Expenses	
7	Engineer @ $ ...... per month	
8	Fireman @ $ ...... per month	
	Fireman @ $ ...... per month	
	Fireman @ $ ...... per month	
9	Coal ...... tons @ $ ...... per ton	
10	Water for boiler, cubic feet @ ...... $ ...... per 100 cubic feet	
11	Removal of ashes, months @ $ ...... per month	
12	Oil, waste and packing	
13	Cleaning boiler	
14	Repairing and maintaining all steam apparatus	
15	Repairing and maintaining all shafting and belting	
16	Repairing and maintaining all motors	
17	Loss of time attending shut-downs for repairs	
18	Overtime for engineers and firemen	
19	Lamp renewals	
20	Loss of output due to speed variation	
21		
	Auxiliary Purchased Power	
22	Electric power for factory	
23	Electric power for elevators	
24	Electric power for other purposes	
25	Electric power for lighting	
26	Electric power for break-down service	
27	Gas for lighting	
28	Gas for heating	
	Total cost for all light, heat and power	

The original capital investment of successful operations must be returned from the earnings. This may be accomplished by means of a sinking-fund reserve, established solely for amortization, in which case depreciation is taken care of separately, or both depreciation and amortization may be represented by a single sinking-fund reserve. For small plants the depreciation account for obvious reasons usually serves both purposes and will be so considered here. The process consists of setting aside a certain percentage of the earnings each year to be invested in a safe security which at compound interest will equal the original investment in a given number of years according to the life of the plant.

Fig. 1 shows the amount in per cent. of the original investment to be set aside each year as a sinking fund in order to return the principal in (from 5 to 20) years, according to the life of the plant. The upper curve provides for a return without interest and the lower one with interest compounded annually at 5 per cent. The account thus established is wholly for depreciation and amortization and is not intended to provide for maintenance or repairs, which come under operating expenses, or for additions or renewals which are capital charges and should be treated as original costs.

In connection with this it may be well to remember that the life of a power plant is not determined solely by its physical ability to operate satisfactorily. Circumstances bearing on business growth, location, management and cost of power from a public supply may render it useless long before old age makes itself felt. It is the general experience that from 12 to 17 years constitute the life of the average plant and many have been abandoned at a much earlier age.

From the curves in Fig. 2 can be determined the present plant value for a useful life of 10, 15 and 20 years. These curves show that a $10,000 plant estimated to have a useful life of 15 years will be worth a trifle over $4000 after 10 years' operation. Any number of curves might be constructed in a similar way corresponding to different lengths of plant life. Having in this manner fixed the present value, other values may readily be determined when the question of abandoning the plant is being considered. If, as cited, after 10 years' operation the plant were to be abandoned, the new power account should assume responsibility for the difference between $4000 and the salvage obtainable. In other words, the amount due to obsolescence would be chargeable to the new power account as an investment charge, when by the operation of a new sinking-ing-fund reserve it will be returned as original capital. In fact, it could not be otherwise, for, partly due to the ability of the new account to carry the obsolescence charge, it proves its claim to the right to replace or supersede an existing plant. In the many cases where large power companies replace comparatively new machinery with larger, more efficient and more expensive machinery, and where large, beautiful buildings are being replaced with larger and more modern ones, a like method of determining the amount chargeable to obsolescence is employed with good effect.

Table 1 will serve to show the items of expense involved in operating a plant, and is arranged for the purpose of showing the exact average yearly cost at any time during the life of the plant. The average yearly cost is important to consider, and it is absurd for one to say that the plant has paid for itself, and now costs nothing except the operating expenses of labor, coal, water and repairs. The fact is that the former yearly average cost may have been slightly reduced or increased by reason of continuous operation, but could never be reduced to nothing even if the plant were to operate indefinitely.

There is perhaps little need of calling special attention to all of the items appearing under the heading of "Annual Cost of Steam Power" since each appears to be a proper charge. However, items Nos. 6 and 22 may require further consideration. Item 6 provides for, first, the time and thought given to the plant affairs by the head of the establishment and the superintendent of the factory, who must assume the responsibility of keeping all things going, directing the buying of coal, lamps, oil and supplies, engaging engineers and firemen, and seeing that repairs are made; second, a power plant is not an essential part of the business but an independent business and should be able to show a profit on the money invested in it over and above bare interest. The profit to be expected should be at least equal to the profit of the principal business engaged in; otherwise the owner would be much better off if the plant investment were in the form of a safe security paying only 5 per cent. and the factory were purchasing power from the public supply.

Item 22 refers to the loss of output due to a variation of speed at the driven machines, thereby affecting the output. It is plain to be seen that if the average speed of a productive machine were 5 per cent. below the maximum, due to such variation, the output would suffer; or, in other words, by the use of purchased power—presuming that its amount would be constant—nearly 5 per cent. increased output could be obtained with the same factory equipment and labor.

Table 2 shows an electric-power cost form corresponding to the steam-power form. As inspection will show, it provides for every item of expense likely to be incurred for light, heat and power supply.

It is believed that such a method of accounting for power costs will produce results which are fair to all parties concerned.

TABLE 2. ELECTRIC-POWER COST REPORT

INCLUDING LIGHTING AND HEATING. FOR FACTORY OF..................

Name.......................... Address......................................

Industry.......................... Per cent. of individual drive......................

	Motor Equipment	First Cost			
	No. of motors.... Average horsepower.... Total horsepower.				
	Wiring..				
	Belting and shafting....................................				
	Total for complete installation.........................				
	Obsolescence charge on old steam plant to be carried				
	Total amount as investment charge.....				
	Annual Cost for Electric Power				
	Item Chargeable to Investment Account	Cost			
1	Interest on investment of $..................@......per cent.				
2	Depreciation on equipment values$...... Life ......years..............................@......per cent.				
3	Taxes, owing to increased valuation..........@......per cent.				
4	Insurance due to motor equipment..............................				
	Items Chargeable to Operating Expenses				
5	Electrical energy for factory...kilowatt-hours @....per kilowatt-hour.....................................				
6	Electrical energy for lighting...kilowatt-hours @....per kilowatt-hour.....................................				
7	Lamp renewals..				
9	Gas for lighting...				
10	Repairing and maintaining motors, shafting and belting........				
	Items Chargeable to Steam Heating				
	Required to provide annually ...... pounds of steam for building heating and ...... pounds for manufacturing purposes.........				
	Value of old or new boilers for heating $..				
11	Interest and depreciation on boilers @ ...... per cent......				
12	Coal............tons @......per ton................				
13	Labor..........months @......per month				
14	Water..........cubic feet @......per cubic foot.........				
15	Removal of ashes......months @......per month......				
16	Repairing and maintaining boilers and heating apparatus...				
17	Gas for heating..				
	Total cost for all light, heat and power....................				

Compression

Steam is let into the cylinder of a steam engine for the sole purpose of turning the crank shaft at a predetermined speed against resistance. When the legitimate resistance is augmented by avoidable friction the possible efficiency of the machine is not reached.

To turn the shaft, pressure is applied to one side of the crank pin and whatever reduces the pressure upon this side of the pin or adds to that upon the other reduces the total output of energy at the flywheel and decreases the efficiency of the engine.

Compression of steam on one side of the piston reduces the effective pressure of the steam on the other side and decreases to this extent the pressure available for turning the crank shaft of the engine.

When the pressure of compression exceeds the pressure of the expanding steam the energy required for the work must be taken from the flywheel, reducing the amount of energy available for useful work.

Compression reduces the area of the indicator diagram, showing that for any given point of cutoff less work will be done in the cylinder when compression is used.

Though compression fills the clearance space with steam taken from the exhaust pipe instead of from the boiler, it takes steam from the boiler to run the engine to do the compressing, and if there is no other loss the friction of the engine during the period of compression is the price that must be paid.

Flexible Operation with Oil Fuel*

By Herbert A. Wagner

At the Westport station of the Consolidated Gas, Electric Light and Power Company of Baltimore, oil fuel is used for banking and in conjunction with coal for handling peak loads. With this arrangement the boilers have been forced to four times their rated capacity.

It is well known that the capacity of the modern water-tube boiler depends, within fairly wide limits, upon the amount of fuel burned per hour. Several plans have been proposed and used to increase the grate area so that more fuel can be burned, but the only practical plan for doing this necessitates firing from both ends; this requires increased space and additional devices for coal handling, etc.

The load on the Westport station of the Consolidated Gas, Electric Light and Power Company of Baltimore has well defined peaks of comparatively short duration, and these considerations led to experiments with fuel oil for supplementing the coal fires and obtaining the desired increase in boiler output.

After trying several settings the furnace arrangement shown in Fig. 1 was finally adopted, and proved so satisfactory that it was decided to equip the entire boiler plant in this way. The boilers are of the standard Babcock & Wilcox type and are rated at 650 horsepower. The space back of the usual coal grate is made into a large combustion chamber with the oil burners at the extreme rear end. This combustion chamber is separated from the boiler tubes above it by tiling and from the coal grate by a low bridgewall. The hot gases from the burning oil pass over the coal grate and upward through the first pass in the usual three-pass Babcock & Wilcox setting. Ample air inlets are provided around the burners and also in the side of the combustion chamber. Each furnace is provided with four oil burners.

The oil is delivered to the burners under 70 pounds pressure and is atomized in each burner by a steam jet, the steam required for this purpose being less than 1 per cent. of the amount generated by the boiler. By this arrangement either oil or coal or both together may be used to fire the boiler. Furthermore, the changes from the ordinary boiler setting are very slight and require no additional space. One of the four burners in each furnace is used as a pilot and for the equivalent of a banked coal fire for keeping the boiler ready for steam. These pilot or banking burners are operated from a separate oil line, so that a single valve in the main oil line may be used to turn oil into any number of furnaces desired, thus putting any number of banked boilers into commission instantly. The general arrangement of piping is shown diagrammatically in Fig. 2. The master valves 1 and 2 each control the pilot or banking burners for a group of five boilers, and in like manner the valves 3 and 4 control the remaining burners in each group. For illustration, assume that group A is being fired with coal for the usual load, and that group B is banked with oil; valves 1, 3 and 4 will then be closed and valve 2 will be open. If a sudden increase of load occurs the opening of valve 4 upon signal from the switchboard will instantly put group B into service. Still greater capacity could be obtained by opening the valves 3 and 1 to operate boilers A with both coal and oil. In addition to the master valves shown there are, of course, valves for controlling each burner and the group of burners for each boiler.

*Abstract of a paper read before the National Electric Light Association at New York City, June 2, 1911.

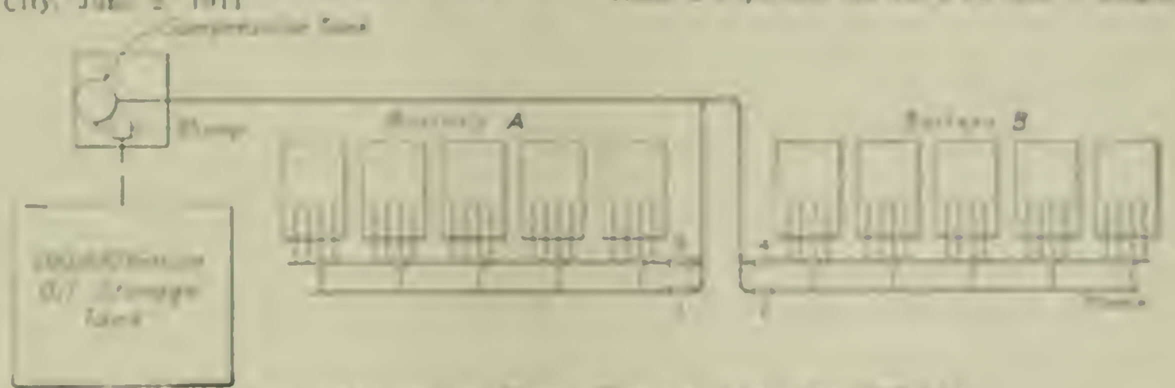


Fig. 2. Arrangement of Piping Shown Diagrammatically

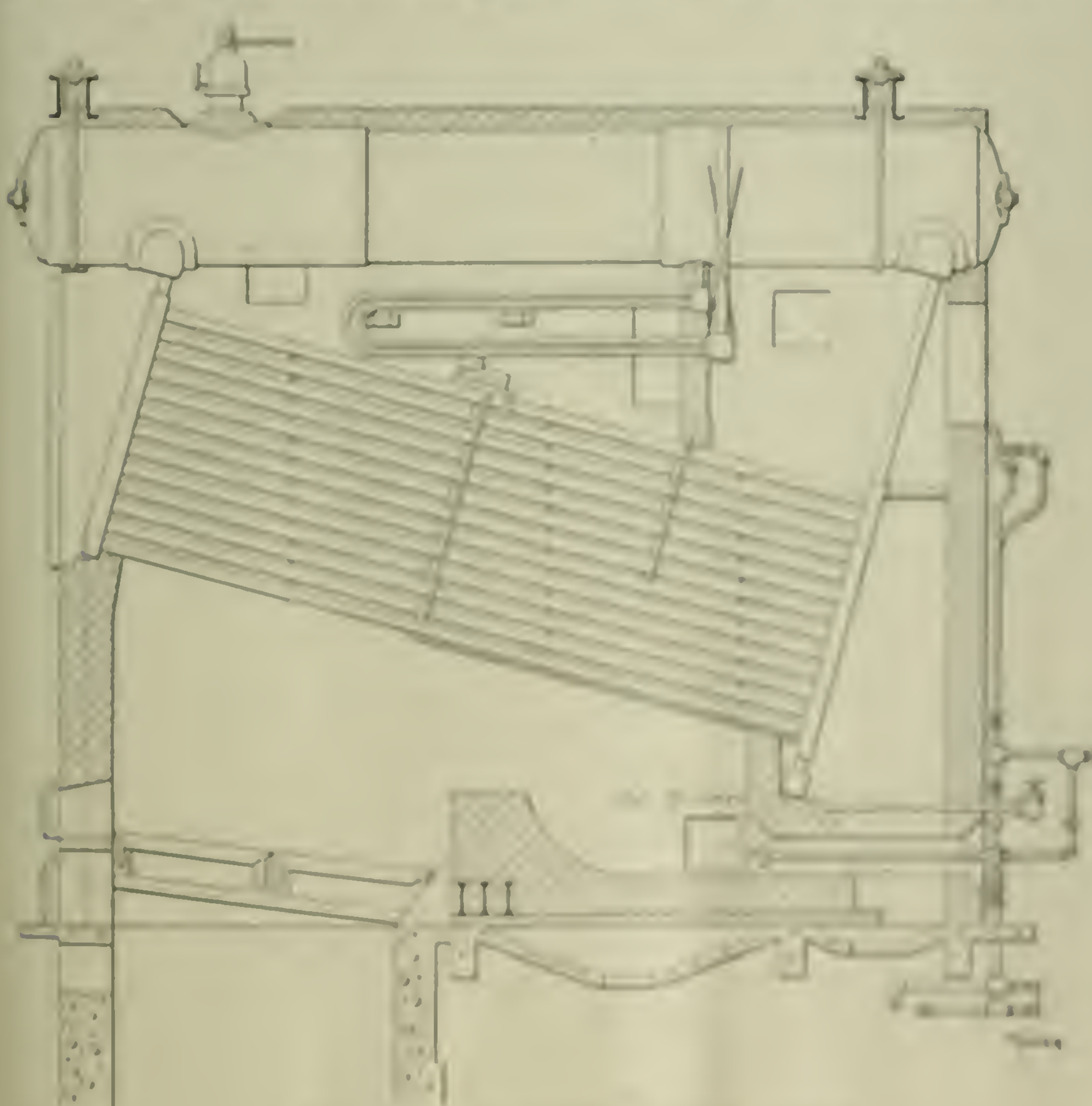


Fig. 1. Furnace Design Finally Adopted

Ordinary boiler tests with this arrangement have shown approximately the following results for maximum boiler output during eleven-hour runs:

Coal alone	[illegible]
Oil alone	[illegible]
Coal and oil together	[illegible]
Coal and oil [illegible]	[illegible]

Under actual operating conditions, however, the gain by the use of oil is more marked. It has been found that 2000 kilowatts of station load can be carried by each boiler when using coal and oil together, with as much ease and certainty as 1200 kilowatts per boiler can be carried by coal alone. This shows, under operating conditions, a gain in capacity of 66⅔ per cent. by the use of oil, or a saving of 40 per cent. in the cost of the boiler plant for a given capacity.

It is under emergency or peak-load condition, however, that the advantages of fuel oil must be considered, and the durations of load under such conditions are usually too short for any comparisons by the usual boiler-test methods. Tests were made, therefore, under regular operating conditions to determine the minimum number of boilers which could be used to carry actual peak loads. The best record obtained in past operation at the Westport station with coal was 16,888 kilowatts carried on eleven boilers; this is equivalent to 1535 kilowatts per boiler.

The same station operating in conjunction with a hydroelectric-power transmission line recently carried a load of 11,100 kilowatts for two hours with four boilers fired with coal and oil. This represents a load of 2775 kilowatts per boiler of 650 horsepower rating.

Tests have shown that a cold furnace, with water in the boiler at 142 degrees Fahrenheit, could be made to steam at 175 pounds pressure in 25 minutes with oil fuel as compared with 42 minutes with coal.

The cost of fuel oil at Baltimore is 43 per cent. more than coal, per heat unit, but in spite of this difference the actual cost of "banking" is less with oil than with coal, for the reason that the oil is burned efficiently while the coal is necessarily burned very inefficiently.

Fuel oil shows its advantages as compared with coal most markedly when used as fuel for operating steam plants in connection with long power-transmission lines from water-power plants. Owing to conditions which, up to the present time, are inseparable from high-tension transmission lines, steam auxiliary or standby plants are a necessary adjunct to such lines where power is used to supply the various needs of a large community. Such steam plants may be required merely to supply power during brief interruptions due to transmission-line troubles, or to supply part of the power for peak loads, or to make up for deficiencies in the water flow during dry seasons.

In Baltimore the local company purchases at present about 15,000 kilowatts from the Pennsylvania Water and Power Company. This is transmitted over 40 miles of transmission line at a pressure of 70,000 volts. The local company generates by steam all power for peaks over the 15,000 kilowatts purchased. The steam plant is operated in parallel with the water-power plant, and normally carries a constant load of about 2000 kilowatts, and as much over that amount as peaks may demand. In addition to this the steam plant stands prepared at all times to take the entire load should the transmission-line power fail.

So far during six months of operation there have been few interruptions on the transmission line. With but one exception these have been due to the failure of relays to operate properly. Such failures as have occurred, however, have thoroughly tested the value of fuel oil for quick steam generation. A few of these severe tests will be mentioned.

December 4, 1910: The transmission-line service was suddenly interrupted, throwing a load of 10,500 kilowatts on five 650-horsepower boilers. Oil was turned on under these boilers, which were at the time operating with coal, and steam pressure was held until the transmission-line service was restored. Moreover, the primary voltage at the substations was held within 1 per cent.

January 28, 1911: With the steam station carrying 2000 kilowatts on three 650-horsepower boilers, using coal, with three firemen on watch, the transmission-line service was suddenly interrupted and the load on the steam plant was increased to 8500 kilowatts. Oil was turned into eight additional boilers, and, although the steam pressure dropped from 175 to 165 pounds, it gradually came up to 175 pounds during the next 15 minutes. This drop in steam pressure was well within the range of automatic voltage regulators to maintain the primary voltage at the substation within 1 per cent.

May 12, 1911: The steam station was carrying 2000 kilowatts with four coal-fired boilers in service, and four additional boilers banked by means of one oil burner under each. The transmission service was suddenly interrupted and a load of 7600 kilowatts thrown on the steam plant. Oil was turned onto the four boilers in service and the four banked boilers; the steam pressure was maintained and in four minutes the boilers were blowing off.

Lignite Deposits in the United States

In an address on lignite, delivered before the American Philosophical Society, at Philadelphia, Penn., on May 5, by Joseph A. Holmes, director of the Bureau of Mines, the extent of the lignite deposits in the United States was shown by the accompanying figures, giving the areas in several of the States.

In several of the States in the Rocky Mountain region there are large areas of coal that represent a transition between typical lignite and bituminous coals. For these the name "subbituminous coals" has been suggested, and is tentatively used by the United States Geological Survey.

While the lignite beds in Alabama, Mississippi and Tennessee represent a transition between peat and the more typical lignites of the Dakotas and Texas, little or no use has been made of the lignite beds in these three States.

The lignites in Texas and Arkansas have been used to a limited extent, as have also the lignites of the Dakotas and eastern Montana. In this latter field the lignites contain 20, and in some cases more than 40, per cent. moisture. They slack badly and rapidly on exposure to the atmosphere, and this quality seriously interferes with their use and value for fuel purposes.

"The outlook for the utilization of lignites," said Mr. Holmes, "is favorable along three lines: First, in gas producers,

LIGNITE DEPOSITS IN UNITED STATES

	Lignite, square miles	Subbituminous, square miles
Alabama	6,000	....
Tennessee	1,000	....
Louisiana	8,800	....
Arkansas	5,900	....
Texas	53,000	....
South Dakota	4,000	....
North Dakota	31,000	....
Montana	7,000	8,800
Wyoming	....	21,360
Washington	....	1,100
New Mexico	....	5,000
Colorado	....	5,910
Idaho	....	1,200
Total	116,700	43,370

without either drying or other treatment; second, in boilers of special construction, such, for example, as that installed more than a year ago at Williston, N. D., by the United States Reclamation Service, where lignite is used in its natural condition almost immediately after being brought from the mine, and, third, made into briquets. In this case the lignite should be thoroughly and finely crushed and dried to a moisture content of from 5 to 10 per cent., and then compressed while still warm into briquets."

Limited quantities of lignite from California, North Dakota and Texas have been made into satisfactory briquets at the Government mine-experiment station at Pittsburg, using the full-sized German briquetting press, which develops a pressure of from 20,000 to 25,000 pounds per square inch. In the cases just mentioned the briquets were made without the use of any binding material, a sufficient amount of tarry material remaining in the crushed and dried lignite to serve as a bond to hold the particles together in the briquet.

"It is believed," said the speaker, "that the investigations of the Bureau of Mines along this line will demonstrate that the lignite in Texas, the Dakotas and Montana can be made into briquets on a commercial scale, and that in this form the lignite can be used as a substitute for other domestic fuel in these regions." There is sufficient raw material in these States to last for some time.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Electrification of Textile Mills*

By George P. Gilmore

The application of the electric drive to textile machines has reached the stage where many manufacturers, superintendents, engineers and mechanics are giving it much time and attention and I expect to see in the near future a large increase in its use. One result of the mill men's study of the question will probably be that textile and power-machinery manufacturers will make many alterations in the design and construction of their machines with a view to making them as a unit more adaptable one to the other and both to the requirements of textile manufacturing.

In my opinion, too much that is not true has been said about the cost of installation of electric power, its maintenance and economy, as compared with mechanical power, for the best interests of electric power, and too little regarding its real advantage.

Prime Movers

The steam turbine as a prime mover for the generation of electric power has no rival. It has none of the irregularities of the reciprocating engine, is more economical than a reciprocating engine, except possibly when the engine is new and operating at its most economical point of cutoff, and requires less floor space, oil and attention. Because of its high speed, the generator is smaller and consequently costs less and the exhaust steam from the turbine can be used for any purpose requiring low-pressure steam, as it contains no oil.

On test a 1500-kilowatt turbine has shown an economy of 17.22 pounds of water per kilowatt-hour at full load and 17.68 pounds at 25 per cent. overload, equivalent to 12.80 pounds per horsepower at full load and 13.2 pounds at 25 per cent. overload. Immediately after this test the turbine was run 2½ hours at 50 per cent. overload; then temperatures of the generator were taken and the windings showed a rise of 20 degrees Centigrade.

Safety

Thanks largely to the insurance companies, who have established a code of rules for the proper installation of electrical equipment, it is practicable to supply current from the generators to motors and lamps so that there is no danger of fire or of shock to operatives. In fact, there is much less danger from a well installed electric drive than from a mechanical drive.

The Motors

Modern motors are efficient, rugged and reliable and require very little care; they can stand heavy overloads for long periods without injury—in fact, I ran twelve 5-horsepower motors 58 hours per week for five months, developing 9½ horsepower each, and not one of them was injured or caused a shutdown. They may be placed in any position or location and arranged to drive shafts either horizontal or vertical or at any angle.

Of course, it is necessary to use different types of motors for various machines and locations. For motors up to and including 10 horsepower, simple oil switches are used for starting. For card rooms or other places where there is lint, fly or dust in the air, the squirrel-cage induction motor, which has no resistance coils in the rotor but has its starting resistance in a stationary closed case, is best suited; for other purposes or places an induction motor with an internal resistance may be used.

Some attention is now being given to variable-speed motors direct connected to cylinder shafts. In view of results obtained from one large installation where the motors were directly coupled to the cylinder shafts I am of the opinion that it is not necessary to change the cylinder speed with this drive as often as has been the practice with belted drives.

Table 1 herewith shows the results of spinning yarn at a constant spindle speed on frames having the same size rings in counts varying from 10 to 120 as compared with the production previously received from belted machines, using varying speeds and size of rings. The great increase shown in the production of 10s was largely due to the fact that the mechanically driven frames were not properly equipped or fitted to spin this count.

Installation and Operating Costs

The following figures cover the costs of an installation using turbine-driven generators, individual motors on pickers, ring spinning and some twisting frames and group drives for cards, combers, sliver and ribbon laps, drawings, fly frames, reels and spoolers. The prime movers are two 1500-kilowatt units. The total cost, including buildings, chimney, boilers, prime movers, all auxiliaries, motors, wiring, shafting, belting and all equipment, was $345,150. The cost per kilowatt of rated capacity, therefore, was $115.05, divided as follows:

TABLE 1. COMPARISON OF PRODUCTION RATES

Yarn	Twist per Inch	R.P.M. Front Roll	Pounds per Spindle in 58 Hours: Motor Drive	Belt Drive	Per Cent. Increase
10 C. P.	11.0	[illegible]	7.45	[illegible]	[illegible]
24 Card. P.	17.2	[illegible]	[illegible]	[illegible]	[illegible]
30 C. P.	19.2	[illegible]	[illegible]	[illegible]	[illegible]
34 C. P.	20.4	118	[illegible]		
36 C. P.	20.7	[illegible]	[illegible]	[illegible]	[illegible]
36 Card. P.	21.0	111	1.16	[illegible]	[illegible]
40 C. P.	[illegible]	[illegible]	[illegible]	0.87	[illegible]
45 P. Card	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
46 P. Card	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
60 C. P.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
70 C. P.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
100 Comb. S. I	[illegible]	[illegible]	[illegible]		
120 Comb. S. I	[illegible]	[illegible]	[illegible]		

	Cost per Kilowatt
Buildings, chimney and foundations	[illegible]
Power-house equipment	[illegible]
Motors installed	[illegible]
Wiring	[illegible]
Shafting	[illegible]
Belting	[illegible]

This was an expensive installation, owing to the fact that the power house was built in water, requiring concrete foundations under walls, boilers and machinery as deep as 9 feet in many places, and it was necessary to construct water-

*Extracts from a paper read before the Master Mechanics Association of America at Fall River, Mass., May 18, 1911.

ways to and from the power house, costing $10,343.

It was originally intended to group-drive the ring spinning frames, but after the purchase of the frames it was decided to use individual motors and as it was impossible to get motors of the correct size for the number of spindles per frame, the nearest standard size, which was 25 per cent. larger than necessary, was used, thus increasing the cost per spindle for installation and decreasing the efficiency of the motor.

The costs of installation for frame drives were:

	Per Spindle
Ring spinning, individual drive	$0.53
Ring spinning, group drive	0.35
Ring twisting, group drive	0 60
Ring twisting, individual drive	0.89

TABLE 2. COMPARISON OF INSTALLATION AND OPERATING COSTS FOR RECIPROCATING ENGINE AND MECHANICAL DRIVE AND TURBO-ELECTRIC PLANT

INSTALLATION

	Engine and Mechanical Drive	Turbines and Electric Drive
Plant capacity	4,000 Hp.	3,000 Kw.
Installation investment	$258,860	$345,150

OPERATION

	Mechanical	Electrical
Interest, 5%	$12,943	$17,257
Insurance, $2\frac{1}{2}$%	776	1,035
Depreciation, 5%	12,943	17,257
Taxes	2,790	3,726
Fuel ($4.50 per ton)	46,476	46,476
Wager	6,796	7,546
Repairs	1,000	1,100
Supplies	960	600
	$84,684	$94,997
Cost per horsepower per annum	21.17	23.75
Relative cost, per cent	100	111.2

Installation investment includes buildings, chimney, shafting, belting, motors, boilers and all power machinery and equipment.

TABLE 3. COMPARATIVE COSTS OF PRODUCTION FOR AN ENGINE AND BELT-DRIVEN SPINNING ROOM AND ELECTRIC INDIVIDUAL MOTOR-DRIVEN SPINNING ROOM, TO SPIN 38,362 POUNDS PER 58 HOURS OF NO. 46 COMBED PEELER YARN

Data	Mechanical	Electrical
Spindles	51,840	46,000
Horsepower	864	767
Floor space, square feet	50,100	44,390
Yarn per spool per 58 hours (pounds)	0 74	0.83
Labor and expense per pound	$0.02663	$0.02342
Power per horsepower per annum	21 17	23 75

TOTAL COSTS PER ANNUM FOR SPINNING ONLY

	Mechanical	Electrical
Interest, 5%	$14,076.00	$12,228.00
Insurance	844.00	733.00
Depreciation, 5%	14,076.00	12,228.00
Taxes	3,042.00	2,646.00
Power	18,290.88	18,216.25
Expense	51,079.00	44,922.00
Total	$101,407.88	$90,973.25
Cost per pound	0 0508	0.0456
Saving, per cent		10 23

Mules are a group-drive proposition as the great variations in power required during each cycle of their operation would require a very large motor, making the cost and efficiency prohibitive. In one case I applied an ammeter to a 200-horsepower motor driving 22,288 mule spindles and found the load varying from 125 to 250 horsepower.

For comparison of power costs between plants driven by reciprocating engines through mechanical transmission and those driven by turbines through electrical transmission, I have used the actual cost of the 3000-kilowatt plant previously referred to for the electric drive and carefully estimated the cost of an engine and belt drive of equal capacity, using figures submitted as prices by power-machinery manufacturers at the time this proposition was under consideration.

The fuel, repairs and supplies for the electrical plant and all figures for the mechanical drive are estimated. The efficiencies of the two types of drive are assumed to be equal. (See Table 2.)

From these figures it would seem to be necessary to find some material benefits to be derived from the electric drive over the mechanical to warrant the extra expenditures necessary for its installation and operation. In these figures I have tried to be conservative and, if either, favor the mechanical drive.

It is generally understood that the power costs amount to about 6 per cent. of the cost of production; therefore, if the production were increased two-thirds of 1 per cent., the 11.2 per cent. excess in power costs would be balanced.

In Table 1 I have shown the increased production of various counts obtained in one plant where the electric drive has been installed. Taking the results obtained on the count for which this mill was laid out as a basis for the comparison of a mechanical and electrical driven spinning room, the figures in Table 3 are obtained.

It was found that an operative attended the same number of spindles at their increased production as before, that there was less breakage of ends, because of the constant speed and absence of belt slip; consequently better yarn was produced with less labor. The breaking of ends is not caused by the creeping of belts but mostly by short jerky slips such as occur when dry or hard spots in the belt get on the small driving pulleys.

Table 4 gives the results of tests made to determine the power required for dif-

TABLE 4. RESULTS OF TESTS MADE TO DETERMINE THE POWER REQUIRED TO DRIVE VARIOUS MACHINES AND PER CENT. SPEED LOST IN TRANSMISSION

Operation	Drive	Motor Horsepower		Spindles			R.p.m.*	Percentage of Loss from Drive to Spindle
		Rated	Actual	Per Horsepower	Per Frame	Total		
Ring spinning	Bicycle Group Tight side of drive	150	115	79	240	9,120	7,880	3 6
Ring spinning	Loose side of drive	...	...	.....	...	.....	7,732	5.4
Ring spinning	Individual	5	4	60	240	240	7,854	0.0
Ring twisting	Bicycle Group Loose side of drive	150	145	42.81	280	6,208	5,573	5
Ring twisting	Tight side of drive					5,720		2.7
	$\frac{1}{4}$ twist						Shaft Mch.	Shaft to Mch.
Jack frames	Group	100	75	65.23	4,900	275	486	1.8

*In computing the spindle speed $\frac{1}{8}$ inch was added to whorl and cylinder.

NOTES:

Ring Spinning Group Drive. $1\frac{3}{8}$″ Ring—$2\frac{3}{8}$ oz. per bobbin—full bobbin. Avg. counts 30 Combed Yarn.	Ring Spinning Ind. Drive. Yarn 30 P. Co. B. T. Special Combed Peeler. $2\frac{5}{8}$ oz. $1\frac{3}{4}$″ Ring. Full bobbin.	Ring Twisting Group Drive. $2\frac{1}{4}$″ Ring, $3\frac{3}{8}$ oz. per bobbin. Avg. Counts 50|2 P. Co. Full bobbin.

Mule Spinning	Motor Horsepower		Number of Spindles	Spindles per Horsepower
	Rated	Actual		
	200			
Minimum		125	22,288	
Mean		185	22,288	120.4
Maximum		250	22,288	
Individual Drive				
Bale breaker	5	3.22		
Self-feeding opener	5	1.61		
Breaker lapper	5	9.65		
Finisher lapper	5	3.6		

No.	Machines	Motor Horsepower		Horsepower per Machine
		Rated	Actual	
64	Cards	50	45	0.703
24	Combers	15	15	0.625
16	Lappers	25	15	0.93

NOTE.—In mule spinning, average counts 12 hank, combed Egyptian—76 silk.
NOTE.—Peeler cotton was being opened during test on bale-breaker, opener and lappers.

ferent machines, as shown by electrical instruments, and the loss due to slippage of belts, bands, etc., between the drive and the spindle. It was found that the ⅛ inch added to whorl and cylinder fully compensated for the band slip on the individually driven spinning frames.

As spinning requires about 60 per cent. of the power used in a mill it is not strange that it has received more attention than other processes and therefore is in a more advanced state of development than the other drives.

Advantages and Disadvantages of Electric Power

Advantages—The advantages of electric power have been discussed by electrical engineers and power-machinery manufacturers in many papers on the subject, but are more fully understood and appreciated by mill agents, superintendents and mechanics who have daily experience with it and have a better chance of studying and because of their knowledge of the work required of it are better qualified to judge its merits.

Among the advantages and possibilities of the electric drives may be mentioned the following: Smaller power house and foundations; separation of power house and mill; economy of prime movers over a wide range of load; steady and even speed; no chance of wrecking the prime mover by a charge of water from the boiler; maximum use of the expansive power of steam; utilization of exhaust steam, because it is clean; more reliable power; more accurate knowledge of the power developed and used; information supplied by switchboard; absence of belt race and large belt troubles; less floor space required for a given output because of increased production; lower ceilings and lighter roof construction because of the absence of heavy shafting; better lighting because of the absence of belts; increased production; better machinery arrangement; more operating flexibility; lower operating costs; cleanliness; ease of determining machine troubles by applying electrical instruments; ability to stop all transmission by any employee in the room, and the ability to make use of purchased power as an auxiliary for overtime work, in case of accident, or to build a mill without a power plant.

Disadvantages—The principal drawbacks to electric power are the cost of installation and, in some cases, whether real or fancied, the cost of operation.

Cost of Engine Operation

I give in Table 3 the actual cost of power, which is an average for three years figured from well made and complete reports, developed by a reciprocating engine. This plant was probably as skillfully operated and well managed as the average plant in textile mills. The high repair item was caused by the reboring of all cylinders and ports and fitting same with new valves and pistons, which was done in the first year covered by the account. This may be of interest in showing that theoretical economies are not always obtained in practice.

TABLE 3. COST OF POWER PER YEAR PER INDICATED HORSEPOWER AVERAGED OVER THREE YEARS USING TANDEM COMPOUND CONDENSING ENGINES

Repairs	$ 2 [illegible]
Fuel at $4.00 a ton	14 1[illegible]
Labor:	
Engineers	0.77[illegible]
Firemen	1.[illegible]
Transmission	0.[illegible]
Handling coal and ashes	0.7[illegible]
Supplies	0.3[illegible]
Interest, 5 per cent	$ 5.3[illegible]
Depreciation, 5 per cent	5.3[illegible]
Taxes and insurance, 1 per cent	0.6[illegible]
Coal in storage, 5 per cent on 3 months' supply	0.5[illegible]
Total cost per year per indicated horsepower	$[illegible]
Equivalent cost per year per kilowatt	[illegible]

All costs given in this paper are prices of 1908 and 1909; the prices of electric machinery have since been lowered 10 per cent.

Discussion

In the discussion which followed the reading of Mr. Gilmore's paper, Sidney B. Paine, manager of the General Electric Company's mill power department, said that about 500,000 horsepower of electrical equipment has been installed in textile mills up to date. Among the large installations he mentioned 23,000 horsepower in the Amoskeag mills, 80,000 at Lawrence, 40,000 at Lowell, 68,000 in the various mills of North Carolina and 52,000 in those of South Carolina.

The average size of textile mill motors ten years ago, Mr. Paine said, was 75 horsepower, whereas the average size now is 23 horsepower; the change is due to the increased use of individual motors. He also said that the speed of motors used on all textile machines except mules would not vary 1 per cent., and cited a number of instances of increased production due to substituting motors for belt drives, notably with respect to looms.

An Easily Built Switchboard

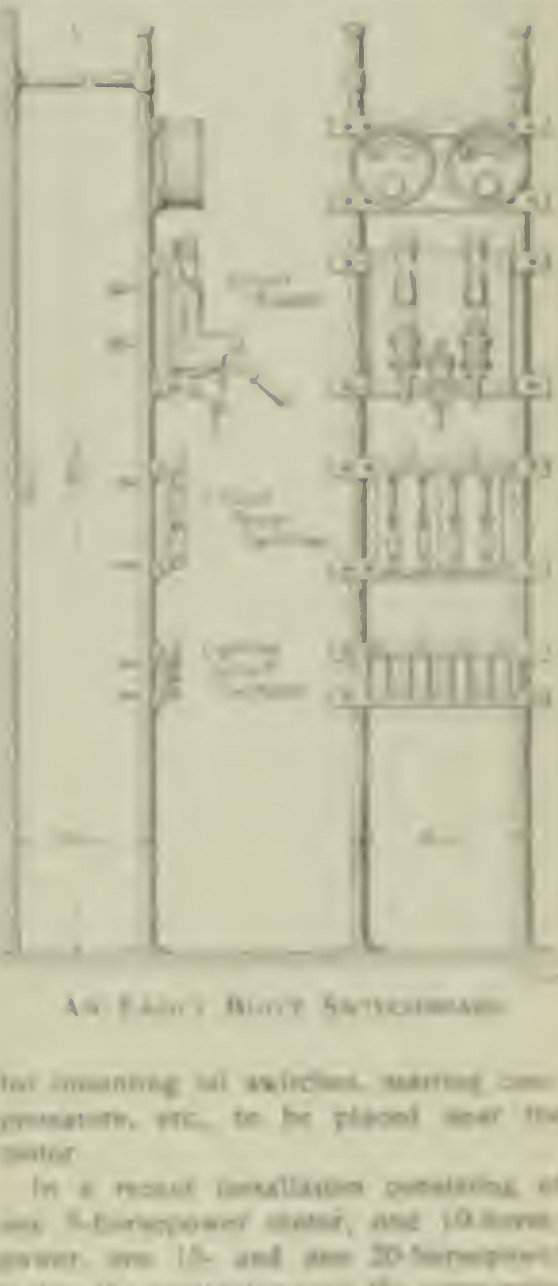
By J. H. Crane

The accompanying sketch shows an inexpensive and serviceable switchboard for use in small machine shops, woodworking establishments or other places where a few motors are to be installed and the owner does not wish to go to the expense of buying a conventional slate or marble switchboard and corresponding fittings. The uprights are 1¼-inch pipes set in floor-plates fastened to the floor, closed at the upper ends by ordinary pipe caps and braced to the wall by 1¼-inch pipes screwed into tees in the uprights and floor-plates on the wall.

The meters, circuit-breakers and switches are supported by pieces of oak or other hard wood ¾ of an inch thick by 2 inches wide, held in place by U-shape axle clips which can be secured at any blacksmith shop or carriage-hardware store. The wiring on the rear should be fastened to the boards by means of porcelain cleats.

The whole outfit can be painted black and presents a very neat, attractive appearance—in fact, it will look much better than a slate board will after being in use six months or longer. It is easy to add as many panels as are wanted and to change the switches at any time.

Such an arrangement can also be used



An Easily Built Switchboard

for mounting oil switches, starting compensators, etc., to be placed near the motor.

In a recent installation consisting of one 5-horsepower motor, one 10-horsepower, one 15- and one 20-horsepower motor, the contractor gave the same price on the total installation, using this style of switchboard, that was quoted for a slate switchboard, with its switches and circuit-breaker, but without the motors.

In a vessel of 5400 tons now under construction, the use of Diesel motors adds 18,000 cubic feet to the hold space. At four voyages a year in the Black Sea trade, this means a profit of $4,000. The saving in fuel would be $20??, and in wages, $1,100. It is also stated that a fishing boat of 140 tons equipped with a Diesel motor is doing the same amount of work in the herring fisheries as is performed by a steam-driven fishing boat of 184 tons.—Scientific American.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Hot Tube Ignition

By Olaf Olafsen

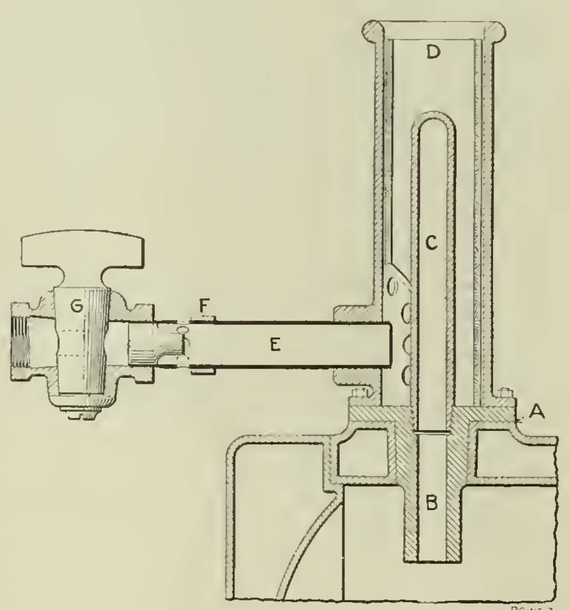
In these days the hot tube is tabooed and not even given consideration by many intelligent men in the gas-engine industry. However, there are thousands of hot-tube igniters in use and a good many are built and sold yearly; consequently, there must be a number of men to whose lot it falls to take care of gas engines equipped with hot-tube ignition. From personal contact with many mechanics, I know that the hot-tube igniter is not universally understood and this article is intended for the benefit of those who are not clear on the subject.

The drawing represents what is most common practice in hot-tube construction today. Mounted upon a pad *A* on the cylinder head or cylinder proper is a flanged bushing *B*, into the upper opening of which is screwed a tube *C* with one end closed. Surrounding this is a chimney *D*, usually of cast iron with an asbestos lining and a boss on one side for the entrance of the bunsen burner *E*. Around this boss are air holes for the admittance of air to prevent the gas flame from smothering in the chimney or from going to the top to get the oxygen necessary to complete combustion.

The bunsen burner is usually made up of a short length of brass tubing with a drilled plug forming the gas orifice at one end. A number of small holes arranged circumferentially about the tube, at a distance from the end about equal to the total length of the orifice plug, forms the air inlet. The amount of air admitted is regulated by a small sleeve *F* which is arranged either to screw or to slide over the holes.

The adjustment of the bunsen burner is one of the most frequent duties of the trouble man. It should never consume more than ten feet of gas an hour for any size of engine and in most cases six feet should be sufficient. Usually an attempt is made to regulate this consumption by means of the cock *G*. This is entirely wrong in principle because it cuts down the pressure and therefore the velocity of the gases flowing through the orifice, and as the amount of air drawn in through the inlet holes depends on this velocity it follows that the air supply will also be cut down and it will be difficult to secure a proper flame.

The proper way to remedy excess of gas is to peen the orifice partly shut and then ream the hole with a fine taper reamer until the proper amount of gas, that is, that just sufficient to heat the tube properly, is allowed to pass. These reamers, ranging in size from a fine needle to a darning needle, may be bought at most large hardware stores for an insignificant sum. A piece of octagon tool steel drilled at one end with a common lathe center drill forms an extremely convenient and mechanical set for closing up the orifice of a burner such as the one shown in the sketch. When the flame hovers at the top of the chimney it is a sure sign that too much gas is being burned or that either the air inlet holes in the burner or those in the chimney are clogged with dirt or that the air sleeve *F* is not properly adjusted and is admitting too much air. It is impossible for the manufacturer to make the gas orifice just right, as local gas pressures vary to such an extent. Should the bunsen tube cause trouble by burning back at the orifice it is probable that not sufficient gas is being delivered and that the orifice should be made larger, or else that the air sleeve *F* is not open far enough. Of course, this may happen in lighting the burner if the flame is applied before the mixture has had sufficient time to fill the tube *E* and attain some velocity through it.



Sectional Elevation of a Typical Hot-tube Igniter

In piping the burner to the source of supply, it is best and often necessary to take the gas from the illuminating pipe line; if taken from the power-supply pipe, it must be drawn from the meter side of the gas bag to avoid the fluctuations in pressure set up by the intermittent suction of the engine. In certain cities a gas bag is prohibited and small gasometers are used which are sealed with oil. To prevent starting the engine with the main gas cock closed and thereby drawing the sealing fluid out of the gasometer into the pipes, the hot-tube connection is taken off between the shut-off cock and the gasometer, on the meter side of the engine; this insures that the tube will never be heated sufficiently to start unless the main gas cock is turned on.

The chimney *D* is a simple casting. The asbestos lining should always be kept intact, as the proper heating of the tube is assisted by it. The tube is usually made of a piece of wrought-iron pipe with the end welded over or a piece of nickel-steel rod having a hole drilled almost its whole length. The nickel-steel tube is far preferable, its life being from six months to a year, under average conditions, while a wrought-iron or mild-steel tube may last only a few days or weeks. The thread is usually either 1/8 or 1/4 inch, gas-pipe size. In former times, porcelain and platinum tubes were used, the former being abandoned probably on account of their brittleness and the latter on account of their cost.

A very important, although apparently minor, part of the hot-tube apparatus is the bushing *B*. First it would probably be best to explain the manner in which the ignition is timed with a hot-tube igniter. I can see the younger gas-engine men smiling at this, but I have seen many hot-tube diagrams showing a regularity of successive explosions which compared favorably with any of those produced by a engine equipped with electrical ignition. It will be evident from the sketch that there is no chance for the tube and the hole in the bushing to be scavenged on the exhaust stroke; therefore, when the piston starts back on the compression stroke with a full charge of fresh gases in the cylinder, these will be forced up through the bushing, compressing the burnt gases ahead of them and possibly mixing for a certain distance beyond the line of contact with them, but this is unimportant as the amount would be practically constant. When the piston has advanced far enough to cause the fresh gases to rise to that part of the tube which is at the ignition temperature, they will be ignited and will shoot a tongue of flame down into the charge in the combustion chamber and ignite it.

Calling the part of the tube and bushing below that point which is heated to the ignition temperature the cool length and the part of the tube above that point the hot length, and bearing in mind the fact that the movement of the fresh gases up the tube will be nearly proportional to the piston displacement at each part of the stroke and that the length of the column of burnt gases will shorten somewhat under the compression, it is clear that a longer bushing, all other conditions remaining the same, will cause ignition to occur later in the compression stroke, because the ratio of hot length to total length is smaller; on the other hand, a longer ignition tube will cause earlier ignition, because the ratio of hot length to total length is greater. Of course, this will not conform rigidly to the laws of compression, as there are too many variables; the proportions must be established experimentally for each design of engine. Further reasoning will show that enlarging the bore of the bushing will cause later ignition, the bore of the tube remaining unchanged.

An example of how these dimensions work out in practice is given in the accompanying table, which presents the practice of one well known engine builder. Unfortunately I am unable to give the exact hight of the bunsen tube above flange here, although it is very close to one inch to the center of the tube. Occasionally the length or bore of a bushing must be changed for some engine which does not come up to the usual performance. This occasions no trouble as a record of the bushings is kept under the shop numbers so as to fill repair orders properly.

It is advisable for a mechanic engaged in adjustments on hot-tube engines not to tamper with either the original length or bore of either the tube or the bushing unless he is prepared to make a thorough test with indicator, brake and gas meter to prove that he is working in the right direction; the long experience and careful work of reputable engine builders are far more efficacious than haphazard field methods. Adjustment of the bunsen burner and of the fuel mixture delivered to the engine will usually cure any ignition trouble. Serious loss of compression is liable to make ignition late and even uncertain, but the fuel mixture in the engine cylinder has considerable effect on the performance of hot-tube igniters. A rich mixture will hasten the rise to maximum pressure and a lean mixture will delay it; I am not able to say just how the mixture affects the rate or the timing of ignition, however.

The bushing B is an important part of the apparatus for further reasons.

Upon one occasion I was called to examine an engine which usually "laid down" about twenty minutes after the full load was applied, the shutdown being accompanied by heavy pre-ignitions and backfiring. Upon reaming the hot-tube bushing I found that it was made of a piece of wrought-iron pipe screwed into a flange and that the joint between the flange and the cylinder was packed with a heavy asbestos gasket. There was also about ½ inch clearance all around the tube in the passage by which it connected with the cylinder. The tube had scaled and wasted away until it was very thin, showing that it had often been above red heat. The cure in this case was to substitute a cast-iron flanged bushing in one piece, with the same size of hole and of the same length, made of sufficient outside diameter to fit the hole through the cylinder wall and having a ground joint instead of packed one, thereby allowing the heat to be conducted away to the water jacket and keeping the bushing reasonably cool.

HOT TUBE IGNITER PROPORTIONS

Bore and Stroke	R.P.M.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Had it been possible, the best arrangement would have been to raise the bushing, keeping the original length of hole, so that it projected very little into the combustion space, the free end extending into the combustion space always being liable to overheat unless properly protected as described. This is best placed where the entering charge will sweep over it and keep it cool. Of course, this would cause considerable backfiring if the proper precautions were not taken to conduct a large part of the heat to the water jacket.

In former years many attempts were made at positive timing of hot-tube ignition, this usually being accomplished by a valve actuated by the cam shaft opening the passage to the hot tube at the proper instant. These were of little value as the valve faces and seats were short-lived. Mechanical timing is not advantageous on engines up to 15 horsepower unless operating on gases containing an extremely high percentage of free hydrogen; in such cases it would be far better to employ some other ignition system.

To the best of my knowledge the insurance companies do not distinguish in their rates on gas-power plants between hot-tube and any other method of ignition unless gasolene supplied from a small elevated tank (as is usual with gasolene engines) is used to heat the tube. This is manifestly an extra risk and such an installation should never be allowed except in a small, absolutely fireproof building, such as might be used for a small private plant located in large grounds.

The Status of Gas and Oil Power*

By J. B. Klumpp

The economy of operation of gas-power plants was shown in last year's report to be considerably better than that of steam-power plants, except possibly in those stations where steam-turbine units of larger sizes and most approved design were installed. It is believed that for plants of, say, 2000 horsepower and under, the fixed charges due to investment for gas-power plants, including producers, should not exceed the fixed charges of steam-power plants, including boilers, and it is also believed that the depreciation charges for gas-power plants should not be greater.

What may be considered one of the greatest incentives for the introduction of the gas producer and gas engine is the utilization of low-grade fuels which are unsuitable for use in steam-power development, such as the lignites of Texas, Colorado and Washington State, and the low-grade refuse fuels, as the "culm" of the anthracite-coal mines and the "bone" of bituminous-coal mines. From tests made by the United States Government, and also from the operation of plants installed in the above named districts, it is acknowledged that lignite coal with a high percentage of ash can be handled with efficiency, and from reports of plants in operation, both in this country and abroad, the tailings of coal mines having percentages of ash as high as 50 per cent. have been used with more or less satisfaction. In view of this fact, it is obvious that many gas-producer power plants will continue to be installed throughout certain sections of the United States where such low-grade fuels are in abundance and that central power stations will be erected to distribute electric power at high tension from these points.

The use of anthracite fuel has been successful in a great many types of gas producer and it is in a matter of very little moment which type is adopted for the purpose of handling this kind of fuel—either the updraft, downdraft, suction or pressure type—but the use of bituminous fuels is more complicated and has necessitated the adoption of methods that will produce a gas free of tar and lampblack. For this purpose various meth-

*Part of the report of the Power Station Engine Committee, presented at the recent convention of the National Electric Light Association.

facturers have so designed producers that the tar will either be consumed in the fuel bed, or if appearing in the resultant gas, will be removed by means of special tar extractors. Producers of this type are being made updraft, downdraft and double zone forms and it is fair to say that for a perfect utilization of the fuel at hand, certain modifications must be made in the design and operation of each type of producer to suit the local fuel conditions. In Europe, where the use of gas-producer plants has become more of a general proposition on account of the relatively high cost of fuels and low cost of labor, the adoption of the byproduct installation is more prevalent where bituminous fuels are used than it is in this country. From such byproduct installations a relatively high return can be made from the residuals in the shape of tar and ammonia, but this factor has not been seriously considered in this country, owing to the relative cheapness of fuels and expensiveness of labor; also on account of high cost of the plant necessary to work up these residuals.

During the last few years the design of the gas engine has been simplified in many ways and, while there have been no radical changes in the general type, the construction has been improved by added refinements in the details of the mechanism, and more particularly in the adoption of high-grade materials and the appreciation of the resultant strains and stresses that take place in these materials. This general tendency to improvement has enabled the manufacturers to lighten the engine, reduce the number of working parts, simplifying the machine as a whole and at the same time this general improvement in design and construction has increased the reliability and reduced the repairs of gas engines.

Changes in valve gear have been made by some German manufacturers in returning to the throttling governor. In the same country they also show a tendency to adopt the Lodge system of ignition, which system has no moving parts to the spark plugs, the current being supplied from storage batteries and intensified by Leyden jars, producing a system similar to the ordinary automobile system of ignition.

One of the objections to installing gas-engine units, introduced more particularly by the industrial people, has been the want of auxiliary steam for heating and other purposes, which auxiliary steam is so convenient when a steam-power plant is installed. The opportunity to increase the economy of a gas-engine plant by utilizing the waste heat of the engine jacket water and engine exhaust is apparent and the attempts to do this so far have met with more or less success, but further developments must be made before it can be said to be successfully accomplished.

In discussing the internal-combustion engine, we must not omit those engines utilizing a liquid fuel directly in the cylinder. Such types of engine will always be in demand where the liquid fuels are obtainable at a reasonable cost. The gasolene engine may be included in this classification (this engine having its own special functions, when the high cost of fuel does not prohibit its operation), but in this discussion the heavy-fuel-oil engine only is considered. The method now generally adopted of obtaining power by the combustion of this liquid fuel creates excessive internal pressures in the engine cylinder, which necessitates a high-grade, expensive and heavy engine being built to withstand the pressures. Their use in the past, however, has been very satisfactory, and improvements in design, now constantly taking place, are reducing both their weight and cost. Many engines of this type have been installed during the past year by the American Diesel Engine Company, recently reorganized and now of St. Louis, and the De La Vergne Machine Company. of New York City.

In submitting this report it is desired to bring before the association the fact that development on this line of construction is progressing, and that there are many instances where the gas engine and producer may be installed for our own central-station practice that will prove beneficial to the operator by the economies that will be obtained. The introduction of gas engines for central power purposes will be continued where gaseous fuel is obtainable, either as a byproduct, in the case of coke-oven operation, or where natural gas is available, as the installation of such engines will give economies far exceeding the utilization of the same fuel when consumed under steam boilers. But when such cheap gaseous fuels are not obtainable, the installation of a power plant in each individual case should be carefully studied and the installation, whether gas or steam, should be made on its own merits.

LETTERS

Inspection Plugs for Poke Holes

Mr. Lee's inspection plug, mentioned in the issue of May 16, is worthy of more than passing interest. It is a new application of an old method used by brick and tile manufacturers to determine the temperature of the brick and tile on the inside of a kiln. It had been suggested while the mason was sealing up the kiln door. A piece of 1½-inch pipe 12 inches long was set in the brickwork through the door and when the job was completed a thick piece of window glass was cemented over the outer end of the pipe. This soon smoked up from the dampness of the brickwork and the fresh green fire and the cement cracking allowed the glass to drop from the end of the pipe. The pipe was then plugged with clay until the fires were built up and the contents of the kiln began to turn red; then the clay plug was removed and the glass replaced. This proved very successful and several peep-hole plugs were made in the other kiln doors as well as side walls. We could not obtain mica in those places and the glass had to serve the purpose. The length of the pipe seemed to be such as to provide sufficient dead air insulation to prevent the heat from cracking the glass. I have since seen peep-hole plugs of this kind in use in forge shops for watching the "heat" temperature rise on the work within the forge without opening the door, which would chill the work on the side nearest the door

R. A. CULTRA.

Cambridge, Mass.

Corrosion of Water Cooled Exhaust Pipes

In reply to the inquiry under this heading in the May 9 issue, I would say that the preferred method of cooling the exhaust pipe of a large gas engine is by means of a closed water-jacket around the outside of the exhaust pipe proper, the cooling water discharge from the engine jacket passing upward through the pipe jacket. The diameter of the inner pipe should be 10 to 30 per cent. larger than that of the engine exhaust valve to allow the pressure and temperature to drop rapidly. For the first 10 feet of pipe from the engine gray cast iron is most suitable. If bends are required, they must be of large radius. As ample provision for expansion is required, slip joints and rollers under the pipe are necessary.

If internal water injection is applied corrosion is bound to follow, but it can be much reduced by using, as far as possible, extra heavy glazed vitrified acid-proof sewer pipe. Possibly the vitrified portland cement conduit shells, made in halves, in sections three feet long, described in POWER of April 11, can be utilized for this purpose. To enable this type of conduit to withstand the pressure of an occasional explosion in the exhaust pipe, the conduit may be enclosed in a cast-iron or steel pipe, the space between being filled with portland cement grouting; or a thick inclosure of concrete alone will probably hold. Concrete conduit without any protective lining will not stand up as well as it is porous and likely to disintegrate. No matter what construction is used, provision must be made for expansion and for cleaning and draining.

CHARLES H. HERTER.

New York.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Check Valve in Blowoff Pipe

A few years ago I was engineer in a plant containing two 60-inch by 16-foot return-tubular boilers, set in one battery. The blowoff pipes connected to a single pipe in the rear which led to the sewer. Boiler No. 1 was cut out for cleaning. When I entered the boiler I forgot to close the blowoff valve. After inspecting the inside I had just crawled out when the fireman opened the blowoff valve on No. 2 boiler and steam and hot water rushed into No. 1 boiler. Had I been a minute later I would have been scalded. The next week I got two 2-inch swing check valves and put one in each vertical pipe so that the valve would open to the sewer.

The fireman said it was only wasting brass putting them in. He is now engineer at the plant, and on a recent Sunday was in No. 2 boiler when his fireman opened the blowoff on No. 1. The hot water and steam rushed up the blowoff pipe and striking the disk closed the check in the blowoff pipe of No. 2 boiler. He told me that the check valve had saved his life, as he was directly over the blowoff pipe, examining tubes and braces. His candle was extinguished and enough hot water and steam got by the check to scald his arm slightly. The check is always open and does not interfere with the blowing off of the boilers and requires very little pressure in the opposite direction to close it.

Edward Henlow.

Camden, N. J.

Friction Load Diagrams

The pair of friction indicator diagrams herewith presented in Fig. 1 are worthy of study. They were taken from an 8x10-inch Ames engine having a 1¼-inch piston rod; the engine ran at 250 revolutions per minute. The diagrams are of the friction load. An outside-spring indicator was used with a 60 spring. The reducing motion was of the pendulum type and the indicator cord was about 2 feet long.

There is no reason for believing that the diagrams do not truly represent the action of the steam in the cylinder, although they may contain some unsuspected error. Under the same no-load running conditions the engine produced diagrams identical to those shown, on different days. It seems, therefore, that the peculiarities of the crank-end diagram are due to the valve action and, possibly, to heat interchanges between the steam and the cylinder walls. That the valve is properly set for normal load is shown by Fig. 2.

The point of release R, Fig. 1, distinguishes the expansion line E from the compression line which crosses it. Assum-

Fig. 1. Diagram of Friction Load

ing the diagrams to be correct, it appears that some exhaust steam is trapped in the crank end of the cylinder and compressed during the return stroke to the highest pressure. It also seems that no live steam is admitted to the crank end as the pressure does not rise as high as on the head end and the steam line falls vertically, instead of rising, at the beginning of the stroke. If this interpretation is correct, negative work is done in the crank end, the piston compresses exhaust steam, which in expanding does not return all the work put into it. Upon this basis, the crank-end horsepower is minus 1.20. As the horsepower of the other end is 3.37, the friction horsepower is 2.17.

Fig. 2. Full-load Diagram

The peculiarities of the crank-end diagram suggest the following questions:

Why does the steam line fall vertically at the beginning of the stroke?

Why does the expansion line cross the compression line?

Why is the back pressure after release less than during the return stroke before compression?

Julian C. Smallwood.

Syracuse, N. Y.

Removed Flywheel Blocking

At one time the plant of which I was chief engineer was shut down for repairs. After the boilers had received a thorough overhauling, the firemen were called in to help put things in shape for starting up. Part of the work was the installation of new piston-ring packing in the blowing-tube cylinder of the vertical 42 and 84 by 60-inch blowing engine.

The engine flywheels had been properly blocked and I was sure that no movement could occur, but some of the men who were putting in a new electric-lighting outfit, wanted some blocking and removed it from the flywheel. This left the large engine unprotected and placed lives of three men working in the blowing tub in jeopardy.

Entering the engine room I noticed that the blocking had been removed and lost no time in getting a piece of steel rail, and placing it between the spokes of the flywheel to prevent it from turning. Then I told the men to drop everything and come out.

A commotion was heard inside as three men, one of them a nervous Swede, tried to get out of the manhole at once. Finally, the two men managed to break the Swede's hold and one held him down while the other climbed out. When the Swede got outside he beat it for the door and that was the last I ever saw or heard of him.

The piston remained in place for about 10 minutes more. I had just got the boys to work blocking the wheel once more, when the rigging gang, hoisting a connecting rod into position on one of the other vertical engines, let go of one end which swung with considerable force against the blowing tub. The flywheel immediately turned, but the rail stopped it before the piston moved more than 30 inches of its stroke. The rail certainly did its work for the three men would have been killed had the piston moved when they were working inside.

I read an account some time before this occurred where two engineers were killed because they neglected to properly block a flywheel while working in a cylinder.

D. L. Fagnan.

New York City.

Putting in Gage Glasses

When putting in gage glasses I have noticed that in nearly every case the little washer that is furnished with the connections is put in the bottom of the nut on top of the gasket.

The proper place for it is between the gasket and the threaded end of the connection.

The washer in this position makes a division between the gasket and the connection and the nut can be turned without the gasket sticking and bunching up in the connection, as it is almost sure to do if the washer is not properly placed.

I have found it good practice to smear the glass and washer with finely powdered graphite, before putting them in place. This prevents the gasket from sticking to the glass, which will crowd the glass and possibly cause it to break. The graphite should be put on dry, as oil will rot the rubber.

James W. Little.

Fruitland, Wash.

Faultily Marked Corliss Valve

A simple 16x24-inch Corliss engine pounded badly. Each shift engineer took a turn at setting the valve according to the data given by the factory blueprint, and they had failed to stop the pound. The bearings were carefully taken up, but the trouble still continued.

The chief engineer was advised of the trouble and after noting the action of the engine decided it was due to improper valve setting, notwithstanding the fact that the valves were set as per instructions.

The blueprint gave the lap with the wristplate in mid travel as 3/16 inch for the steam valves and 1/16 inch for the exhaust valves, and the lead with the valve gear hooked up and the crank on the dead center as 3/32 inch.

The chief got out his indicator and took a diagram and then adjusted the cutoff rods and took a second diagram. The lack of compression and also the fact that the exhaust was late, causing the toe of the card to point decided him to advance the eccentric. Another diagram was taken which indicated that the engine needed more of the same medicine, but the steam was being admitted too early and caused a hump on the top of the card; also advancing the eccentric alone a reasonable amount would not give quite enough compression. He, therefore, lengthened each exhaust-valve rod a turn and the steam-valve rods a turn and a half each and then advanced the eccentric another ¼ inch on a 6-inch shaft. As a result the pound had disappeared.

Upon examining the factory marks on the valves and eccentric, the steam valves had ⅜-inch lap, and the exhaust valves had ⅛-inch lap when the wristplate was in mid travel. Then the engine crank was placed on the dead center and the steam valves had 3/32 inch lead as per factory direction.

The eccentric had been advanced on a 6-inch shaft so that it stood ¾ inch, by the old marks on the shaft, ahead of its original position.

H. P. Porter.

La Fundicion, Peru.

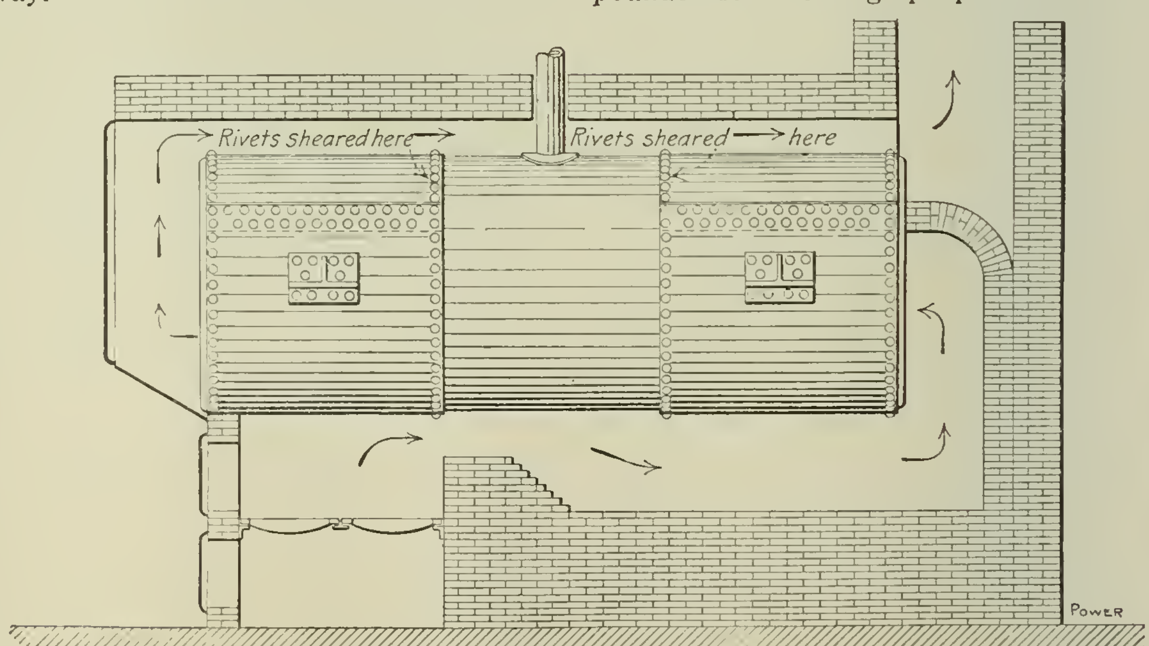
A Boiler Explosion Averted

"Some years ago," said an old engineer, "I took charge of a newly installed power plant. There were two 70-inch by 16-foot return-tubular boilers.

"These boilers had been put in with the idea of superheating the steam by bringing the hot gases back over the top of the shell, as shown in the illustration, the stack being located at the rear end of the boiler.

"Things went on apparently well for a few weeks, but one day I noticed water oozing through the brickwork near the top of the setting.

"It called for an investigation, and upon going in on top of the shell, it was found that in the seam nearest the fire, the rivets had begun to shear, some having been sheared over ⅛ inch. The plates had been left entirely unprotected and as there was nothing but steam on the inside, the seam had begun to give way.



Showing Where Rivets Sheared

"A boilermaker was called and the needful repairs made, after which the top of the shell was covered with fine loam, and no more trouble was experienced. The other boiler was also taken off and the same conditions were also found to exist on the end plate."

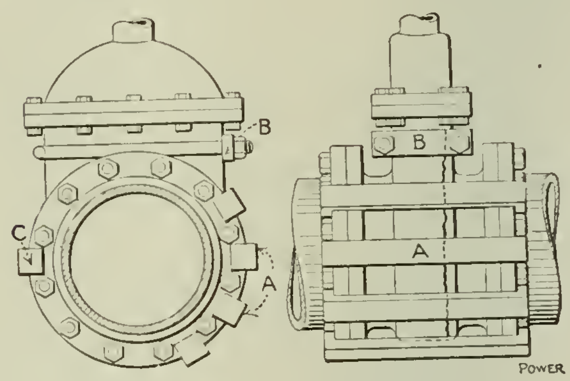
Edward T. Binns.

Philadelphia, Penn.

Temporary Valve Repair

An emergency repair job was recently made on an 8-inch gate valve that was in a water line and split, as shown in the illustration.

The valve was drawn together by four ⅝x1½-inch iron clamps *A*, shrunk on as shown. A yoke piece was made to fit around the neck of the valve, the ends



How the Valve Was Repaired

being threaded for nuts which held a cross piece *B* in place on the cracked side of the valve neck. The clamp *C* was used to hold against the other four clamps. This arrangement completely closed the crack.

W. E. Dean.

Superior, Wis.

A Drip Problem

There are two lines of steam piping in the plant where I am employed, one a 12-inch heating main, the other a 2½-inch auxiliary steam main; each pipe is fitted with a reducing valve in the engine room. The boiler pressure is 110 pounds per square inch and is reduced to 5 pounds for heating purposes and 70 pounds for the auxiliary steam lines. The piping was arranged as shown in Fig. 1 before making the change, the drip being piped as shown at *A*. It was made up of 1-inch pipe, taken out of the bottom of the 12-inch ell. A ¾-inch drip was taken out of the tee on the 2½-inch line, with valves placed as shown; both drips were connected to one outlet.

In order to drain the 12-inch main, a hose was connected to the 1-inch drip valve and discharged out of doors. After

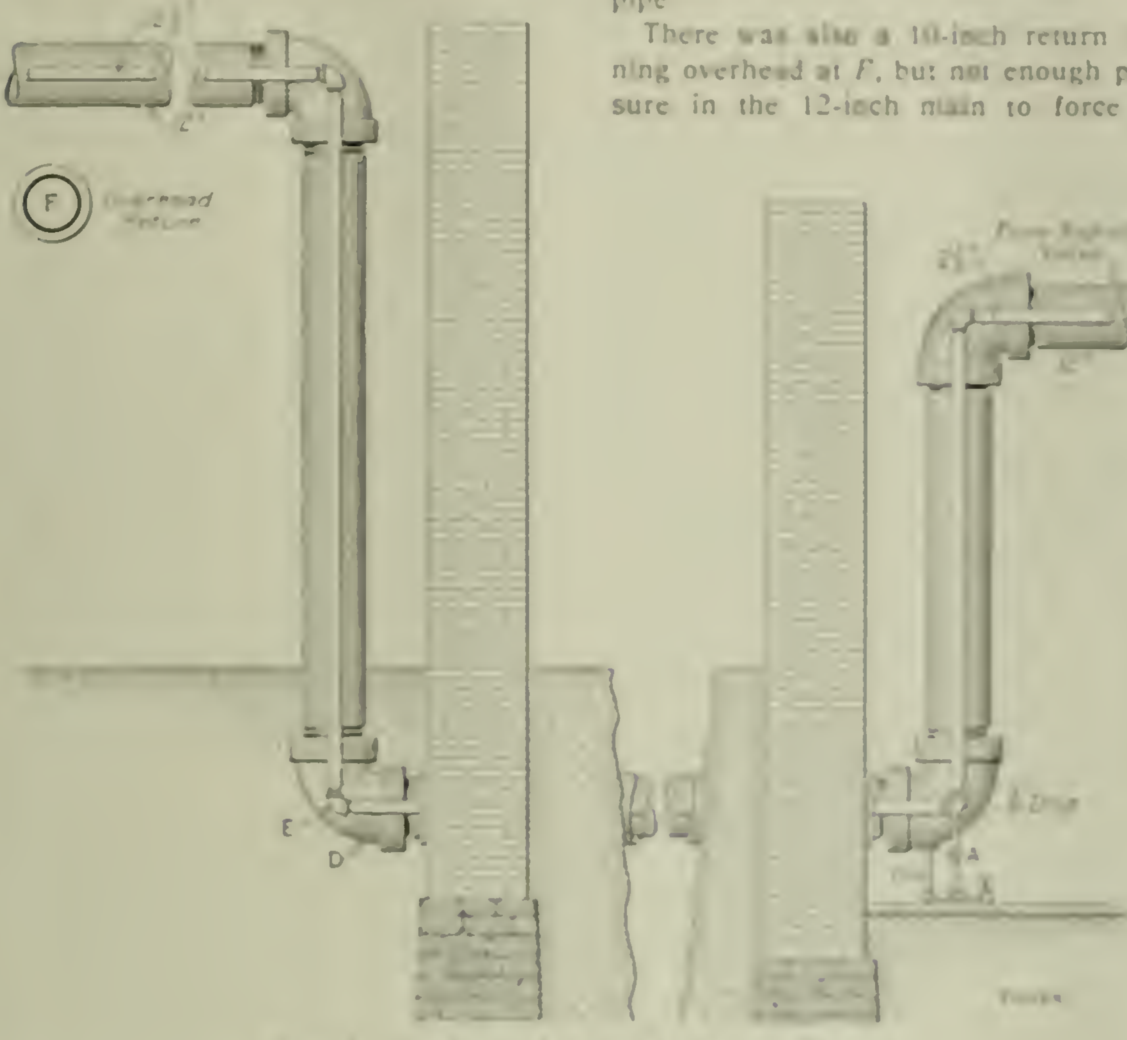


Fig. 1. Original Arrangement of Piping

opening the valve it sometimes required over an hour to drain the pipe. The ½-inch valve *A* was shut all the time and the steam in the 2½-inch line took what condensation there was over into another building. In the engine room the pipes dropped down a distance of 8 feet and ran out through the wall into a conduit across the street, then into another building, where it ran up 12 feet and overhead to three other buildings. This was an unhandy and dangerous arrangement and caused frequent rumblings in the 12-inch heating main due to water. This necessitated getting busy with the hose and drawing the water out through the drip valve. If anything should happen to the valve *A*, and the drip valve were shut, as is always the case except when drawing out the water, the steam would have a direct flow into the 12-inch main and the high pressure might burst some of the radiators.

Changing this system of piping was not as easy as it would seem. To drain both lines at *A* would mean using two traps, one for the high- and one for the low-pressure steam pipes. I could not put the low-pressure trap at *A* because there was insufficient pressure to discharge the condensation from the trap overhead and across the engine down into the receiver, and there was no space under the floor. Both pipes on leaving the engine room had a slight pitch toward *D* and I determined to drain the lines at that point. The main return pipe from the buildings ran a distance of 20 feet from *D* and 8 feet underground in a 10-inch conduit made of cast-iron water pipe.

There was also a 10-inch return running overhead at *F*, but not enough pressure in the 12-inch main to force the water into it against the low-pressure in the pipe if using an ordinary separating trap. Having an old return trap, I overhauled it and connected it as shown in Fig. 2. I broke the elbow at *E* and arranged the piping as shown. I also drilled and tapped a hole in the bottom of the 12-inch ell, and made a connection to the automatic valve at *N*. The discharge was piped to the return pipe *F*. A 1½-inch relief valve was put in this return pipe and set to blow at 10 pounds pressure so that if anything should happen the valve *N* would not shut tight and the pressure could not increase to a dangerous point in the heating system. The pipe *O* supplied the trap with steam and also drained the 2½ line of condensation, thus draining both lines with one trap.

Anson Falls.

Mattapan, Mass.

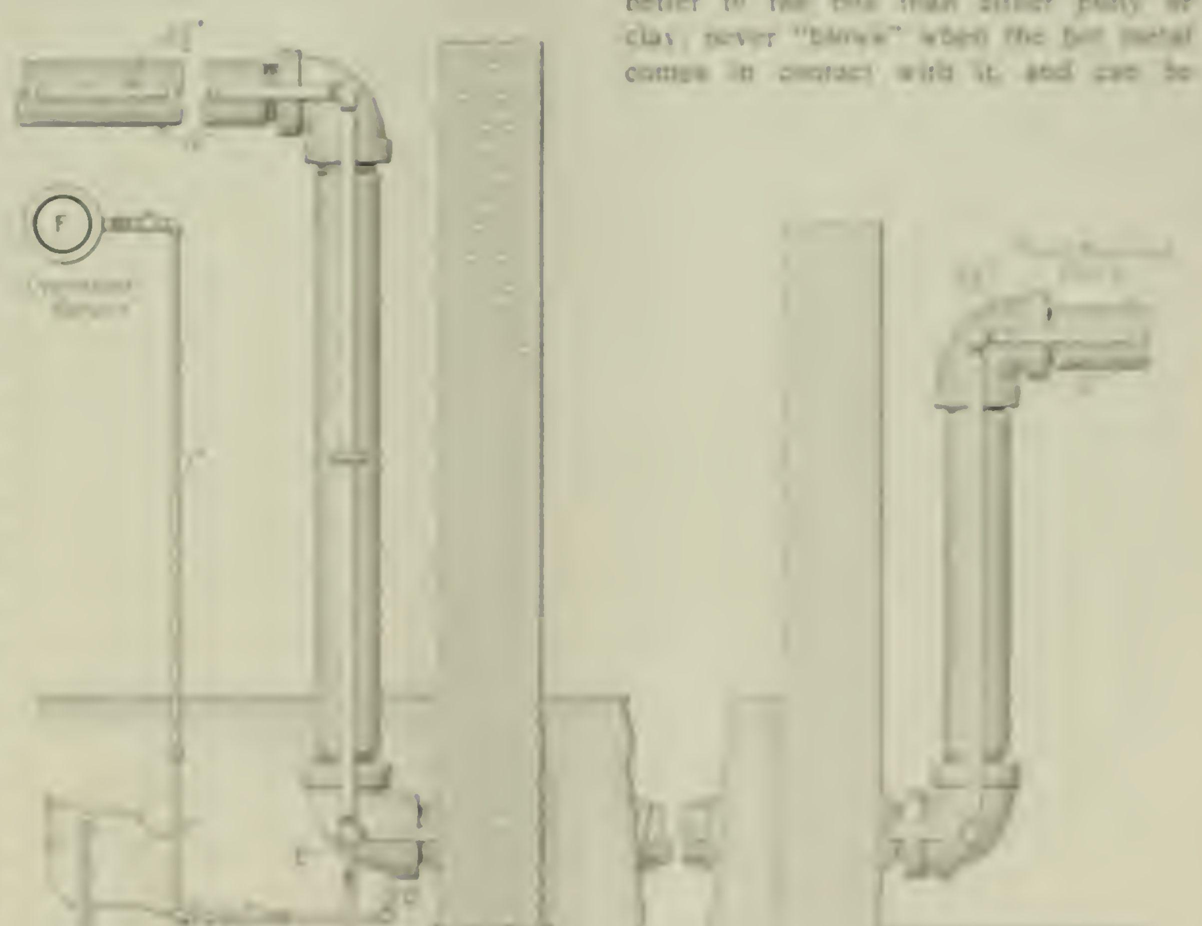


Fig. 2. Separate Trap Connection

Mixture Used in Babbitting Bearings

While visiting the power plant of the Anderson Traction Company recently, at Anderson, S. C., my attention was called to a little wrinkle in babbitting boxes.

Instead of using putty or clay for plugging up the ends of the boxes while the babbitt is being poured, some old asbestos pipe covering is ground up and mixed with cylinder oil to the consistency of a stiff putty. This mixture has these advantages: It is proof against the softening influence of heat, sticks far better to the box than either putty or clay, never "blows" when the hot metal comes in contact with it, and can be used over and over without loss or hard putty.

S. Kirlin.

New York City.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Did Not Hook On

I submit the following to S. E. Mead, regarding the indicator diagram from the low-pressure cylinder of a cross-compound engine which appeared in the May 23 number. While the diagram from the end which did not hook on shows area, it is negative area. Starting with the piston at the beginning of the stroke, the pressure at this point is due to the compression of the steam trapped by the exhaust valve on the preceding return stroke. While the engine is passing the center this steam loses some of its heat and therefore the expansion line does not follow out the compression line. In this case the expansion line is the lower line of the diagram. The steam on the forward stroke will have to expand to the point of release, which would give a constant drop in pressure if no more steam was admitted to this end of the cylinder. The area of the exhaust port for a velocity of 4000 feet per minute would be about 200 square inches or for a velocity of 6000 feet per minute about 135 square inches.

At the middle of the expansion stroke the steam below the exhaust valve is

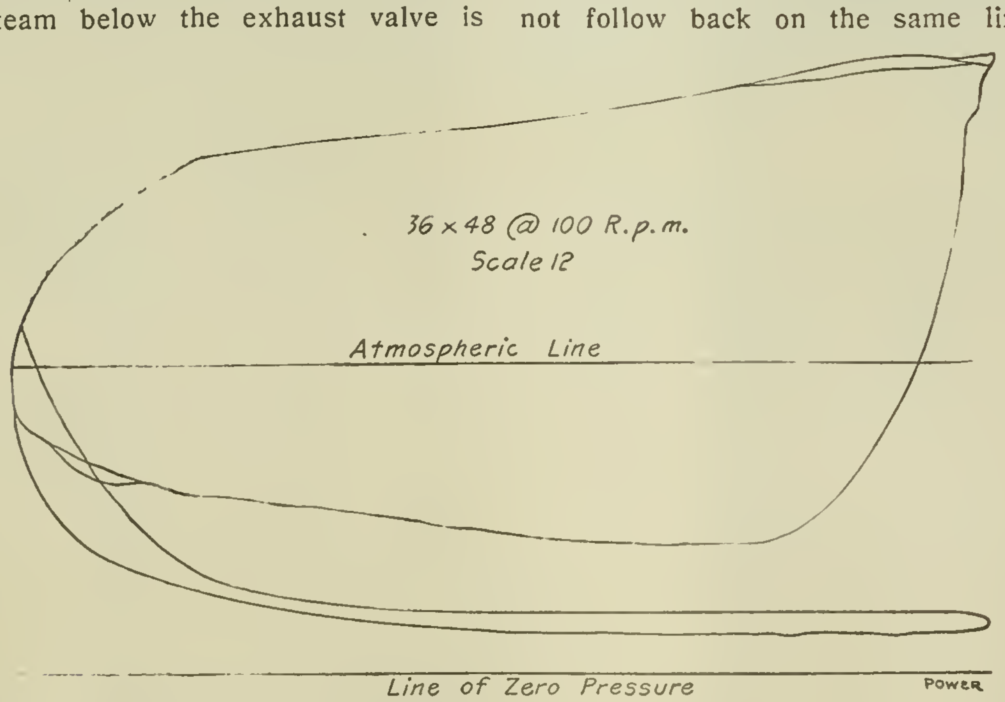


Diagram from Low-pressure Cylinder of Corliss Engine

about 5 pounds higher than that in the cylinder. Taking the smaller area,

135 × 5 = 675 *pounds*

lifting this valve from its seat. I believe this exhaust valve lets a little of this steam into the cylinder and holds up the expansion line.

After the compression begins in the opposite end of the cylinder the condenser removes the excess pressure down to the upper line of the diagram under discussion, the exhaust valve opening, and the pressure in the cylinder raises to that in the exhaust pipe connecting with the condenser.

On the return stroke this pressure holds nearly constant, rising a little with the velocity of the returning piston until the closing of the exhaust valve, when the steam is compressed to the highest point of the diagram, losing some heat and pressure as the piston is nearly stationary when the crank is passing the center.

Lester Fitts.

West Fitchburg, Mass.

Mr. Mead asks why this diagram has any area, why the expansion line does not follow back on the same line as the compression, and why the expansion line runs practically parallel with the atmospheric line.

In experimenting with an indicator a few weeks ago, I prevented one steam valve from hooking on and took an exact duplicate of Mr. Mead's card except that mine was from the high-pressure cylinder.

Consider the diagram to have been taken from the head end of the cylinder and start the diagram just as the piston starts to move from the crank end; steam is then exhausting into the condenser through the head-end exhaust valve. This subjects the cylinder and the indicator connected to the head end to the pressure existing in the condenser, which is practically constant and therefore accounts for the line parallel to the atmospheric line which Mr. Mead calls the "expansion line," when it really is the exhaust and compression line. When the exhaust valve on the head end closes for compression this line takes an upward turn; this is the compression line which ends as the piston reaches the head end of the cylinder.

As the piston starts on the return stroke the steam valve does not open, the exhaust valve is also held closed, the small amount of steam compressed in the head end condenses and expands rapidly, as the volume increases, until it reaches a point lower than the pressure in the condenser; just how much lower this will be than the pressure in the condenser depends on the tightness of the valves and piston.

The area represented by this diagram is work done in moving the piston against the unbalanced pressure between the condenser and the head end of the cylinder. This work is done during this stroke by the flywheel.

A consideration of the different events and their relation to the diagram should make the diagram plain.

C. B. Hudson.

Lowell, Mass.

Getting a CO_2 Recorder

The article in the issue of May 9 on The Value of the CO_2 Recorder, written by H. S. Vassar, was very interesting.

I am the mechanical engineer for a Nevada concern engaged in the mining and reduction of copper ores. We have a 10,000-horsepower plant, 160 miles of railroad and extensive shops, employing about 2000 men. The plant is four years old and has been very successful throughout.

I have been given a free hand in operating the plant, the management only demanding that the cost per horsepower per annum be as low as was consistent with proper upkeep.

As coal costs about $6 per ton in Nevada, I have been very keen about anything which would reduce its consumption per indicated horsepower, and so fell an easy victim to the CO_2-machine man when he appeared.

I was getting an evaporation of 9.40 from and at 212 degrees Fahrenheit with coal which analyzed as follows:

Free carbon, 53.5 per cent.; volatile, 35.5; ash, 4.8; water, 6.2; total, 100 per cent. This gave 12,975 B.t.u. per pound of coal and indicated a boiler efficiency of 70 per cent. Daily records of coal and water were kept, recording thermometers were placed in the hotwell, the heater, the econnomizers and the flues, and I also had recording pressure gages on the stack, the forced draft and the steam header. The CO_2 recorder, seeming to be the final touch required to give complete data on the plant and put me in a position to evaporate the last possible drop of water per pound of coal, I placed a requisition for one forthwith. Three months later the machine arrived, without instructions for assembling, piping or operating. I sent for the instructions, which were received a couple of months later. Then I discovered that some of the ground-glass connections were loose enough to leak and not loose enough to get in any packing, but after some experimenting I found that a mixture of glycerin and litharge would seal the opening and not dissolve under the action of the fluids used in the machine.

Then I found that the rubber tubing was old and leaky. It was replaced. The marking pen was poorly made, and after fooling with it for some time I replaced it with a thin sheet-silver pen which we made at the plant. Next the draft obtained by bypassing the economizer proved too small to pull the gas sample through, and this I corrected by putting in an aspirator worked by compressed air. It then developed that the amount of draft must be regulated within very narrow limits; too much pulling the solution through and too little gave no results at all, this feature causing more trouble than any other one thing about the machine.

Of course, there were incidental occurrences along with these; the cotton thread between the float and counterweight broke twice in the night and resulted in mixing the various solutions; then mud kept getting into the water line and choking up the needle-like jet which furnishes power to operate the recorder. I finally got so I could make the machine work for a few days at a time, then something would happen, which meant a complete readjustment throughout.

I believe that for six months I devoted more attention to the machine than to the rest of the power plant, and in that time I acquired sufficient skill to keep the recorder going for a few days at a time.

As a result of my spending so much time in the fire room I improved the system of firing in vogue, made some improvements in the methods of coal and ash handling, and found some air leaks in the flue system which were cooling the gases passing through the economizer. None of these improvements, however, were due to the records from the machine.

During the periods in which the recorder condescended to record, I would select one battery and experiment with the different methods of firing, keeping track in the meantime of the rate of evaporation per pound of coal. I was by this means able to spot a few of the firemen who were too deliberate in their movements when the fire door was open, but I could not get any relation between boiler efficiency and the percentage of CO_2.

Lindsay Duncan

McGill, Nev.

Isolated Plant versus Central Station

From time to time I have noticed in the columns of Power articles, both pro and con, regarding the isolated power plant. After reading these articles I believe that both the arguments in favor of and against the isolated plant have very little real bearing on the subject. It seems to me that this is a matter which must be decided individually, as each existing case has its own characteristic peculiarities which must be considered and which enter largely into its determination.

For instance, in the May 23 issue, Mr. Rushmore cites a case as an example where the isolated plant is a great deal cheaper than buying power from a central station and gives very convincing figures substantiating his claims. One cent per kilowatt-hour is certainly cheap for power from a station of only 350 horsepower rated capacity. He has certain existing conditions, however, such as using part of his producer gas for purposes other than power, which practically preclude all thought of getting power from a central station.

On the other hand, there appears in the same issue, on page 822, an editorial which states that the manager of a certain hotel says "that if he had it to do over again he would install central-station current." The editorial further states that if this manager would pay wages that would insure competent engineers to run his plant, he would have no cause to regret having his own power plant; nevertheless, he is not satisfied with his present installation.

Naturally I do not wish to advance this letter as an argument in favor of the central plant; I merely wish to point out the fact that the isolated plant is not universally the better proposition, although it may be so in a majority of cases.

I had a little experience a few years ago regarding the power question in a small shop of which I had charge, where we gave up generating our own power and secured it from a power company.

When I took charge, the power plant consisted of four gas engines, two of which were rated at 50 horsepower each and the other at 30 and 20 respectively, making a total of 150 horsepower. We used natural gas, getting it from the local gas company. Three of the engines were belted to direct-current generators and the fourth to one of the line shafts on the main floor. This equipment was located in the cellar, was difficult of access, and every spring was subject to considerable water seeping in and damaging the machinery.

We had some ten or twelve motors, all smaller than they should be, scattered throughout the shop to run the machines.

The engineer in charge of all of this equipment was getting $75 per month, plus about $25 for overtime, which he managed to put in on some pretext or other. Questioning this man as to the operations of his engines, etc., he told me that the whole plant was very much run down and sadly in need of a thorough overhauling. I also learned, much to my annoyance, that much time was lost in starting the engines in the morning—we were only running single turn—particularly on Mondays, because of losing over Sunday the air pressure in the receiver tank used in starting up. Often about a dozen men would be in the engine room pulling away at the belts, trying to turn the engines over. In addition, we received regular complaints and threats to move from one or two of our tenants on the upper floors who needed power for light manufacturing.

I lost no time in getting at the problem of better power facilities and, after some figuring on the subject, decided to call in a central-station man and see what he had to offer. He agreed to furnish us power on a sliding-scale basis, similar to that spoken of by Mr. Rushmore in the article mentioned above, at the rate of 2½ cents per kilowatt-hour for the first 1000 kilowatt-hours and 2 cents for all over and above that amount. The minimum charge per month, however, must be $150.

This offer was accepted and we immediately began changing over. I found there were large line losses under the old system so we had the entire building rewired and, as far as practicable, particularly on the larger machines, we installed individual drives.

The current put in was three-phase alternating current with induction motors. We decided upon this system largely because of the great expense for repairs on the old direct-current motors, the repair work being done by an outside concern.

While this increased the initial cost somewhat, we figured that the continued saving would justify the expense. We also figured that we would only pay for the current actually used and instructions were issued to always stop the motor when changing work on the machines, etc.

Our tenants' agreements guaranteed a total minimum power charge of $50, thus reducing ours to $100.

After the new installation was completed, we disposed of the old engines, generators and motors as well as the engineer. Summing up the whole situation, I found that our tenants were perfectly satisfied and that we were getting better power service than ever before, and at no increased cost. We were also able to run one or more machines overtime as our work occasioned, without the necessity of operating a 50-horsepower engine to run a 10-horsepower motor and pay a man in addition to watch the engine.

I do not deny that it might have been possible to fix up the old plant so that we would have had practically as good results, but I doubt that it could have been done as cheaply, and I also doubt that the cost of our power would have been any less. The installation of an entirely new plant, modern in every respect, would undoubtedly have given cheaper power, but with a small concern such a large outlay of money as this would entail is a serious question.

I give this example merely to show that "circumstances alter cases."

EVERARD BROWN.

Pittsburg, Penn.

Writing for the Technical Papers

I quite agree with Joe Smart, whose criticism on my advice to writers is based upon the axiom, "If worth doing at all, do it well." However, there are altogether too many who are deterred from telling us many interesting facts because they are afraid of their ability and of the labor involved in avoiding mistakes in diction and spelling—and fear that the editor will turn them down. If there is a good story in your system, get it out. When you have got the first one out, others will follow more easily. Of course, it would be real nice if each one of us had a typewriter, an Encyclopædia Britannica, and a Century and a Funk & Wagnalls dictionary. But once having seen some of his ideas in print a few times, and found out how nice the water really is, he is a dead one indeed if he is not bitten with the idea to improve himself. It is at this stage of the game that the suggestions outlined by Mr. Smart should be adopted. The main thing is to get the first message out.

Too many good stories die stillborn, because the writer endeavors to make a literary monument of them and is smothered in the mass of detail raised by his own hand, details which do not affect the worth of the idea, but which cause the embryo author to take a course around the block to reach the house next door. I do not deny the value of writing and rewriting; then rewriting and setting the manuscript to one side, perhaps to be entirely rewritten at a later date. I consider this time well spent, but the new writer, the one I am after, has neither the time nor the patience to do this, though later on he will, if ambitious and properly inoculated with the desire to write.

Before one can run he must learn to crawl and then to walk. The best way for the new writer telling his first story is to tell it in the same way he would relate it to one of his mates. If he has a message, the editor will come back at him to get all he has left out. Of course, this takes time, but POWER has found it worth while to do this.

A. D. WILLIAMS.

Cleveland, O.

Belting vs. Electric Transmission

Replying to the communication of Henry D. Jackson, which appeared in the May 2 issue of POWER, I am disappointed, to say the least, that he regards my letter in the issue of March 21 as "taking exception" to his article in the February 14 issue.

A perusal of my letter will, I think, satisfy any impartial reader that the general trend of its subject-matter is in corroboration of Mr. Jackson's exposé of cases where owners of shafting transmission have been "flim flammed" by adopting motor drives.

There is no occasion for commenting on his enlargement and confirmation of several points suggested in my letter. But I do wish to disclaim having attempted to make so thorough an enumeration of advantages of electric drives as to demand designation of a "tabulation of advantages."

As to the additional advantage of motor drives pointed out by Mr. Jackson—that by their use greater uniformity of speed is obtained than by shafting transmission —it is a fact that this is not true in all cases. Occasional drop in voltage and in speed of motors is liable to be experienced with current supplied from the best power plants due to variation in speed of engines or other prime movers, though speed may be corrected more quickly and more easily than with shafting transmission.

The influence which slip of belts has on "production factor," mentioned by Mr. Jackson, cuts a small figure in the average manufacturing plant having properly designed shafting transmission. If speeds are found to fall away from intended ratios, what is easier than to adopt ratios of pulley diameters which will compensate the slip?

One advantage of electric transmission which has not been referred to is that, with or without economy for power, it has wiped out of existence many poorly designed systems of shafting transmission.

Viewed solely from the standpoint of economy for power, the advantages of electric motor drives cannot materialize by the insertion of motors up to the point where the cost of power by shafting transmission balances the cost for power by motor drives. Beyond that point we may confidently look for economy in favor of the motor drive; but no hard-and-fast rules can be laid down to be safely used by tyros in determination of that point. Each proposition for substitution of shafting drive by motor drive, or choice of initial installations, must stand on the merits of conditions, and for successful determination the conditions require intelligent and disinterested engineering analysis.

Average American manufacturers pride themselves on their alertness in adopting improvements that are conducive to economy, but when it comes to inaugurating improvements they are seldom moved to engage advice beyond their own organization. It is not until mistakes have become unendurable that they are brought to realize that something different might have been.

FRANKLIN VAN WINKLE.

Paterson, N. J.

The Need of License Laws

There have appeared in recent issues of POWER several articles on how the average engineer might better his condition and fit himself for promotion. I hearily agree with the suggestion that each State or city adopt license laws. If an engineer were compelled by law to satisfactorily discharge his duties, many of the accidents occurring today would be avoided. During a visit to a small country town a saw and cider mill, which also boasted of a small grist mill, came under my observation. There was a small slide-valve engine, about 10x22 inches, running, or trying to run, at about 120 revolutions per minute. While examining the engine I was accosted by the engineer, who was also the owner, the sawyer and the mill operator. Upon learning that I was an engineer he proceeded to enlighten me regarding his experience, to the edification of several spectators, as follows:

"So you be an engineer, be ye? Wal, what dy'e think of that fer an ingine! Never laid out a dollar on her in 15 years. No, siree; never had the cylinder head off. The feller that fixer her up fer me told me not to let anybody monkey with her but myself, and, b'gosh, I ain't either, and she's better'n she ever was.". I remarked that she must be a pretty good engine to run that length of time without any repairs. "Wal, the feller that fixed her up was a mighty good mechanic, but he did have a job to rig her. Yer see, when ther ingine first come here ther blamed stuff that goes in the cylinder was all broke ter pieces and was sent in a pail. That feller ha'd some job fixing them pieces together. He said he had to buy a bigger biler as ther old thing was leaky and didn't hold steam enough."

I said that probably the piston was down and that steam might be blowing through to the exhaust.

He replied: "No, siree; how in thunder could the piston get down? It was a tight fit after the feller had got all ther pieces together, for he had wired them all up. As he hadn't taken ther cylinder head off how in thunder could ther durned thing cum down?"

As I watched him he prepared to saw a log, having obtained the necessary steam. As soon as the log approached the old engine slowed up badly.

He explained this by saying that, "Ther governor took some little time to git a hold on her; she didn't always work that way."

Let those who oppose the passing of a license law visit such a plant as the above and I am confident they will cease their opposition.

Bridgeport, Conn. H. TAYLOR.

Piston Rings

In Lloyd V. Beets' article on packing rings in the May 2 number, Mr. Handley's sketch showing side plates fastened on the ring lap with small screws is a poor apology for a joint and there is not much merit in the lap joint offered by Mr. Beets. I have had these same joints

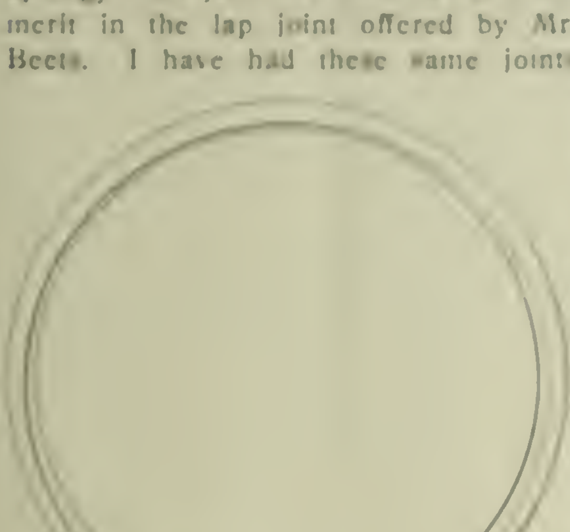


FIG. 1. ONE METHOD OF MAKING TIGHT PISTON

to contend with in practice, both to repair and to replace, and the small screw that holds this lap in place can never be kept tight. The only way to make this joint secure is by using rivets of brass or copper. The small springs will not stay in place for long, and when they wear off will cut the cylinder or the side plates. Both constructions from a practical point of view are useless and unsafe.

Fig. 1 shows one of the better ways of making a tight piston, the block *E* at the bottom of the piston being simply a section turned to fill the groove. With a well formed ring making a joint at *M* on either side there will be no doubt about making a satisfactory job. I have seen this type of ring give satisfactory service after being in constant daily use for a period of 10 to 12 years. The tension of the ring keeps the joints in contact until the ring has been completely worn out.

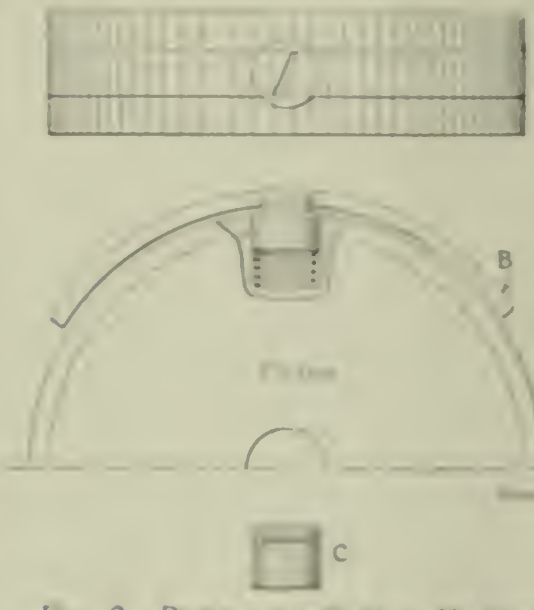


FIG. 2. PLUG AND SPRING METHOD

Fig. 2 shows another method of making a good ring joint. A bronze plug is sunk into the ring groove, as shown, with a heavy spring beneath it to set it out. As the spring is placed beneath the plug there is no chance for it to break and damage the cylinder. A ring fitted to the groove, with a dowel on the side so that the ring will not turn too far, will insure a good tight piston. The ring is shown set out of place at *B* in Fig. 2 and a cross-section of the ring at *C*.

C. R. MCGAHEY.

Baltimore, Md.

Return System

In the April 18 number, page 610, William Bopp asks if the drips from the steam mains, separators, reheating coils and four engines which are collected in a manifold in the basement 20 feet below the boiler water line, and having 10.5 pounds pressure less, can be returned to the boiler by the Holly system.

The condensation in this manifold may be returned by a Holly system, of which the discharge chamber has a vertical hight of 42 feet from its bottom end above the boiler water line, the diameter of the riser and other pipes to be determined by the size of the job, of which no mention is made. The average Holly receiver is 30 feet below the boiler water line, and many of these are 50 feet or more.

RUSSELL B. HOBSON.

New York City.

Test for Valve Leakage

In answer to S. Kirlin's article in the issue of April 25 referring to the high steam consumption of a four-valve engine, I would suggest that if he close the steam and exhaust valves, open the indicator cocks and the throttle, he will see a display of high-pressure steam that will explain to his entire satisfaction that the cause of the high-steam consumption of this engine is not the long dry pipe but leaky valves.

Many engineers will no doubt be surprised to learn that the loss due to valve leakage amounts, in many cases, to 50 per cent. or more of the steam used.

O. H. LINDEMAN.

New York City.

Central Station Failure

The failure of central-station service due to fire or other acts of Providence certainly furnishes a strong argument in favor of the isolated plant.

Such an instance occurred recently in the central district of Philadelphia when an early morning fire damaged the plant to the extent of about $250,000 and interrupted the service for several days. While the actual fire damage was comparatively small, it resulted in temporarily putting the entire plant out of commission and in causing immeasurable inconvenience to its consumers.

As the result of this failure of service many small manufacturers were unable to operate their machines and had to dismiss their employees. In some of the large office buildings it was impossible to run the elevators and many business men and clerks had an enforced holiday. In some of the large stores the loss of power for elevator and for lighting service made it necessary to suspend business. This caused a loss of about $250,000 in sales alone.

These few instances serve to show the large financial loss that manufacturers, mechanics, business men and merchants may suffer through getting their service from a central station. It now remains to be seen whether they will profit by their experience.

In abandoning their isolated plants many of power overlook the possibility of such a contingency as cited above, and would be their sorrow they have found to be small. Possibly, if they take advantage of the Philadelphia instance's experience, overhaul their power plants and secure the services of an efficient engineer at a suitable salary, they may be surprised to find that not only are continuity of service and independence assured, but that there is also a saving in the cost of power. Such a result is not impossible.

C. WISE.

Philadelphia, Penn.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Effect of Eccentric Advance

What effect has increasing the angle of advance of a plain slide-valve engine eccentric on the amount of port opening?

C. N. M.

It does not affect the port opening because it does not change the valve travel. The effect of angular advance of the eccentric is to bring all of the events earlier in the stroke. Lead and compression are increased and release and cutoff hastened.

Momentum of Railway Train

A railroad train weighs 600,000 pounds and is running on a level track at the rate of 45 miles per hour. Suppose the steam shut off and no brakes applied. How far will it run before coming to rest?

J. McC. C.

The train velocity in feet per second would be

$$\frac{45 \times 5280}{3600} = 66 \textit{ feet}$$

The energy stored in the train would be

$$\frac{WV^2}{2g} = \frac{600{,}000 \times 66^2}{2 \times 32.16} = 40{,}634{,}328 \textit{ foot-pounds}$$

The sum of the products of the average resistances into the distances through which they are overcome must equal this number. Each axle bearing, for example, has a certain resistance to turning which depends upon the weight it carries, its diameter, its condition as to smoothness, temperature, lubrication, etc. This resistance measured in pounds applied at the radius of the bearing and multiplied by the number of feet through which a point on the surface of the bearing would travel would be the number of foot-pounds absorbed by this particular bearing. Then there is the rolling friction of the wheels on the track, the friction of the engine pistons, valves and connections and the windage, a very important resistance when the speed is high and diminishing as the speed increases.

The subject of train resistance is a complex one and not enough is known about it to solve the present problem with the information given.

Opening of Drain Cocks

Should the drain cocks on the cylinders of a duplex pump be open when starting up?

E. S. H.

Drain cocks are provided on steam cylinders for the purpose of drawing off any condensation that may interefere with the proper action of the machine. While no material damage may result from the starting of a direct-acting steam pump, as would be in the case of an engine, the pump will start more easily and more quickly with steam than with water. Some engineers allow the drain cocks on steam pumps at the end of long steam lines to blow a little all the time to make sure that water does not accumulate in the cylinders and make the pump action irregular.

Alternating-current Generator and Motor Speeds

Does the speed of an alternating-current generator affect the speed of an induction motor taking current from its circuit?

H. E.

Yes; the speed of the motor is directly proportional to the frequency, under any given set of operating conditions, and the frequency is determined by the generator speed.

Transformers

How many kinds of transformers are there?

H. E.

That depends on what you mean by "kind." There are single-phase and three-phase transformers; also constant-potential and constant-current transformers. Any of these may be of either the core type or the shell type. Read Mr. Meade's article in the issue of March 29, last year.

Effect of Pulley Coverings

Does covering a pulley increase its efficiency? Is canvas a suitable covering? What kind of cement is used to hold it? Can a steel pulley be covered as effectively as a wooden one?

E. L. D.

Pulley coverings increase the friction of the belt; consequently the power that may be transmitted is also increased. Canvas is frequently used and is secured by glue. Steel and iron pulleys may be as readily covered as wooden pulleys if the metal is cleaned and painted.

Object of Two Eccentrics

What is the object in placing two eccentrics on Corliss engines?

O. T. E.

An additional eccentric was first put on Corliss engines for the purpose of getting an early opening of the exhaust valves without reducing the range of cutoff. Incidentally, it is used to provide for a range of cutoff beyond half stroke.

Water and Oil in Compressed Air

We have been experiencing trouble from water coming through with the air from our compressor. Sometimes small particles of oil will pass. The air, as it leaves the compressor, is warm and it occurs that if this air were cooled to a point lower than it would again become and drained at the point of lowest temperature, that it would not again form water.

O. J. B.

An aftercooler, as it is called, built something after the manner of a closed feed-water heater, or a surface condenser, will lower the temperature to a point where most of the water will separate from the air. From the aftercooler the air should go to a large receiver with inlet at the top and outlet about half way up on one side. Here the remaining water and oil will fall to the bottom and may be drawn off.

Curing Premature Ignition

A single-acting gas engine runs smoothly at light loads but thumps badly from premature ignition when fully loaded. The compression can be changed by screwing the piston rod into or out of the crosshead block; will that help matters?

E. B.

Possibly, reducing the compression by screwing the piston rod into the block one or two threads may cure the trouble. It is possible, however, that your ignition is advanced too far for full-load conditions. Better try adjusting the ignition for less advance before you make any such fundamental change as altering the compression. Also examine your exhaust gas and see if it is black and sooty; if it is, the premature ignition is due to too rich a mixture.

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Contents

POWER

A Heating and Ventilation Department

For some time there has been a demand for a heating and ventilation department. We have, of course, published articles on these subjects from time to time, but there has never been a definite location in the paper to which readers interested in such matters could turn and find all the material contained in any one issue.

Beginning with this issue the new department will alternate with the refrigeration department, therefore appearing every other week. Material such as will be useful to the practical operating engineer is specially solicited, although some consideration of the fundamental underlying principles and directions for figuring the amount of heating surface required, the amount of boiler surface necessary to supply it, etc., will not be out of place.

"Old Sol" will, of course, deliver all the heat that is necessary for the present, but now is the time to get the system in shape for next fall. Tell the other fellow the troubles you have had and what you are doing to overcome them. We need this kind of material to make the department a success.

The Central Station Viewpoint

The article on "Analysis of Industrial Power," which appears elsewhere in this issue, is representative of the central-station point of view. Undoubtedly, in many small plants the cost of power is figured without due regard to the fixed charges; items of interest, depreciation, and obsolescence are ignored, and as a result the apparent cost represents the operating expense only.

All items which legitimately belong to the fixed charges should be included; but, as a rule, the central-station advocates are not content to play the game fair, and insist upon burdening the isolated plant with all sorts of fictitious charges. These tactics are employed in order to offset the enormous overhead and distribution charges which the central station is forced to carry. The isolated plant does not have to pay a *franchise tax*; it does not have to pay high-salaried officials nor expert solicitors for canvassing new business; and it is not burdened with the initial cost and upkeep of an elaborate distribution system.

According to the reports of the Public Service Commission, the actual operating expense of a large central station in New York City forms only twenty-six and one-half per cent. of the total cost of production, the remaining seventy-three and one-half per cent. being made up of overhead and distribution charges. Furthermore, this same company is capitalized at over four hundred and forty dollars per kilowatt of rated capacity. Considering that a small up-to-date plant may be installed for about one hundred dollars per kilowatt capacity, the comparison is striking. In view of the foregoing, it would make interesting figures if some of the arguments of the central-station people were applied to their own plants.

Reverting to the previously mentioned article, a statement will be found to the effect that tenants in a building are obliged to pay a *pro rata* share of the plant investment and other fixed charges; hence, when comparison is to be made between two similar plants only the operating costs need be considered. Granting this, why should the plant be charged again with these fixed items of expense when comparison is to be made with central-station service? Surely the tenants' rent is not reduced.

Furthermore, it is contended that a plant should show a return upon the capital invested equal to that of the average manufacturing business. This is the "marginal principle" upon which we have expressed opinions on several occasions. It will suffice to say that this principle is applicable only when a man is at the limit of his credit.

In Table 1, which represents a report for an isolated plant using exhaust steam for heating, provision is made for the time and thought given to the management of the plant by the superintendent. In Table 2, however, which represents a report covering a case where power is purchased from a central station and a separate heating plant is installed, the superintendence item is omitted. It would seem that the supervision and attention in the second case would require nearly as much of the superintendent's time as in the first case.

Again, it is claimed that the presence of a power plant materially increases the insurance rate on the rest of the building. This contention is groundless, for where the requirements of the building laws and the Fire Underwriters' Code are met, it has no effect upon the rest of the establishment.

Perhaps the most absurd contention of all is that which refers to the loss of output due to a variation in voltage in the case of the isolated plant, and a consequent charge against the plant to cover this loss. While it is true that few small plants are equipped with voltage regulators, still, with a good engine governor and a watchful attendant the voltage should be kept within two or three per cent. If it varies as much as five per cent. there is something wrong with the equipment or the method of operation, but the isolated plants as a class should not be held accountable.

Where there are a number of customers supplied from a central station by a feeder of considerable length, it is impossible for them all to receive current at the same voltage. If the regulation at the switchboard is effected so as to supply those nearest the power house at the specified voltage, those at the end of the line suffer, and *vice versa*. In any event, there is a significant drop in voltage which is apt to be greater than that in the average isolated plant.

As there are two sides to every argument it is only fair that both the central-station and the isolated-plant advocates be heard. However, the intelligent engineer or superintendent will not be misled by unreasonable claims of either side but will select the sound arguments and formulate his opinions thereon.

Ignorant or Careless?

One State and one municipality have this year taken steps forward in the matters of engineers' licenses and boiler-inspection legislation. On the other hand, bills providing for such supervision have been turned down by the legislatures of Colorado, Connecticut, Indiana, Iowa, Maine, New Hampshire, New Jersey, New York, Oregon, Pennsylvania and Rhode Island. Just why such reactionary and unsound views should be held by the legislators of these States is not clear.

We have been reliably informed that since the creation of the Board of Boiler Rules by the legislature of Massachusetts, there have been installed in New Hampshire, Connecticut and Rhode Island boilers that have been forbidden entry and installation in Massachusetts because they were manifestly unsafe for power-plant purposes.

By what mental process a Connecticut law maker arrives at the conclusion that a boiler which is unsafe in Massachusetts is safe in his own State is not easily imagined. Why a New Hampshire legislator is willing to have his State called the dumping ground for worn-out Massachusetts boilers or is opposed to having it known as a commonwealth where some regard is paid to the common safety of its people is also very obscure. In fact, it is incomprehensible that any class of men could be so completely forgetful of the duty they owe to society as to deliberately sidetrack or kill any proposed measure to enhance public safety.

It is not to be expected that legislators should know all about these things without being shown, but it would seem that the most ordinary degree of intelligence and common regard for human life would prompt them to investigate the merits and meaning of measures of the kind under discussion before condemning them. It is assumed that legislators have ordinary intelligence; if this assumption is justified, then some of them evidently do not care anything for the hazard to life and property represented by an uninspected or improperly operated steam boiler.

Opportunities for Self Advancement

There has never been a time when the young man had more or better opportunities for self-advancement than at present. Few consider the strides that have been made within the last twenty-five years or that will be made in the future. Each succeeding generation of young men holds the mistaken idea that the day of opportunity and possibilities to succeed belongs to the past. They lose sight of the fact that success is attained by earnest, hard work.

Looking back twenty-five years, many of us can remember when a boiler carrying one hundred pounds pressure of steam per square inch was out of the ordinary. Men saw the need of high steam pressure and boilers were designed to meet the requirements.

It is but a few years ago that the electric light was in the experimental stage and the electrically propelled street car was unknown. But the opportunity was at hand and as a result artificial daylight has been obtained and street cars are counted by thousands.

The gasolene engine is another instance. The possibilities of this type of prime mover were made apparent, and from the once unreliable unit used to run a wood saw, gasolene engines are now built in capacities ranging as high as 5400 horsepower.

So fast have been the developments along mechanical and scientific lines that we take a new discovery or invention as a matter of course, exclaim "What next?" and go on with our work. Men pay the toll for a wireless message much the same as they would for a shoe shine, and seldom consider the thought and energy which have been expanded in perfecting the wireless apparatus.

An engineer may say, "I am not an inventor." He does not invent, it is true, but every engineer can discover some method whereby power can be developed cheaper than under old conditions.

Every man has his opportunity. Some profit by it, others do not see it at all and others think it is not worth while.

One thing to remember is that when the chief engineer of a plant wants an assistant he will not select the man who has not shown that he has qualifications for filling the position.

Every chief has his eye on his subordinate, and unless the man can show that he is capable and willing, has original ideas and exercises them, besides having a practical knowledge pertaining to his work, he cannot expect that he will be the fortunate candidate for advancement.

It is not a bad idea to learn to work, but one cannot do that while looking at the clock with one eye and for Saturday night with the other. One of the mistakes made is to assume that a certain work is beneath one's dignity. The successful men are those who have formed the habit of doing the best they know how, no matter what task has been given them. A capable workman will not be asked to do the common work after he has shown his worth. Giving a dollar's worth of work for eighty cents' worth of wage is a practice that leads to ultimate success. It is the man who fears he will give more than he receives who fails to see the opportunities as they appear.

There are opportunities before you now. They will be before you tomorrow. Wake up and make use of some of them.

In all phases of the steam engineer's vocation there are efforts and resultant achievements and the intensity and intelligence of the efforts determine the value of the achievements. Perfunctory, half-hearted effort never "gets anywhere"; neither does ignorant groping around, however vigorous.

Have you noticed how some men neglect the oil supply and then wonder why that bearing ran hot?

Have you ever noticed how overbearing some chiefs are with the firemen and ashmen?

Recording instruments in a power plant are valuable instruments, but if you do not know how to read and handle them they might just as well be in the other man's plant.

Leakage past a solid plug or piston valve is a hard matter to determine, but that there is leakage is well known. The amount depends on many things; probably the first is the quality of the material of which the engine was built; the second, possibly, the accuracy with which the engine was built; and, thirdly, the care with which the engine is handled.—*The Engineer*.

Heating and Ventilation

Considered as power plant problems. Layout and operation of systems and apparatus

The National District Heating Association

The third annual convention of the National District Heating Association was held at Pittsburg, Penn., on June 6, 7 and 8. The sessions were held in the banquet hall of the Fort Pitt hotel, the first being called to order at two o'clock on Tuesday afternoon, when President George W. Wright, of Baltimore, presented his annual address and the association was welcomed to the city by representatives of the mayor and the Chamber of Commerce. E. J. Keifer, of Easton, Penn., presented a progress report of the committee on data and the committee was continued to complete its work, which has been largely preparatory.

At this and subsequent sessions the following papers were presented, several of which with their discussions will be treated at length in other columns and issues: "Investigation of the Transmission of Heat through Radiating Surfaces," by Prof. John R. Allen; "Heating Franchises," by A. C. Gillham; "Results of Measuring Station Load by Venturi and General Electric Meters," by F. C. Chambers; "The Heating and Ventilating Equipments of the City Investing Building, New York City," by J. Byers Holbrook; "The Preparation of a Rational Rate System," by R. D. De Wolf; "Superheated Steam," by W. E. Dowd, Jr.; "Handling Customers," by George W. Wright; "Best Systems of Radiation for Economy and Steam Consumption When Fed from a District Heating Station," by Walter J. Kline; same for hot water, by A. C. Rogers.

On Tuesday evening the delegates and visitors were entertained at the Grand theater. On Wednesday afternoon they were taken to the Westinghouse shops, and in the evening a reception was given upon the roof of the Oliver building, which was handsomely illuminated and decorated for the occasion. On Friday they were the guests of the National Tube Company at its McKeesport works.

The election resulted in the choice of the following officers for the ensuing year: A. D. Spencer, Detroit, president; W. Patridge, Springfield, Ill., first vice-president; R. D. De Wolf, Rochester, N. Y., second vice-president; Cadwalader Evans, Jr., Pittsburg, third vice-president; D. L. Gaskill, Greenville, O., secretary-treasurer; E. J. Keifer, Easton, Penn., and J. L. Hecht, Chicago, executive committee.

The next place of meeting is fixed by the executive committee, but Chicago was favorably considered.

Hot Water Heating Systems and Methods of Connection to a District Heating System*

By A. C. Rogers

To illustrate this paper a number of diagrammatic sketches have been made in isometric to show to better advantage the different systems of piping, but before describing each illustration, it might be well to state that district hot-water heating is a forced feed and that the best results and greatest economy come from maintaining a gravity flow and outflow to all radiators. By reason of this forced feed all heating systems are very sensitive, some more than others, but as a class very much more than a regular gravity heating system.

A general supervision of house installations when connected to district heating is incumbent upon the engineering department of the heating company. This holds good for hot water as well as steam heating and is largely practised by all companies. In new work this may be easily accomplished but when contemplating heating systems already installed and being locally heated the engineer may expect to meet difficulties both in the system and with the owner. An owner may be indifferent to results and economy when running his own heating plant and yet may be very exacting when getting service from a district company. The engineer often meets with systems that cause him to wonder how heating was ever thought of or accomplished.

Fig. 1 illustrates a single-belt one-pipe hot-water gravity system which was used more some years ago than now, although when properly laid out and installed gives very good results. The feed of all radiators is taken off at the top of the main and the return enters the side of the main. In this system there is a gradual drop in temperature as the water flows along the main, due to the cooled water in the radiators dumping back into the main, and the radiators must be figured for this drop to give the results desired. The method of adjusting for district heating in this case is as follows: The boiler is cut out by putting valves in the flow and return pipes or blank flanges or blind gaskets in flange unions as at *E F*, the expansion tank is cut off by a valve or by capping or plugging the leads to it; the service is cut in by tapping the main at *J* and *K*. Service valves *G* are always put on the service inside of the building wall and the regulating valve *H* is placed on the service return pipe just before leaving the building; by proper adjustment of *H* the results are fully up to all that was ever accomplished by local heating if not better.

In Fig. 2 a system the same as Fig. 1 is illustrated except the system has two belts and in addition to the instructions for Fig. 1 the return has two connections, and regulating cocks *H* are installed on both returns and adjusted to equalize both belts, preventing a short-circuit in either belt and giving an equal distribution.

Fig. 3 is an illustration of the well known two-pipe underfeed gravity system, and the following method is given: Blank off the boiler at the feed and the return and also the expansion tank; tap the feed service in at the boiler as at *J* and tap the return in at the extreme end of the return main away from the boiler as at *K*; this method prevents short-circuiting and promotes a balancing that is otherwise troublesome.

A single-belt two-pipe underfeed gravity system with parallel mains but opposing flow is shown in Fig. 4. The writer would place this system at the head of all underfeed work. The [illegible] of themselves will practically make a balance in the [illegible], and a building, even though quite large, with allowance for the mains can be accommodated on one belt. This system will work by gravity without any pitch to the mains [illegible] the [illegible] of the mains [illegible]. The method of connecting to the district heating may be readily outlined.

Fig. 5 is a sketch of [illegible] a portion of a multiple underfeed system, only the

*Abstract of paper read before National District Heating Association, at Pittsburg, June 6-8.

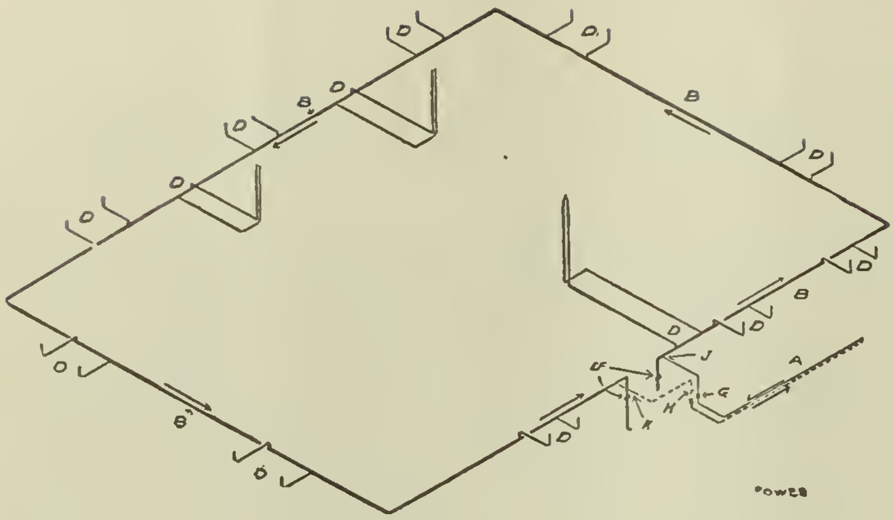


Fig. 1

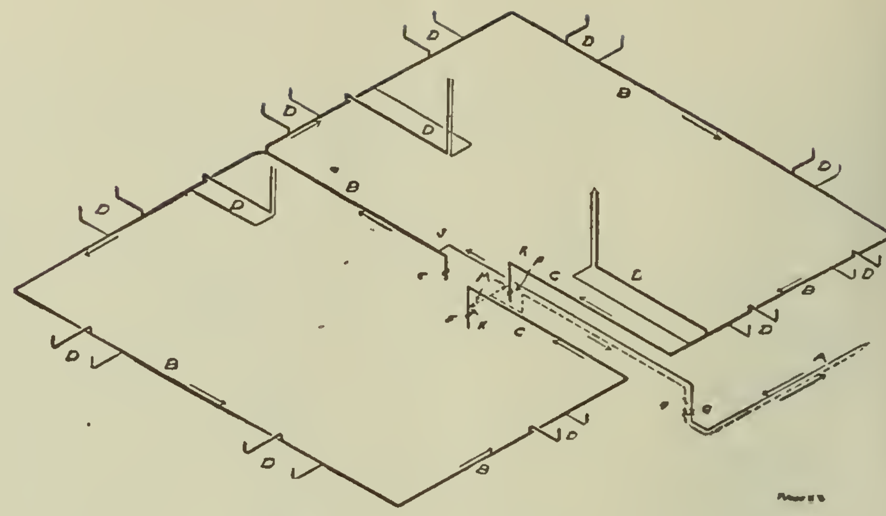


Fig. 2

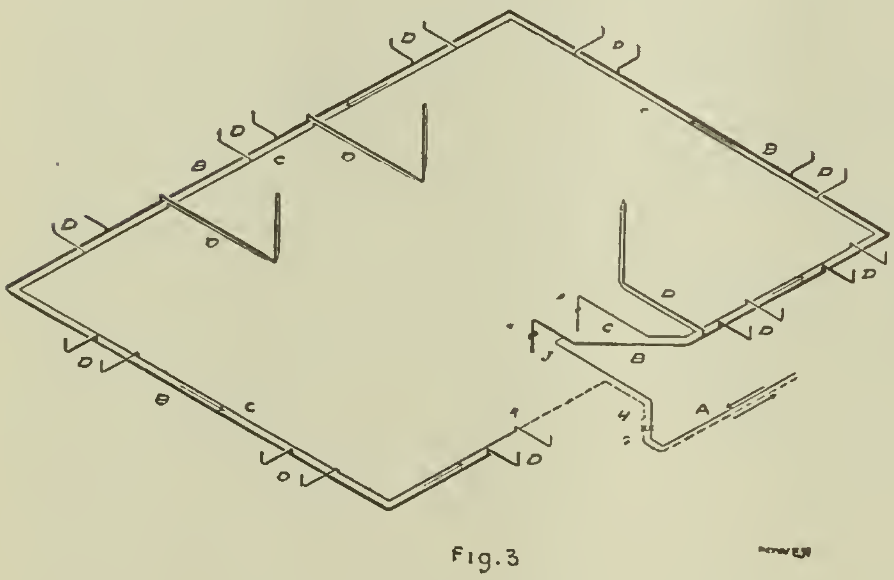


Fig. 3

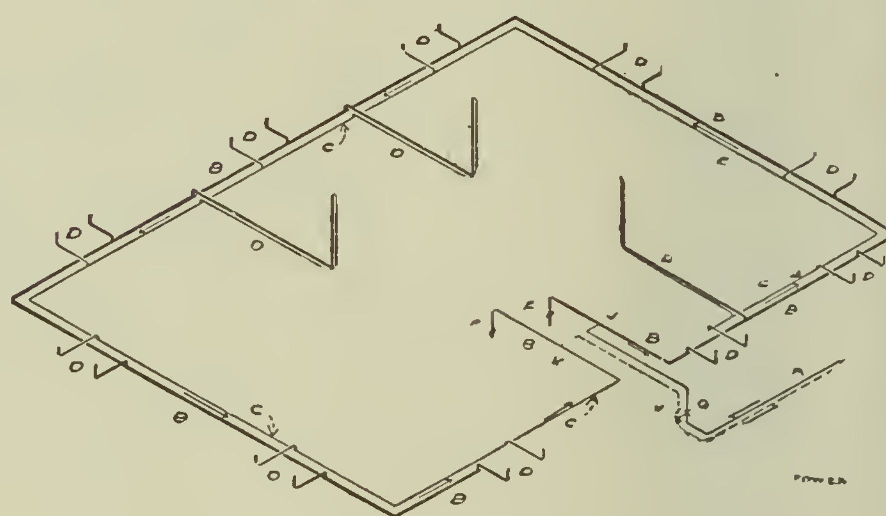


Fig. 4

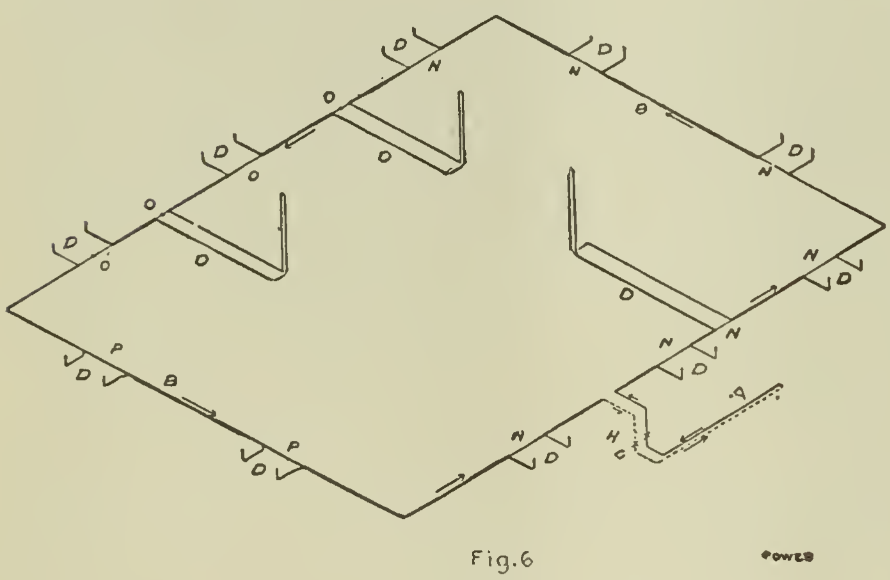


Fig. 6

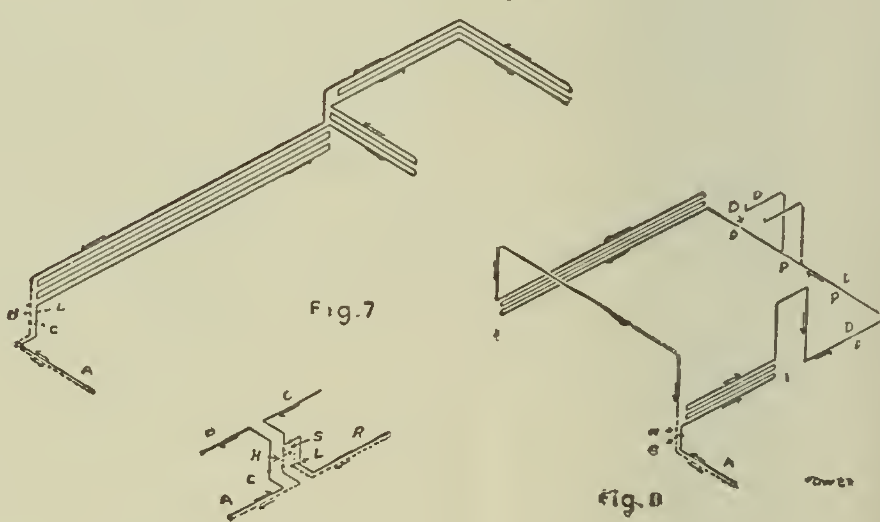


Fig. 7

Fig. 8

Fig. 8

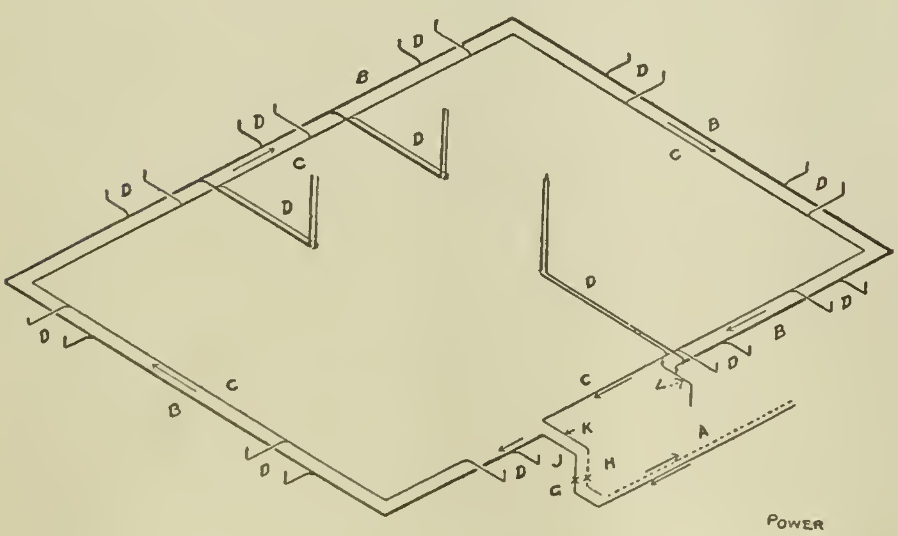


Fig. 9

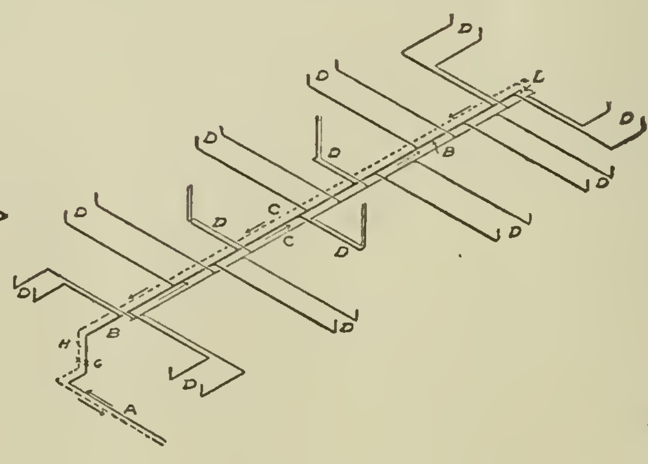


Fig. 10

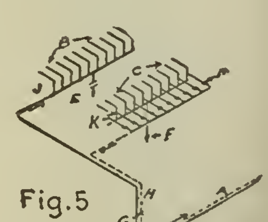


Fig. 5

A—Heating company's service pipes into building.
B—House system feed main or flow pipe.
C—House system return main.
D—Radiator supply and return branches.
E—Valve or blank flange on boiler feed to flow main.
F—Valve or blank flange on return pipe to main.
G—Service valves on district supply service inside building wall.
H—Heating company's regulating valve on return pipe of service.
J—Connection of service flow into *B*.
K—Connection of service return into *C*.
L—Drip or drain connections.
M—Regulating cock or valve on return branches.
N—Small pipe bypass in system, Fig. 6.
O—Disk or regulating cock bypass in system, Fig. 8.
P—Bypass of full pipe with radiator branches taken off with y's or branch tees.
R—Secondary garage service.
S—Bypass with customary three valves to form it.

headers being shown. When this work is encountered the following connections are made: Tap the main flow header at *J* and tap each return marked *C* at *K*, installing a cock *M* for regulation on each unit; the boiler is blanked off as before at *E* and *F*; by adjusting *M* with an opening in each to suit the duty a balance is made and short-circuiting prevented.

Fig. 6 is a one-pipe forced-feed series system for district work only. The sketch shows first a small pipe bypass *N*; the pipe being smaller than the main favors a flow through the radiator; next a bypass with a cock for adjustment or a union with a disk with a hole of proper size, shown at *O*; and next a full bypass as at *P* with branches taken off with *Y* fittings or branch tees; there are some places, as in Fig. 11, where this is the only arrangement possible, but for house or residence work this system is not now allowed.

Fig. 7 shows a forced-feed heating coil, such as for factory and garage work; the feed is connected to the bottom of the coil and the return is taken out at the top; by this method a full pipe is assured and the coil is self-freeing of air, all air being driven out and no air vents being needed; the sketch shows a coil running along the wall with a right-angled branch and a continuation through to another room; headers cannot be used in this work on account of short-circuits and a return-bend coil is used; where a header coil is met with disks or cocks for regulation in each coil of pipes are necessary.

Fig. 8 shows a method of supplying a garage after heating a residence; the garage service is shown and marked *R*, this system being cut in the return pipe only and for control a bypass *S* with three valves is installed; by this method the garage is fed when wanted and otherwise cut out; when the garage is on, regulator *H* is opened for larger feed and good results are obtained.

The standard two-pipe pressure-gravity system which is locally called "double belt" and is the system most generally used, is shown in Fig. 9; it gives perfect results, is low in friction and balances up with no drawbacks; it is very sensitive though and a trap in a radiator branch is fatal to that radiator; this belt on, say, 20x30 feet can supply 1200 feet of radiation with ample results; larger belts are made in 2-inch and 2½-inch plate sizes. Fig. 10 shows the same system for locations where the radiators are placed in a narrow ceiling; it is a three-pipe belt and gives good results.

Fig. 11, a system installed in a large garage, is a series-pipe job with radiators and coils both. A radiator located on the floor above is shown. The front of the garage having large doors and also a side door with cement floor causes the belt to be carried over the opening; traps are thus formed and while not detrimental to heating with this job, yet for safety when the system is shut off drips are placed on all low points.

Two other systems should be mentioned. In both the feed is carried to the top of the building and fed downward, the return being in the basement. The runs of the mains are similar but the branches for the radiators are different. In the first a single pipe making a vertical series is used in which all radiators on that branch are in series. In the other the radiator branches are fed in multiple and the feed supplies all radiators, while a separate return pipe carries the cooled water from the radiators. Both can be used on pressure work, but the writer would strongly urge the last system for both gravity and pressure work. These overhead systems are recommended for buildings of more than three stories high and where attic room can accommodate the main.

An Improved Heating System

By V. T. K[illegible]

I have been experimenting considerably on our heating system, and have finally got it as I think it ought to be to give good service.

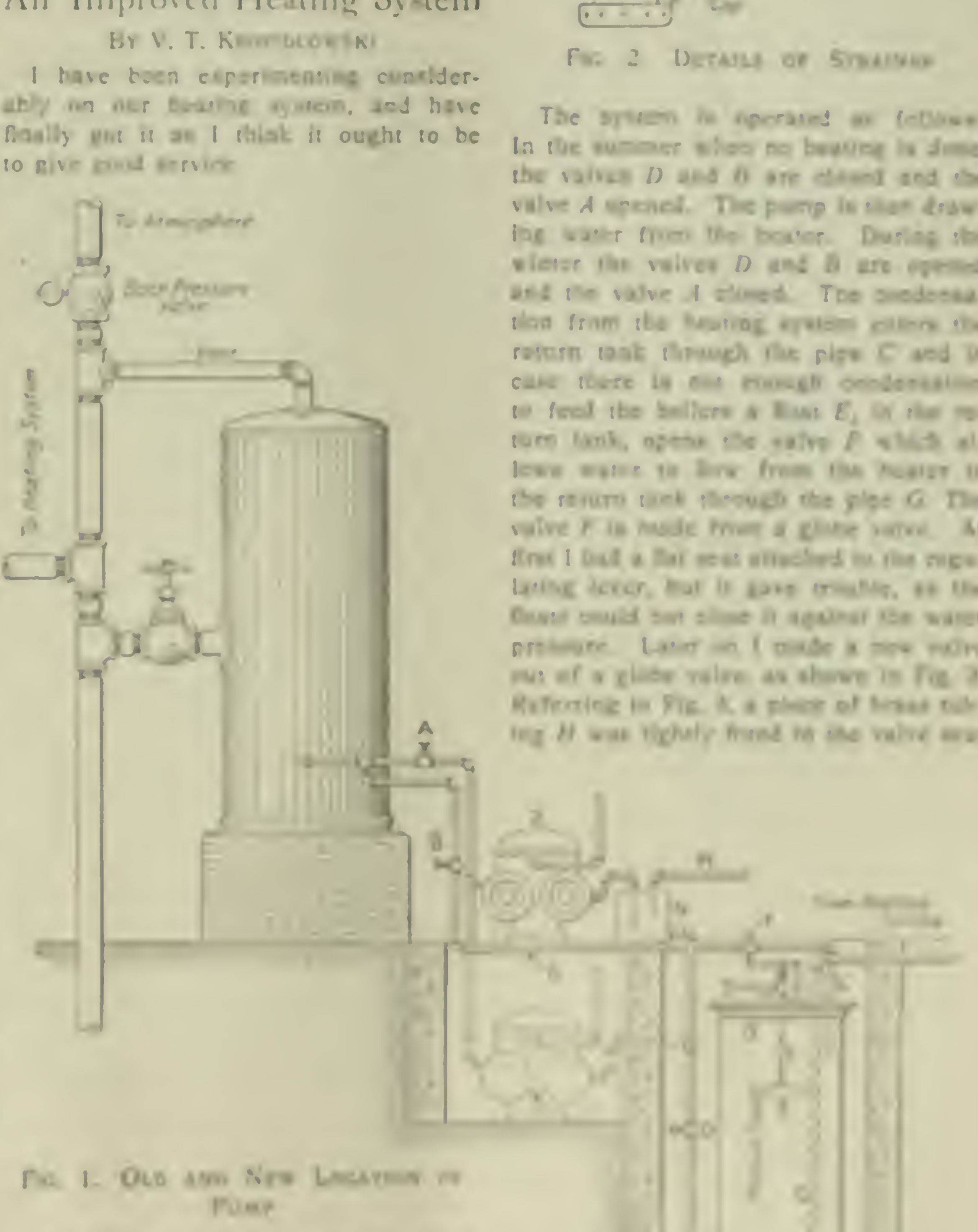


Fig. 1. Old and New Location of Pump

Originally the feed pump was located at *X*, Fig. 1, because it was possible to obtain hotter feed water, as the height of the suction lift was reduced to a minimum. It was soon found, however, that there was still vapor enough to break the vacuum. The pump needed frequent repairs and, as the pit was rather small, the pump was placed as shown at *Z*.

To overcome the vapor trouble I found a small air-tight vessel *N* to use as an air reservoir and connected it up as shown. *M* is the cold-water injector shown in detail in Fig. 2, which is self explanatory.

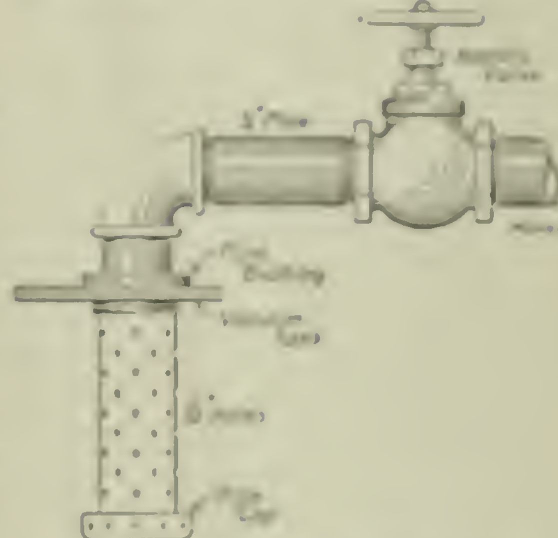


Fig. 2. Details of Strainer

The system is operated as follows: In the summer when no heating is done, the valves *D* and *B* are closed and the valve *A* opened. The pump is then drawing water from the heater. During the winter the valves *D* and *B* are opened and the valve *A* closed. The condensation from the heating system enters the return tank through the pipe *C* and in case there is not enough condensation to feed the boilers a float *E*, in the return tank, opens the valve *F* which allows water to flow from the heater to the return tank through the pipe *G*. The valve *F* is made from a globe valve. At first I had a flat seat attached to the regulating lever, but it gave trouble, as the float could not close it against the water pressure. Later on I made a new valve out of a globe valve, as shown in Fig. 3. Referring to Fig. 3, a piece of brass tubing *H* was tightly fitted to the valve seat and a brass plunger J was turned to the form shown and fitted to the brass tubing so as to work freely. The holes K and L were drilled at a proper location and the stem screwed into the plunger.

Water enters the port M, in the plunger, and the water finds its way through the holes L into the space N, which surrounds the plunger, and exerts its pressure upon the plunger both ways, and thus keeps the plunger in balance. The float has only the weight of the plunger and lever to lift. When the water in the tank gets below its level the float pulls down on the plunger until it passes by the holes K, when the water from the heater will pass to the tank through the passage M and holes L and K.

The arrangement at O, Fig. 1, is made as shown in Fig. 4 and needs no explanation other than that a brass packing nut P has been made and screwed into the pipe bushing, as vapor arising from the tank was a nuisance.

The floats had to be made in sections, because the tank had already been made with the heads riveted on and only a 5-inch hole in one head.

Fig. 4 will give an idea as to how the floats were made. Five of the floats were connected together with a rod after placing them, through the 5-inch hole in the tank, after which the stem R was connected to the float lever.

Referring again to Fig. 1, S is an overflow to the sewer in case the floats get

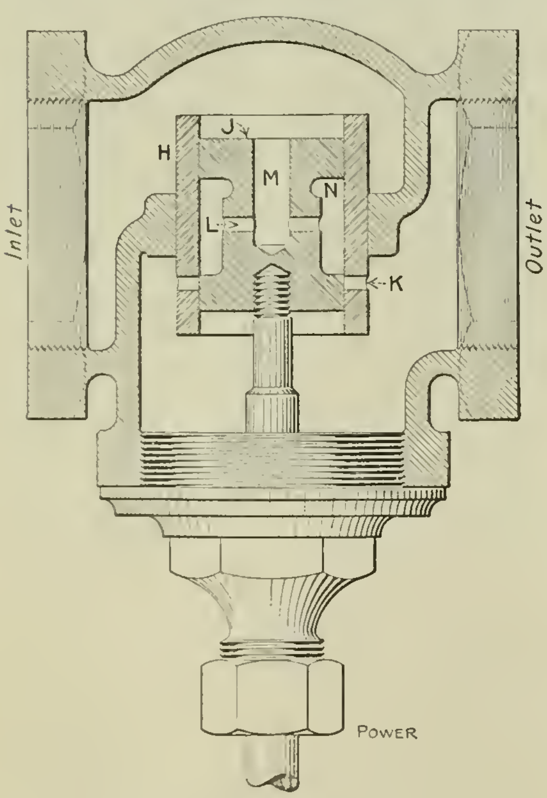


Fig. 3. Sectional View of Valve

stuck or something else happened to flood the tank. Fig. 4 shows how the sewer communication was attached to the tank.

I found it necessary to put in a needle valve for regulating the injection water as, with a globe valve, I could not get a fine enough adjustment and there was a loss of heat due to an excessive amount of injection water. The finer the water can be sprayed the better, as it then takes less water to keep the vapor down, and, consequently, less heat is extracted.

With this arrangement I can feed the water to the boilers at a temperature of 198 degrees. If another pump were available the water could be pumped from the return tank into the heater and the water heated to about 210 degrees. I was convinced, however, that the cost of an extra pump and the steam it would

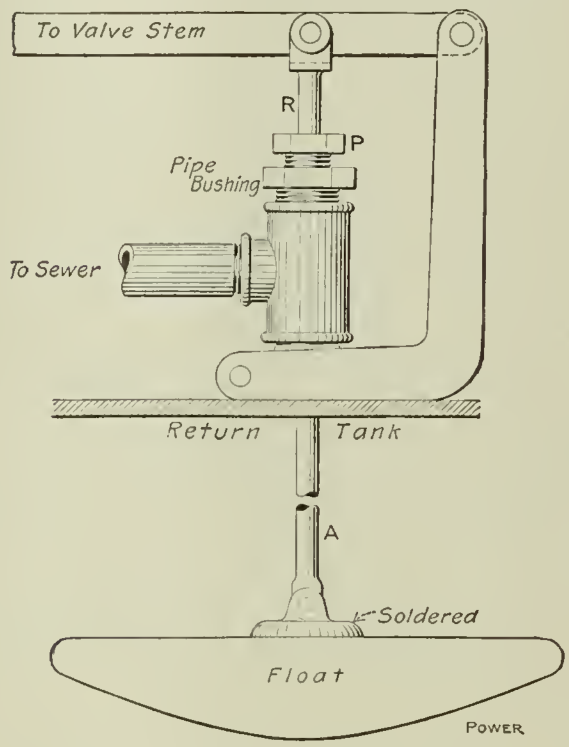


Fig. 4. Details of the Float

consume would cause a greater loss than the cost of the coal it would take to furnish the difference of heat units between 198 and 210 degrees.

Running Condensing on the Heating System

An interesting experiment has recently been made at the First National Bank building, Chicago, in utilizing the heating system of the building as a surface condenser during nights and Sundays, when the heating requirements were not severe but when, nevertheless, electrical current must be furnished 24 hours a day.

It is obvious that this arrangement can only be used when the heating system is partially filled with steam. In practice it has been used when the temperature of the outside air ranged from 40 to 60 degrees and it is estimated that during the months of March, April, October and November conditions will be favorable for its operation.

The heating system is an ordinary Webster installation, controlled by thermostatic valves operated by compressed air, and the method of proceedure is merely to shut off the compressed-air control, which has the effect of opening all the radiator valves of the building to the exhaust. The vacuum pumps then pull a vacuum of 12 to 21 inches through to the engines.

The accompanying curves show the coal consumption and kilowatt-hour load for the month of March. The experiment was not started until March 11 and it is easy to note on the curves what the effect has been.

On March 9 with a load of 2400 kilowatts the coal consumption was 38 tons. On the next Sunday with the heating system used as a condenser and a load of 2200 kilowatts, the coal consumption dropped to 26 tons, showing a saving of twelve tons for the day with practically the same electrical load.

It will be noted that on the following two Sundays the conditions were practically the same, each showing a saving of approximately twelve tons of coal over that obtained before the change was made.

Another point is worthy of remark. On March 6 with an electrical load of 6600 kilowatts the coal consumption was 49 tons, while on March 19 the heaviest peak of the month, 7000 kilowatts, was carried on a coal consumption of only 44 tons. This shows in a striking manner the economical effect of the arrangement.

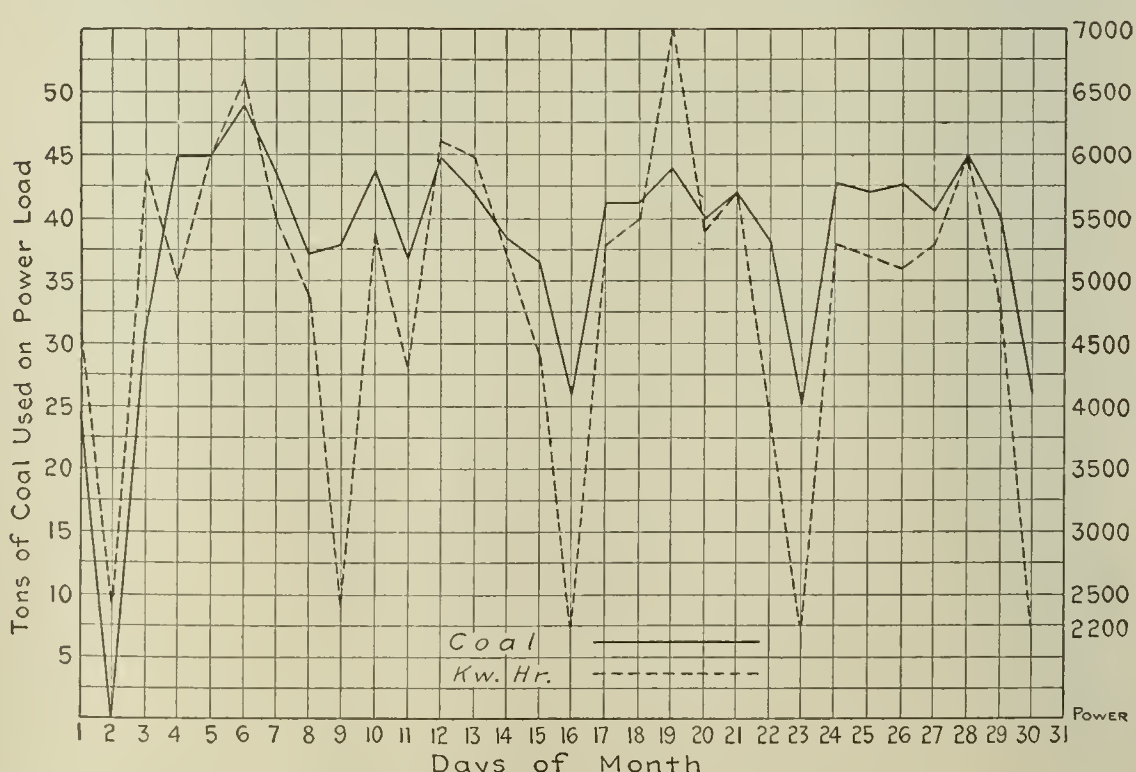


Chart Plotted from Daily Log

Reciprocating Blowing Engines*

By W. Trinks

By increasing the piston speed of the blowing engine to that of the power gas engine or the power steam engine, the first cost of the reciprocating blower is reduced. Standard types of American blowing engines, although satisfactory at low piston speeds, have not, as a rule, been successful at high speeds such as are employed in machines of European design.

During the past twenty years, American blowing-engine practice has assumed rather set forms; certain types of valves and engines have dominated the market, and their operation furnishes today the blast for more than 90 per cent. of the pig-iron industry in this country. A few years ago, however, the contentedness of American builders and users of blowing engines was rudely shattered by a double European invasion: the gas engine and the turbo-blower.

The gas engine, although more economical of fuel than the steam engine, is more expensive in first cost. To reduce the cost per horsepower, high piston speed must be employed; thus the piston speed has been increased from the 300 feet per minute, heretofore considered standard in steam-driven blowers, to 600 feet per minute in modern American gas-driven blowers. In Europe reciprocating blowers run at piston speeds of 750 feet per minute, the gas engines for the generation of power running at speeds very close to 1000 feet per minute.

An understanding of the reasons why the standard types of American blowing engines are so successful at medium speeds and what their shortcomings are at high speeds will be facilitated by a study of the valve motion and of the throttling losses through the valves.

As a high velocity through valves is harmful, the tendency is to keep the velocity at a fairly constant low value; and since the piston of an engine has very nearly harmonic motion, it follows that the valve should also have harmonic

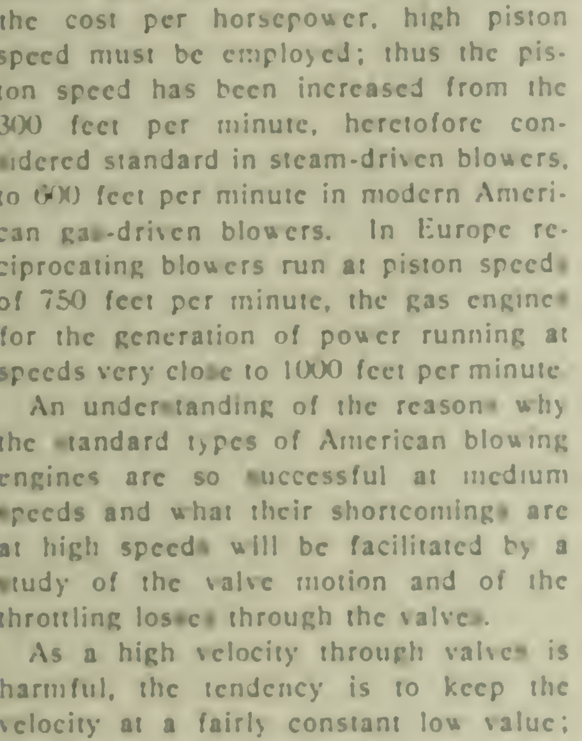


FIG. 1. IDEAL VALVE MOTION ON A DISPLACEMENT BASIS

motion. Fig. 1 shows the valve lift on a displacement basis. The inlet valve is open practically throughout the stroke; the outlet valve should pop open near the middle of the stroke and close at the end.

*Abstract of paper presented before the American Society of Mechanical Engineers at Pittsburg.

Fig. 2 shows this same ideal diagram on a time basis. It will be noted that the curves intersect the base line at an angle, indicating that if these ideal-motion curves are realized the valve will strike a blow in seating. The velocity of striking depends upon the lift of the

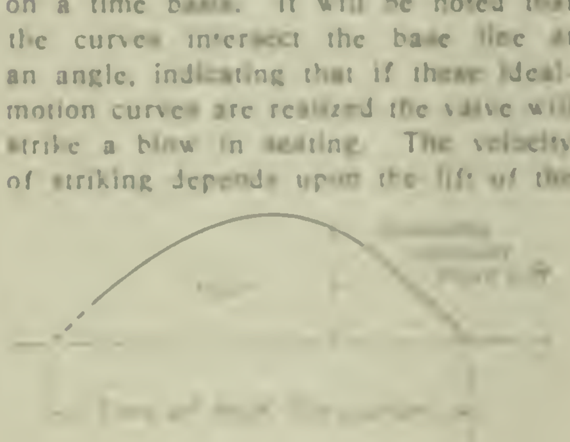


FIG. 2. IDEAL VALVE MOTION ON A TIME BASIS

valve and upon the time of one revolution, which means that high-lift valves, while successful for low rotative speeds, become impractical for high rotative speeds.

Engineers have striven to design valves and valve gears for blowing engines so that these valve-motion curves are approximated. There are, however, two circumstances which interfere with attaining the ideal. One is the quantity of air under a lift valve, which lessens the discharge through the valve during its lift and increases the discharge during the closing period; the other is the mass of the valve, which has frequently baffled designing engineers.

Practically all automatic-lift valves close late, depending upon the rotative speed of the engine, lift of the valve and spring loading. The lower the rotative speed and the valve lift and the greater the spring load closing the valve, the nearer the valve is to the seat in the dead-center position of the crank. Tests and calculations show that in ordinary American blowing-engine practice the valves close so near the dead center that for all practical purposes they may be considered as closing "on time" and without the injurious effects of late closing, namely, the slipping back of the air and the hammering of the valve.

The behavior of the outlet valves is similar to that of the inlet valve with two exceptions: First, the valve has to

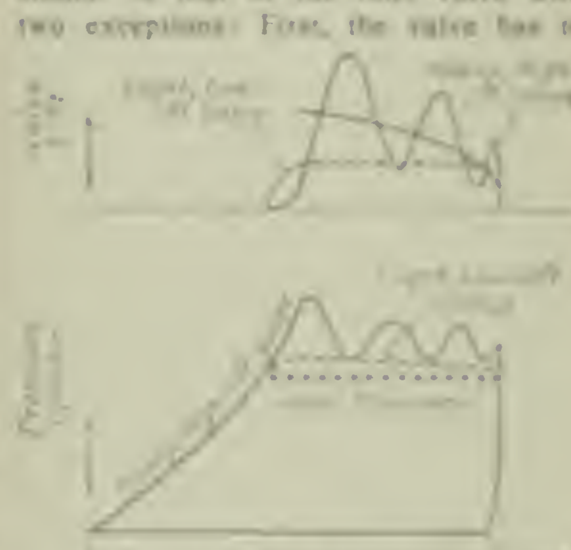


FIG. 3. ACTUAL MOTION OF OUTLET VALVES ON DISPLACEMENT BASIS

open when the piston is moving fastest; second, the pressure difference on both sides of the valve increases rapidly at the dead center. In Fig. 3 the ideal and the actual valve-lift curves are shown in connection with an indicator diagram on a displacement basis. The slower the rotative speed of the engine, the lighter the valve and the smaller its lift, the more perfect is the approximation to the ideal lift curve. High rotative speeds, heavy valves and small areas uncovered by the valve for a given lift cause the pressure in the cylinder to rise considerably over that existing in the blast space and store up a considerable amount of kinetic energy in the valve which must be taken care of by a cushioning device; otherwise fluttering or hammering results. The pressure drops rapidly under the valve immediately after the crank has passed the dead center, and particular care must be taken to have the valve close promptly in order to avoid hammering.

Throttling loss through valves involves two factors: loss of velocity head and surface friction. The vast majority of valves are so designed that surface friction, such as occurs in long pipes or ducts, is practically absent. For this reason, losses due to velocity head only will be considered. Fig. 4 gives the throttling loss for various piston speeds and for various ratios of valve area to piston area. In this chart the valve area does not mean the so-called free valve area, which is a rather imaginary or conventional quantity, but rather the area actually offered to the flow of air at the narrowest part of the valve. It is assumed that the valve has harmonic motion and that the coefficient of discharge is 70 per cent. For a number of valves this latter figure was found to agree closely with the tests.

As long as the clearance volume of the engine is small, mechanical operation of the inlet valve is scientifically correct, because the opening and closing points of the valve remain practically fixed in spite of variations of blast pressure. Conditions are quite different with the outlet valve. Its correct opening point varies with the blast pressure and losses occur if the valve opens at a fixed point and if the blast pressure differs from the one for which the engine was designed.

Naturally, the experiment of running the standard types of valve gears at higher speeds was tried. Comparatively little trouble was experienced with the mechanically operated inlet valves, except that in some of the designs the throttling loss was much greater than might be expected. At 600 revolutions per minute the standard valve gears gave throttling losses ranging from 0.4 to 1 pound per square inch, and engineers were trying to increase inlet-valve areas up to 20 per cent. or more. At the discharge end serious troubles occurred with an increase in speed.

If the American standard valve gears are used for piston speeds of 600 feet per minute or above, inlet-throttling losses of 3 to 6 per cent. of the ideal blowing work occur, and outlet-throttling losses of 7 to 12 per cent. of the ideal blowing work. Besides, power for mechanical operation of the valves increases and other troubles of wear, breakage or regulation appear, depending upon the valve gear.

For piston speeds up to 600 feet per minute and for rotative speeds up to 65 revolutions per minute, the Slick tub, employing a movable cylinder, has been very successful. The design has been severely criticized as "wagging the dog and holding the tail still" and the author confesses that he felt the same way when he saw the first Slick compressor more than ten years ago at the Edgar Thompson Steel Works, but the ingenuity of the design is forcibly impressed upon anybody who attempts to produce the same combination of large areas and small clearance space in some other way. If 65 revolutions per minute are exceeded with this type, trouble begins. The inertia forces of the heavy cylinder are hard to take care of and heat the eccentric which moves the cylinder.

Engines employing the Mesta combination inlet and outlet valve have been very successful up to piston speeds of 820 feet per minute. In this type rocking valves, two for each head, control both inlet and outlet; the inlet passes at the side of each valve, the outlet through the center of the valve. Automatic cup outlet valves are located beyond the rocking valves and are protected against the return closing slam by the mechanical closing of the rocking valves. This latter design has been used on vacuum pumps and compressors for over 20 years. Its adaptation to high-speed blowing-engine practice required doubling the valve equipment for the purpose of obtaining large areas without excessive diameter of rocking valve. The pot outlet valve is cushioned very little and is loaded lightly

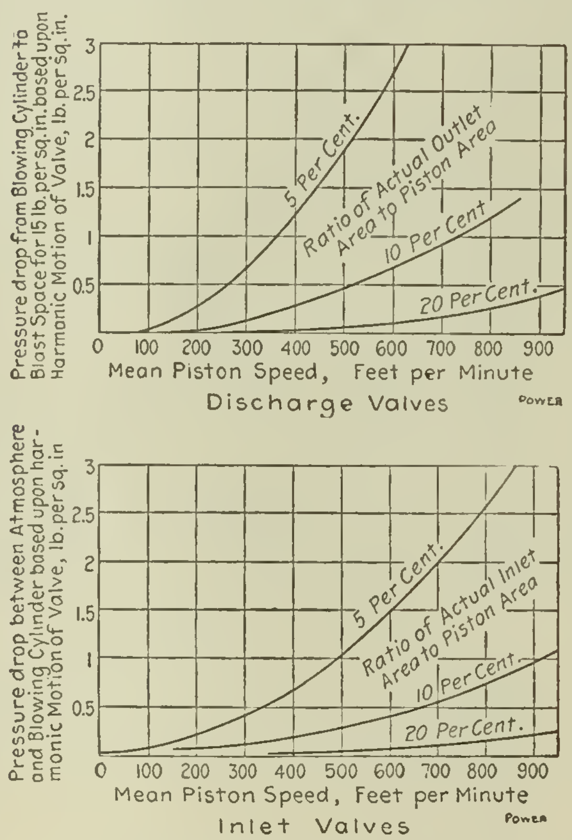


FIG. 4. PRESSURE LOSS THROUGH VALVES DUE TO VELOCITY HEAD

so as to fly out of the road of the blast without fluttering.

In Europe the high-speed blowing engine is an accomplished fact. There the problem has been attacked along altogether different lines. European engineers long since realized that the harmful kinetic energy stored up in a valve is proportional to its mass and to its travel, and that both should be cut down.

Furthermore, European engineers do not hesitate to use large clearance spaces if by so doing other advantages can be gained, and they meet with success. Matters are different in this country. Clearance in a blowing engine seems to be an eyesore to the American furnace man. The influence of clearance can be summed up in a few words.

a Clearance volume increases the necessary size of blowing tub for a given weight of air to be pumped per stroke.

b The larger size of blowing tub results in a small increase of friction work and, therefore, in a larger size of power cylinder.

c The influence of the increased heat-exchanging surface on the true volumetric efficiency is small.

On the other hand, clearance allows the use of very large valve areas, which decrease throttling work and cause better filling of the air cylinder and also allow higher piston speeds, or in other words, a smaller and cheaper engine. The higher piston speed makes possible the use of a more efficient prime mover, namely, the gas engine. When the truth of this is realized, recognition of the merits of the modern European high-speed blower should present no difficulties. The plate valves are so light in weight and the spring load can be made so small that for the greater part of their working time the valves rest against the guard or stop; this, of course, greatly reduces fluttering. Furthermore, there are no wearing parts and no sliding surfaces or sticking or binding from gummed and dusty oil. The low lift does not allow the valve to acquire destructive velocity in closing. If a sufficient number of valves are used the pressure loss through the valves is small and the filling of the cylinder is almost perfect. The life of the valves is long, provided that they are made of the proper high-grade steel and that the spring loading is properly proportioned. If a valve should break, it can easily be replaced because the valves are light; besides, the inlet and outlet valves are alike so that only a few need be carried in stock.

Particular emphasis is placed upon the almost silent operation of these valves, both by users and builders. No separate cushioning means are employed except that in the Hoerbiger-Rogler valve an elastic plate softens the impact of the opening stroke before the valve strikes the guard. This cushioning alone does not suffice, but another circumstance comes in helpfully. Thin films of oil coat the valve plate, cushion plate and guard. The squeezing of the air and oil between these plates provides a sufficient cushion to prevent injury to the valve.

From a study of the various types of valves and valve gears, it appears that at the present time the low-lift, alloy-steel plate valve promises to become the standard valve for high-speed blowing engines, because there is neither wear, binding nor sticking; no lubrication is required; there are very small throttling losses; it can be used for the highest speeds; it is inexpensive; and it does away with mechanical gearing, oiling and adjustment.

No matter with what valves a reciprocating blower is equipped, its delivery remains discontinuous; that is, it delivers air impulses comparable to a constant delivery, over which is superimposed a wave motion or vibration. If the blower discharges directly into the blast main, then vibrations are transmitted with undiminished strength and shake the whole line. In steam-engine practice this evil was cured long ago by placing a large steam or water separator near the engine to damp the vibrations of the pipe line. If a similar request is made of a furnace man for the air line, a great deal of resistance is encountered. The author knows of only one furnace plant in this country where a large tank or equalizer was installed for each blowing engine. The pipe lines thus connected are practically free from vibration.

In conclusion it may be said that the reciprocating blower has made wonderful strides in the past decade toward becoming a successful high-speed machine. While the increase of piston speed was started by the gas engine as a matter of necessity, it has also benefited the steam-driven blowing engine, and isolated furnace plants can now work with two air cylinders instead of three, because one will successfully blow a furnace in case of emergency, or else three smaller units may be used.

The combination of the high-speed reciprocating blower with the blast-furnace gas engine makes the use of the latter profitable even in the Pittsburg district where coal is cheap. The latest group of furnaces in this region has been equipped with slow-speed reciprocating steam-driven blowers. If a high-speed gas-driven blower had been on the market, the result would probably have been different.

A gas-driven blowing engine with a piston speed of 800 to 900 feet per minute and a high rotative speed will be the most formidable competitor of the turbo-blower, if European experience may be taken as a guide. There are engineers in this country who have already carried into practice higher piston speeds for gas engines for electric power, and interesting developments in this line of work may be expected in the next five years.

DISCUSSION

The following discussion applies to both Mr Trinks' paper and that of Mr. Rice, printed in the June 13 issue:

Mr. Johnson: It is generally accepted that the turbo-blower is much more efficient at low pressures than at high pressures, whereas the reciprocating blowing engine is more efficient at high pressures. A condition in the design of the latter is that the air cylinder must be large enough for the greatest volume to be handled, and strong enough for the highest pressures attained. This results in the large and massive construction which makes such machinery so expensive.

The turbo-blower, on the other hand, suffers because it must have stages enough to furnish the highest pressure likely to be required, although, in ordinary operation, this pressure may be needed only a very small part of the time.

Therefore, the best and cheapest blowing engine is a combination of these two types: a turbine-driven blower delivering air, partly compressed, to a reciprocating blowing engine, which will compress it to the desired pressure. The steam from the reciprocating engine could be used to drive the turbine.

In general, the valves of a blowing engine are a source of difficulty, it being almost impossible to get an inlet valve of sufficient area to allow the cylinder to fill without heavy loss by suction, and at the same time be quick enough to give the desired results at the speeds required in modern engines.

The advantage of maintenance is undoubtedly with the turbo-blower, as compared with the reciprocating engine. However, the magnitude of the alternations of stress in the reciprocating blower is greatly reduced by delivering partly compressed air, and the difficulties of the inlet-valve gear are practically eliminated by delivering denser air under pressure.

The governing of such a combined unit is extremely simple. The ordinary governor on the engine does all that is necessary and no governor other than one to prevent racing is needed on the turbine. The steam from the engine passes directly to the turbine, and as long as conditions remain constant, the speed of the turbine will remain unchanged. If, however, the pressure required by the furnace increases, more steam is admitted to the engine by the governor and this increased quantity of steam causes the turbine speed to increase slightly and, in turn, deliver air at a higher pressure. This automatically compensates for any slight lag due to the greater load on the engine and for the lower volumetric efficiency of the reciprocating blowing engine at higher pressures.

C. G. de Laval: It is well to consider the distinction between a blower and a compressor, in which connection it would appear that the machine described by Mr. Rice is not a compressor but a turbo-blower. It is of the multi-stage type and has no rubbing surfaces, the rotating parts revolving freely with ample clearances.

The turbo-compressors manufactured by a number of German firms are made up of multiple cylinders according to volume and pressure. The general principle includes high-speed impellers incased in cylindrical chambers, properly cooled both radially and axially. These impellers draw in the air and discharge it, converting the velocity into potential energy in the form of air pressure, the action being similar to that of a centrifugal-pump impeller.

It does not appear necessary to use six stages, arranged in series, for pressures as low as 10 or 20 pounds per square inch. A turbo-blower built on the Rateau principle for 6000 to 12,300 cubic feet of free air per minute at pressures of 8 to 15 pounds and speeds of 3400 to 2000 revolutions per minute, requires only three stages as against the six stages in the one described by Mr. Rice. For pressures of 80 to 150 pounds it is not necessary to employ more than ten to fifteen stages.

European practice has shown that turbo-compressors with capacities of 6000 cubic feet of free air per minute and above, will give from 70 to 80 per cent. efficiency; for capacities of 3000 to 6000 cubic feet, the efficiencies are from 65 to 70 per cent., and these efficiencies decrease to less than 50 per cent. at one-half and quarter loads.

The use of a turbo-blower in connection with reciprocating compressors has been tried recently in England. The existing compressor was coupled to a turbo-blower, the exhaust from the low-pressure steam cylinder passing to the steam turbine; the turbo-blower takes air at atmospheric pressure, compresses it and discharges to the reciprocating compressor where the pressure is stepped up to 60 pounds. This combination has doubled the capacity and has shown a net gain of 17 per cent. over that which would have been secured had an additional reciprocating compressor been installed. Furthermore, it saved the expense of an addition to the building, which would have been necessary on account of the large space occupied by an additional compressor.

Mr. Baker: Taking all factors into consideration, under certain conditions of fuel cost, the turbo-blower is a close second to the gas-blowing engine. The fuel consumption of the latter is affected by a number of different efficiencies, namely, the efficiency of the blowing tub, which may be called the compression efficiency, the volumetric efficiency, and the mechanical friction of the blowing tub. The sum of these efficiencies is the shaft efficiency, which may be compared with the so called shaft efficiency of the turbo-blower.

The compression efficiency is the ratio of the work required to compress adiabatically to that actually required in the blowing tub; this amounts to about [illegible] per cent. The losses are due principally to the inertia and friction of the discharge valves, the friction of air passing through the suction and discharge passages, and to late opening of the suction valve.

The volumetric efficiency has been actually determined by a long series of tests on various engines, and has been found to be about [illegible] per cent. The losses are due to defective clearance, friction of air through the suction valves, leakage of air past the valves and piston, and to the effect of preheating the incoming air.

The mechanical efficiency of the blowing tub is not easily determined, but was estimated at 90.4 per cent. These make a total shaft efficiency of 75.8 per cent. which may be compared with 68 to 70 per cent. efficiency for the turbo-blower.

Mr. Cardullo: Builders of blowing engines could take lessons from the pumping-engine manufacturers, and build engines with smaller discharge valves. The valves illustrated by Mr. Trinks are 18 or 20 inches in diameter and of a type which is unsatisfactory in water-pumping work. Although they will be more satisfactory in air work than in water pumping, the objections are of the same character and at high speeds are of the same validity as the objection to similar valves in water pumps. The difficulties could be overcome by substituting a large number of small valves of suitable material, about three inches in diameter.

Mr. Freyn: As far as thermodynamics is concerned, the turbo-blower indirectly uses two and one-half times as much gas as the gas-blowing engine. Regarding the relative cost of the two types of installation, based upon actual figures, consider four or five 100-ton blast-furnace plants, with eight gas-blowing engines installed, six operating the furnaces and two spares, and six turbo-blowers, four operating the furnaces and two spares. Under such conditions it will be found that, taking the thermal efficiency, the constant operation and the fixed charges into consideration, the gas-blowing engine is in the lead, even with coal at $1.80 per long ton.

In isolated blast-furnace plants, however, where the gas has no value, the turbo-blower is the proper installation, especially in plants having one or two furnaces where a constant supply cannot always be depended upon. But for any large plant, particularly blast-furnace plants connected with steel works, it is out of the question to put in turbo-blowers.

There is no doubt that in large steel works it is possible to have electric installations which furnish power at a very cheap cost to the municipalities and industries in the neighborhood. In this connection the gas-blowing engines lead the turbo-blowers.

I cannot see any opportunity for turbo-blowers, with the exception of the one case which Mr. Johnson pointed out, but I have, however, a better suggestion to offer. This is to utilize the waste heat from the gas engine for generating low-pressure steam by which turbine blowers may be run to compress the blast for the furnace.

Mr. Ehrhart: In Mr. Rice's paper is to be found the statement: "The pulsations in pressure above noted are an inherent characteristic of all centrifugal blowing apparatus." I believe that in a machine which is not a positive pushing machine, like a reciprocating engine, this pulsation should be avoided if possible. This is especially important where two machines are delivering air into the same line, in which case they should have the same characteristics.

Furthermore, in the case cited by Mr. Rice, the efficiency at one-third of the rated volume is about 45 per cent. In some blowers with which the Westinghouse Machine Company has been experimenting for the past five or six years, it has been found that by merely altering the shape of the blower the efficiency has been brought up to nearly 70 per cent. at one-third load. I do not believe this point has been brought out before, but blowers are now on the market in which the light-load efficiency is within 5 per cent. of what it is at full load.

Discussion on "Purchase of Coal"

The discussion of Mr. Randall's paper upon the purchase of coal, which was published in the June 13 issue, is herewith presented.

Mr. Rice: It is important that a plant be designed to use coal of lower quality, and all attention should not be directed toward the method of buying coal, the effect of which is to defeat the conservation of our natural resources. The emphasis of this paper, unwittingly perhaps, is to direct purchasers to be more particular with the coal dealer; hence, the latter tries to meet the specifications, with the result that he uses the best coal and neglects to find a market for the poor coal.

Mr. Baker: Quite a number of plants in the East are successfully burning a very low grade of fuel, which it would be impossible to burn by ordinary method. This is accomplished through the use of the steam jet, which, from the thermodynamic point of view, is perhaps bad engineering, yet it enables the fuel bed to be kept cool enough to prevent trouble from clinkers.

Professor Carpenter: I do not see how the ideas that have just been expressed constitute an argument against the necessity of testing coal and of purchasing it by analysis. I have lived for a great many years in those districts bordering on the anthracite-coal regions, where we have had to take the poor stuff that nobody else would use. The coal operators are anxious not only to dispose of their coal, but also some of their heaps of slate, some of which reaches the breakers and rock crushers; and, no doubt, thousands of dollars have been paid by the consumer to help dispose of these slate piles.

Professor Goss: I want to emphasize the statement to which Professor Carpenter has called attention. The coal operator must take much more responsibility for the suitable preparation of his coal, and everything should be done to encourage him in improving the product delivered to the consumer. The inferior coal, of course, should be brought out of the ground and should be saved; but before it is delivered to the consumer the operator should wash and sort it or otherwise put it in proper form.

Mr. Barker: If the plant can be so designed and low-grade fuels are available, it is profitable to change the equipment to use the low-grade fuel. However, the variation in the low-grade fuels is such that it is not profitable for the average plant to attempt to burn them without special attention. For instance, the small size of anthracite which comes to the New England market contains from 14 to 24 per cent. ash. It may be conserving some of our natural resources if this 24 per cent. of ash can be burned at all efficiently, but if the ash can be kept down to 18 per cent., the coal can probably be used to advantage. It may be either burned alone or mixed with a good grade of bituminous coal, but if this coal comes to the market with a variation of 14 to 25 per cent. of ash, there should surely be some correction for this variation in quality.

Mr. Baker has suggested the use of the steam jet in burning low-grade fuel. The steam jet is a very efficient piece of apparatus where a small size of anthracite is burned, providing the fireman is familiar with the apparatus. However, I have found a number of cases where the steam jet was a very inefficient piece of apparatus in a power plant, on account of improper regulation.

Pennsylvania State Convention

The Pennsylvania State Association of the National Association of Stationary Engineers held its twelfth annual convention at Johnstown on Friday and Saturday, June 2 and 3, Cambria Association No. 21 being the host. The delegates and visitors were welcomed to the city by Mayor Wilson, to whom a fitting response was made by Past President Charles A. Garlick. Addresses were made by C. W. Leitenburger, chairman of the local committee; Past President Joseph H. Carney, National Treasurer Samuel D. Forse, and State President F. M. Zimmerman.

On Friday afternoon a visit was made to the Cambria mills. On Friday evening a banquet was given at the Merchant's hotel at which Mr. Forse acted as toastmaster and George D. Yohe, the first president of the Pennsylvania State Association; Martin S. Corbett, president of the local branch, and the speakers of the morning, besides several of the representatives of the Cambria works, made addresses.

The election resulted in the choice of George Bu. Miller, of Pittsburg, as president; D. N. Arms, of Johnstown, vice-president; Thomas C. Green, of Pittsburg, secretary; D. E. Seely, of Du Bois, treasurer; John G. Louis, of Sharon, conductor; E. H. Nettle, of York, doorkeeper. The next convention will be held at York.

Convention of the American Order of Steam Engineers

The twenty-fifth annual convention of the supreme council of the American Order of Steam Engineers was held at Philadelphia, Penn., during the week commencing June 5.

There was a large gathering of delegates from the several councils connected with the organization, the meetings being held in the Parkway building on Broad street.

The large auditorium on the main floor of the building was tastefully decorated and was uniformly and artistically arranged for the exhibit of the American Supplymen's Association. The exhibit this year was the largest yet held, and the demand for booths was so great that many of the exhibitors were given space on the stage, which was fitted up as a reception room, and proved to be one of the most popular places in the hall.

The convention was a lively one for the delegates. There were seven sessions of the supreme body, and considerable important business conducive to the welfare of the association was transacted.

At the Wednesday morning session a recess was taken and permission granted to William G. Le Compte, of Jenkins Brothers, to occupy the floor. Mr. Le Compte stated that he was the bearer of congratulations from his firm to the members of the American Order of Steam Engineers, and in a neat speech presented to the supreme council a handsome solid ivory, gold-mounted gavel, and to each subordinate council a similar gavel, silver mounted, in commemoration of the silver anniversary of the organization.

There was a varied program of entertainment. On Monday afternoon a visit was made to the new John Wanamaker building. An excursion on the Delaware river took place on Tuesday afternoon. Dancing and other enjoyments were indulged in, and abundant refreshments were served.

THE EXHIBIT HALL IN ODD FELLOWS' TEMPLE, PHILADELPHIA

On Thursday afternoon the delegates and guests took special trolley cars for a family outing to Washington park. There were outdoor events of all kinds, the fun ending in a baseball match between the engineers and the supplymen.

The big feature of the entertainment program was the "silver jubilee" banquet on Wednesday evening, at the Scottish Rite hall. There were over eight hundred seated at the tables, including the ladies and their escorts. After an appetizing dinner had been served, George W. Richardson, the toastmaster, introduced the following speakers: Frederick Markoe, supreme chief engineer; Franklin S. Edmonds, of the Board of Education, and Lieutenant Hope, of the United States Army Engineers' Corps.

During the evening a pleasing entertainment was given as follows: Joe McKenna, Jenkins Brothers, songs; Jim Devlin, Peerless Rubber Manufacturing Company, monologues; Billy Murray, Jenkins Brothers, popular songs; Jack Armour, POWER, stories and recitals;

THE AMERICAN ORDER OF STEAM ENGINEERS AT PHILADELPHIA

George C. Gray, Watson & McDaniel Company, Scotch songs; Mr. Ryder, Bird-Archer Company, magic; George C. Davis, Thomas Warley & Co., songs.

At the Thursday morning meeting of the delegates the following supreme officers were elected:

Lewis G. Schlehner, chief engineer; George W. Goodwin, first assistant engineer; Florian J. Armbruster, recording engineer; C. F. Noble, corresponding engineer; Thomas J. Donovan, treasurer; T. M. Montgomery, senior master mechanic; F. S. Miller, junior master mechanic; Walter Long, chaplain; Richard Sullen, inside sentinel; William Eccles, outside sentinel; William Parient, trustee.

It was voted to hold the next annual convention at Allentown, Penn.

At a meeting of the American Supplymens' Association on Thursday morning the following officers were chosen for the ensuing year:

Harry Winner, Garlock Packing Company, president; Frank Martin, Jenkins Brothers, vice-president; Fred L. Jahn, Watson & McDaniel Company, secretary; John W. Armour, POWER, treasurer.

The following gentlemen comprise the executive committee: F. V. Stein, H. W. Johns-Manville Company; George C. Davis, Thomas Warley & Co.; J. F. Boreland, France Packing Company; S. McCullam, McCullam & Co.; Albert Schade, Schade Valve Manufacturing Company; Charles A. Hopper, Keystone Grease Company; Charles P. Sanville, McArdle & Cooney Company; Harry E. Souders, John R. Livesey Company; Charles Camp, Strong, Carlisle & Hammond Company; Arthur L. Rice, *Practical Engineer.*

The exhibition hall was formally opened on Monday evening at nine o'clock by A. R. Foley, president of the American Supplymen's Association, who introduced Charles E. Carpenter and Supreme Chief Frederick Markoe, who made appropriate addresses.

There were 81 exhibitors occupying 84 booths. Their names follow: American Engineering and Manufacturing Company, American Order of Steam Engineers, American Steam Gauge and Valve Manufacturing Company, American Pulley Company, Anchor Packing Company, Ashton Valve Company, H. Belfield Company, Bird-Archer Company, Cyrus Borgner Company, A. B. Botfield Company, Brogan & Co., Cancos Manufacturing Company, Corbett Supply Company, Crandall Packing Company, Dearborn Drug and Chemical Works, R. and J. Dick Company, Engineering Equipment Company, Fairbanks Company, France Packing Company, Frick Grate Bar Company, Garlock Packing Company, Greene, Tweed & Co., Harrison Safety Boiler Works, Home Rubber Company, Homestead Valve Manufacturing Company, E. F. Houghton & Co., Huhn Metallic Packing Company, Paul B. Huyette Company, Jenkins Brothers, H. W. Johns-Manville Company, Keasbey & Mattison Company, Keystone Lubricating Company, Lagonda Manufacturing Company, John R. Livesey Company, George W. Lord Company, Lunkenheimer Company, Mason Coal Company, McArdle & Cooney, McLeod & Henry Company, W. B. McVicker Company, Michigan Lubricator Company, National Tube Company, Nelson Valve Company, Ohio Blower Company, Parkersburg Iron Company, Peerless Rubber Manufacturing Company, Philadelphia Bourse, Philadelphia Electrical Construction Company, Philadelphia Grease Manufacturing Company, POWER, *Power House,* William Powell Company, *Practical Engineer,* Pringle Electrical Manufacturing Company, Quaker City Rubber Company, C. J. Rainear & Co., William C. Robinson & Sons Company, E. J. Rooksby Company, Roto Company, Sarco Fuel Saving and Engineering Company, Schade Valve Manufacturing Company, S-C Regulator Company, Smooth-On Manufacturing Company, *Southern Engineer,* Frank H. Stewart Electric Company, Strong, Carlisle & Hammond Company, Trill Indicator Company, Under-Feed Stoker Company of America, H. B. Underwood & Co., Vacuum Oil Company, V. V. Fittings Company, R. G. Von Kokeritz & Co., Thomas C. Warley & Co., Watson & McDaniel Company, Warren Webster & Co., Elisha Webb & Sons Company, Whetstone & Co., Wise & Bailey, Wilkirk Electric Company, O. F. Zurn Oil Company.

The loss of power in a gas engine owing to its installation at considerable elevations above sea level may be roughly estimated at about $3\frac{1}{3}$ per cent. for each thousand feet. The decrease in barometric hight is about one inch for 950 feet of altitude.

New York State N. A. S. E. Convention

The delegates from the several branches comprising the New York State Association of the National Association of Stationary Engineers assembled at Albany, N. Y., to hold its sixteenth annual convention on June 9 and 10.

The Globe hotel was the headquarters and in German hall, situated a short distance away, the sessions of the convention were held, as was also the mechanical display.

On Friday morning, June 6, at 10:30, the convention was called to order by Charles Schabacker. After the reports were read and the various committees appointed, an adjournment was taken.

There were two additional sessions of the delegates on the morning and afternoon of Saturday.

On Friday afternoon a resolution was passed that a committee be appointed to request Senator Seth G. Heacock to use his influence to get the State license bill out of the hands of the committee and introduced into the senate on as early a date as possible.

AT THE N. A. S. E. STATE CONVENTION, ALBANY, N. Y.

An earnest appeal to the members was made by J. Douglas Taylor, secretary-treasurer of the life and accident department of the National Association of Stationary Engineers, requesting them to use their best efforts to induce the members of their local associations to join this excellent insurance organization.

The unanimous support of the delegates indorsed James R. Coe as State deputy for appointment by the incoming national president of the main body at Cincinnati in September next.

The election of the State officers then resulted in the following selections:

B. C. Dunsmore, Buffalo, president; George O. Kaley, Brooklyn, vice-president; E. E. Pruyn, Rochester, secretary;

William Downes, New York, treasurer; Harry Bache, Syracuse, conductor; James T. Fitzgerald, Little Falls, doorkeeper; Matthew Bender, Albany, chaplain.

Yonkers was selected as the city in which to hold the next annual meeting, subject to the approval of the Yonkers association.

There were many features of entertainment, including trolley rides to the places of interest about the city and visits to many of the large plants.

On Friday afternoon the assemblage was given the opportunity of calling at the executive chamber to shake hands with Gov. John A. Dix.

On Saturday afternoon the delegates had a delightful sail on the Hudson river.

At Keeler's hotel on Saturday evening a banquet was held to which the ladies were invited. Covers were laid for fully two hundred. There was a varied program of toasts, songs, stories, recitations and instrumental music which was highly appreciated. The addresses were made by the following gentlemen: Arthur L. Andrews, Charles Schabacker, Hon. Judge T. McDonough, Edward H. Kearney, William B. Jones, Hon. John Williams, Counselor James H. Quinn.

The entertainers were Joe McKenna, Jenkins Brothers; Frank Corbett, Consolidated Safety Valve Company; Jim Devins, Peerless Rubber Manufacturing Company; Billy Murray, Jenkins Brothers; Jack Armour, POWER.

A pleasing diversion to the ceremonies occurred when toastmaster Hugh F. McCoubrie called for Past State President Schabacker and presented him a handsome mantel clock on behalf of the delegates of the State association. Mr Schabacker made an appropriate response.

The exhibits were well located in the main auditorium on the second floor of the convention hall. The booths were unusually large and comfortable, and were occupied by the following firms: Albany Belt and Supply Company, Albany Chamber of Commerce, Albany Lubricating Company, Ashton Valve Company, Bird-Archer Company, Ball Engine Company, Crandall Packing Company, M. T. Davidson Company, Dearborn Drug and Chemical Works, Fairbanks Company, Garlock Packing Company, Greene, Tweed & Co., Harrison Safety Boiler Works, Holmes Metallic Packing Company, Home Rubber Company, Homestead Valve Manufacturing Company, Jenkins Brothers, H. W. Johns-Manville Company, Keystone Lubricating Company, Lunkenheimer Company, McLeod & Henry Company, W. B McVicker Company, Morehead Manufacturing Company, *National Engineer*, Nemcs Brothers, George M. Newhall Engineering Company, New York Belting and Packing Company, Ohio Blower Company, Otis Elevator Company, Peerless Rubber Manufacturing Company, Philadelphia Grease Manufacturing Company, POWER, *Practical Engineer*, J. L. Quimby & Co., Ratz Company, Royersford Foundry and Machine Company, *Southern Engineer*, C. E. Squires Company, Strong, Carlisle & Hammond Company, W. N Swartbout & Co., George H. Thacher & Co., Union Steam Pump Company, Yarnall-Waring Company.

SOCIETY NOTES

The American Society of Heating and Ventilating Engineers will hold its semi-annual meeting in Chicago, Ill., on July 6, 7 and 8.

The third annual convention of the Engineers-Janitors' Association of the Public Schools of New York State will be held in Syracuse on Friday and Saturday, August 4 and 5, 1911, at Fobes hall, Educational building, corner of West Genesee and North Clinton streets. The association was organized two years ago in Albany, and within that period two cities in the State have had pension bills passed to aid the janitors in their declining years. Other cities have had their boards of education awakened to the fact that the engineer-janitors of their schools were not receiving a just compensation for the work required of them and have tried to give them what was due them as far as they were able.

PERSONAL

Martin G. Langguth, Portland, Ore., has been appointed engineer-in-charge of the power plant in the State house at Salem.

At a dinner given to Col. E. D. Meier in honor of his seventieth birthday at the Beaux Arts Club, New York City, on May 29, the employees of the Heine Safety Boiler Company gave him a complete surprise by presenting to him a fine Zeiss telescope and microscope. Among those present were men who started when the company was formed over thirty years ago.

After the dinner, Colonel Meier left for Pittsburg to preside at the spring meeting of the American Society of Mechanical Engineers, where he was honored by a testimonial from the society.

NEW PUBLICATION

THE SPONTANEOUS COMBUSTION OF COAL WITH SPECIAL REFERENCE TO BITUMINOUS COALS OF THE ILLINOIS TYPE. By S. W. Parr and F. W. Kressmann. Has just been issued as Bulletin No. 46 of the engineering-experiment station of the University of Illinois.

The Bulletin describes a series of experiments directed toward the determination of the fundamental causes underlying the spontaneous combustion of coal. These causes may be summarized as follows: (1) External sources of heat, such as contact with steam pipes, hot walls and the impact of large masses in the process of unloading, height of the piles, etc.; (2) fineness of division; (3) moisture; (4) activity of oxidizable compounds, such as iron pyrites. An historical review of the literature upon the spontaneous combustion of coal is given in the appendix. Copies of this bulletin may be obtained gratis upon application to W. F. M. Goss, director of the engineering-experiment station, University of Illinois, Urbana, Ill.

Engineering Societies Library

The facilities offered by the library of the Engineering Societies, at 29 West Thirty-ninth street, New York City, have recently been called to our attention. The library is formed from the combined libraries of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers and the American Institute of Mining Engineers, and contains over forty thousand volumes on engineering subjects. It is open for reference to the general public, without charge, every day and evening, except Sundays. The library is supplied with all the published indexes, has most complete sets of periodicals both domestic and foreign, and has a well trained reference staff.

Students residing in New York City and vicinity are especially invited to use the library in their researches on technological subjects. The library is on the top floor of the United Engineering Societies building, is quiet, well lighted and ventilated. Those who are prevented from visiting the library by distance or business engagements may nevertheless receive assistance. It is prepared to furnish references on engineering subjects to persons at a distance, and also to furnish transcripts, translations and photographic reproductions of diagrams and maps. For such work, if extensive, a moderate charge is made. Correspondence is welcomed; telegraphic and telephonic inquiries will receive especial attention.

Fort Wayne Electric Works Merged with General Electric

On June 1, the Fort Wayne Electric Works was merged with the General Electric Company, of Schenectady, N. Y. Its business will be continued under the name of Fort Wayne Electric Works of General Electric Company. The same lines of apparatus and supplies will continue to be manufactured and sold under the immediate direction of the same organization as heretofore, with F. S. Hunting in responsible charge as general manager.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

The priest who had been summoned in haste, as a substitute, to officiate at a funeral, was making a few remarks about the deceased. Wishing to make some allusion to the departed one, he suddenly realized that he didn't know the name or even the sex of the one in the coffin. To get the necessary information, without letting anyone know his predicament, he turned quickly to Pat, who was a mourner, and asked, under his breath, "Pat, is it a brother or a sister?" "Neither," replied Pat, "it's a cousin!"

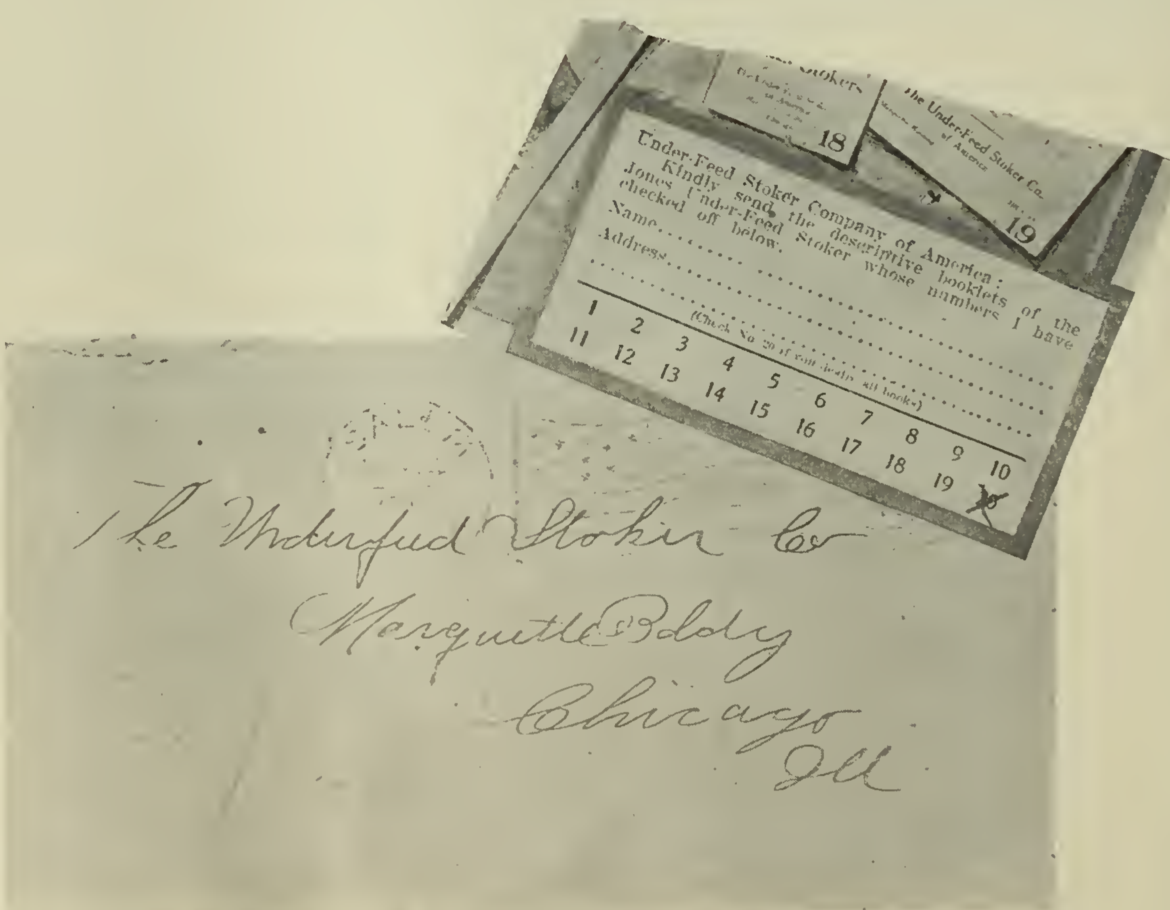
All of which shows that there are times when one's name and identity are important.

The other day the Under-Feed Stoker Company of America sent us the clipping from their POWER ad. and the envelope which are reproduced here.

Some engineer, in Salem, Mass., read their ad. in POWER and was so interested in their proposition that he sent in the coupon asking for all 20 of their booklets and even offered to pay for them if necessary—*but*, he failed to give his name and address.

No doubt he is still wondering why the advertiser hasn't made good his offer to send the printed matter.

And this occurrence is not so unusual as you might think.



Perhaps it isn't often that the reader neglects to give his name and address, but in a great many cases he fails to answer necessary questions which the advertiser asks—answers to which he must have before he can send out intelligent information.

Readers should realize that the ads cannot tell *all* there is to be told about a product.

The complete story is left to the catalogs, booklets and letters which the advertisers have prepared to send to all who become interested through the advertisements.

It is this expansive modern way of doing things that has made advertising a great educational force.

The advertiser does his part at great expense of time and money—

You do your part by reading the ads. and giving the advertiser a fair chance to send you intelligent information on how his product will benefit your plant.

And don't forget to say who and where you are.

We have printed this case because it contains a little "moral" for our readers—and also in the hope that the Salem engineer will read it, realize his mistake and send along his name and address.

POWER

Vol. 33 NEW YORK, JUNE 27, 1911 No. 26

OBSERVE the surprised and agonized look on the face of Alvah, Jr.

Why is Al so astonished and pained?

Simply because he has just eaten one green little apple; that's all. The pained expression is the result of the colic the apple has given him; his surprise is due to the fact that he *didn't know* that green apples cause gripes.

* * *

Every little while you read about someone accidentally shooting a sister, brother or dear friend. The fool always pleads: "I *didn't know* it was loaded."

* * *

Continually, gay youth is rocking the boat. When, as a result, two or three are drowned, the idiot whimpers that he *didn't know* he was incurring any danger.

* * *

Alvah's lack of knowledge concerning the painful possibilities of green apples does not mitigate the discomfort he is suffering amidships.

Because the unintentional murderer didn't know it was loaded, the funeral is not less sad or solemn.

Because the reckless young fool didn't know that the boat could be upset, the resuscitation of the victims of his folly is not less hopeless.

If a man unwittingly violates a law his plea that he *did not know* that said law existed is not sufficient defense. He must pay the same penalty as the man who deliberately breaks the statute.

Now, what in all Gaul has this to do with the price of kilowatts, as one might say?

Just this: Both man and nature agree that ignorance is no defense.

The engineer who unknowingly operates a weak boiler is just as much in danger of suddenly losing his life as is he who, knowing that a boiler is in bad shape, deliberately continues to work it.

The man who ignorantly operates an engine, pump or other machine in such a condition that it is liable suddenly to fail and thereby cause serious loss in money, time and patience, runs just as much risk of losing his job as does the man who is wilfully negligent.

The engineer who *does not know* of the leaks existing in his plant is no more excusable than he who does know, but neglects to stop them. Both are in the shadow of the "big hook."

But, why say more?

Illustration after illustration could be submitted tending to show that the consequences of lack of knowledge are far more severe than the labor involved in acquiring a sufficient amount of it.

When we speak of knowledge, we do not mean book knowledge alone; we mean such knowledge as will make you the best man for your position. This must include, then, a thorough knowledge of your plant—its capabilities and its weaknesses.

Learn the game and all its rules first, then get the philosophy.

Remember: Ignorance is no defense.

The Steam Turbine in Germany

By F. E. Junge
and E. Heinrich

A description of the Bergmann turbine, the important features of which are: a small number of stages; a high degree of expansion before the steam enters the turbine proper; solid attachment of blades, and avoidance of the critical speed at which vibrations of the shaft are set up.

The Bergmann Elektricitäts Gesellschaft, of Berlin, builds steam turbines of the pure impulse type, combining velocity and pressure stages. The steam enters the inlet chest at full pressure and expands in the nozzles down to a pressure of about one atmosphere. Such a high degree of expansion, permitting the formation of a compact steam jet of equivalent velocity without loss, requires the employment of conically divergent nozzles. In cylindrical nozzles the steam does not expand further than the critical ratio, which is a ratio of the pressure in front of the nozzles to that behind the nozzles and this, with dry saturated steam, is about 0.58. Whether the steam pressure before the nozzles be increased or that behind the nozzles diminished, the exit pressure will never be less than 0.58 of the initial pressure; hence the velocity of the steam will never be higher than that proportional to the critical pressure drop.

This critical velocity is practically identical with the velocity of travel of sound in steam of corresponding density; namely, about 1476 feet per second. If the pressure in the space behind the mouth of the nozzles is kept below the critical pressure, the steam emerging from the nozzle assumes the pressure of the surrounding medium; but the energy of this further expansion is entirely absorbed by the breaking up of the jet and by the formation of eddies and stationary fluctuations. A compact jet of definite direction and higher velocity can only be attained by means of a conical prolongation of the cylindrical nozzles in which the expanding steam converts the whole of its energy contents into velocity without considerable loss. By thus expanding from the boiler pressure down to the condenser pressure velocities of 4000 feet per second and higher are attained.

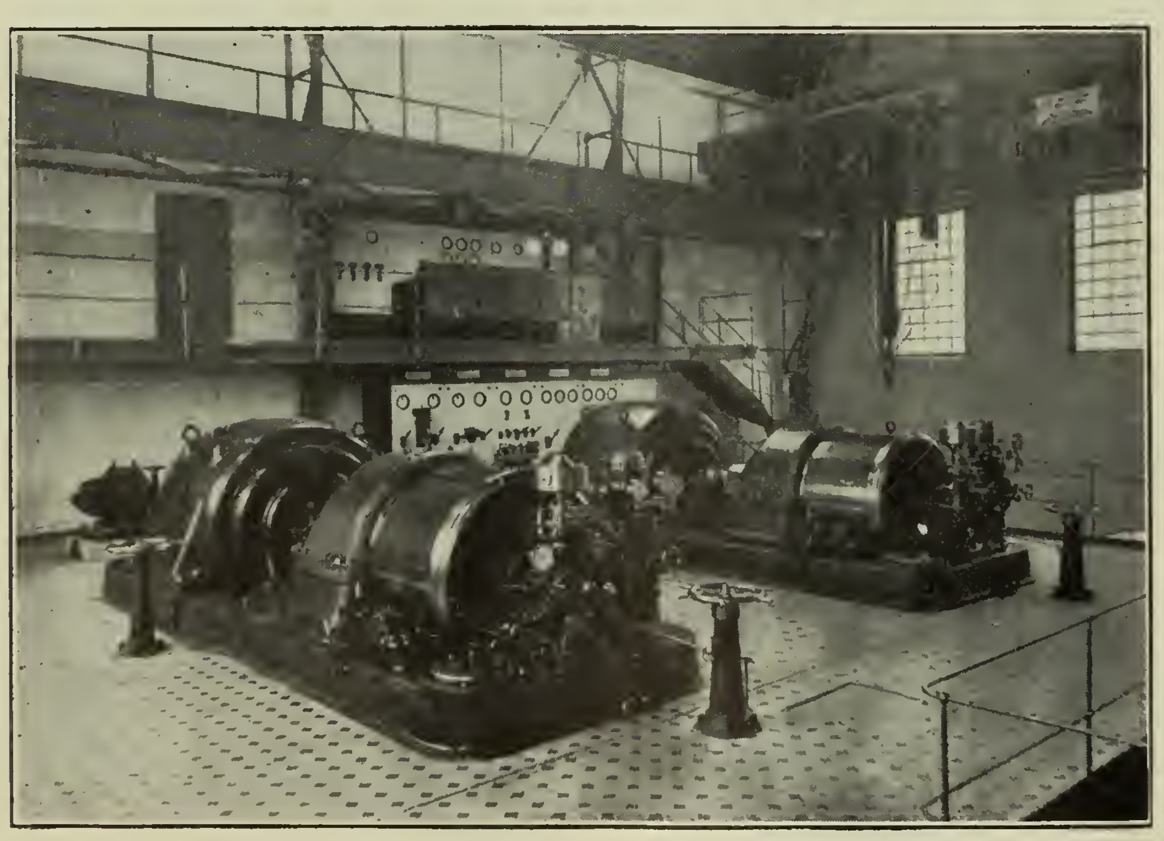


Fig. 41. Two 1500-kilowatt Bergmann Turbines

In the admission nozzles of the Bergmann turbine, expansion is carried down to one atmosphere, giving velocities of from 2600 to 3000 feet per second, and temperatures of about 300 to 340 degrees Fahrenheit. The diagrams in Fig. 42 show the relation of pressure and velocity. One row of blades being insufficient to utilize the whole velocity of the steam at normal blade speeds, the steam after leaving the first row of running blades is reversed in the following series of stationary blades and impinges upon a second row of runners at a suitable angle. In this second row the remaining velocity of the steam is utilized or absorbed, leaving just enough to effect its onward movement and issue. The process of energy conversion and also the process of regulation are the same, essentially, as in the turbines of the Allgemeine Elektricitäts Gesellschaft, previously described.

Before entering the nozzle chamber the steam passes a valve, controlled by the governor, which throttles the steam according to the requirements of the load.

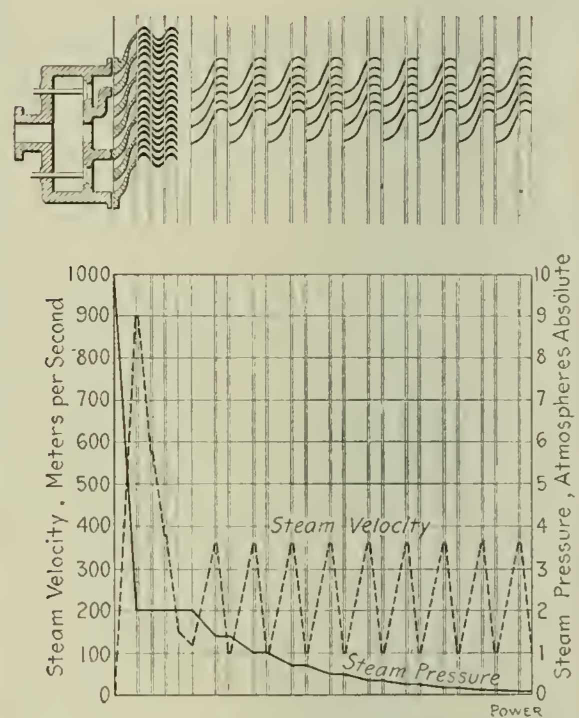


Fig. 42. Relations of Pressure and Velocity

But as throttling involves a loss it is desirable to have the full steam pressure at all loads in front of the nozzles; therefore, when entering the nozzle chamber, the steam is made to pass a number of valves which give admission to the various groups of nozzles, each group containing a different number. By combining various groups any number of nozzles are made to operate on the turbine. In this way both the cross-section and the quantity of steam admitted are adjusted to every condition of the load and the unavoidable losses at partial loads are reduced to a minimum (see Fig. 43).

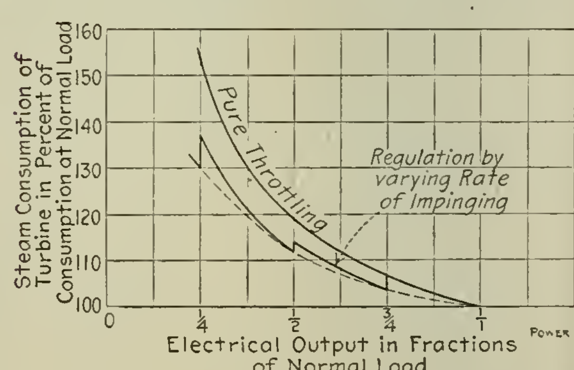


Fig. 43. Results with Different Means of Regulation

In some turbines the nozzles are distributed symmetrically over the whole circumference of the casing. But there is the disadvantage in such an arrangement that the blade channels must be filled and emptied behind each nozzle, involving losses through shock and eddies, and by a symmetrical arrangement these losses are multiplied; whereas by concentrating all the nozzles into one closed segment the losses are minimized. the whole circumference of the disk. Fig. 45 shows the first running wheel with two rows of blades. The remaining pressure drop is then divided into so many stages that the velocity of the steam in each stage remains below the velocity of sound, which is the upper

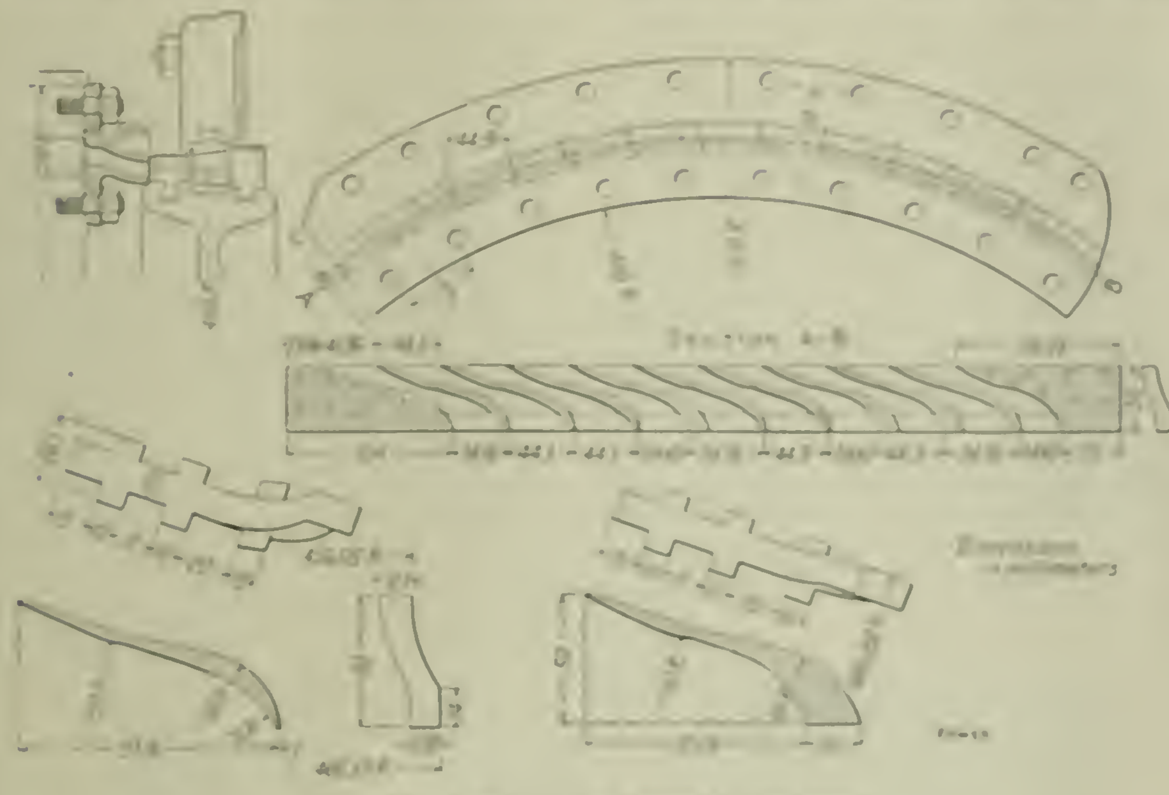


Fig. 44. Details of Nozzle Segment

Fig. 47. Ring on Stationary Disk

Fig. 44 shows the details of a nozzle segment for a turbine of 550 kilowatts running at 3000 revolutions per minute. The latter arrangement, moreover, has the advantage that the high admission pressure and the high temperature of superheat occur only in a comparatively small section, which can be designed with limit of the velocity attained by steam in prismatic nozzles. The latter are, of course, simpler in construction than conically divergent nozzles, and the shock and friction losses are much smaller at lower speeds. In the pressure stages, speeds range from 1000 to 1150 feet per second and can be effective-

Fig. 45. First Running Wheel with Double Row of Blades

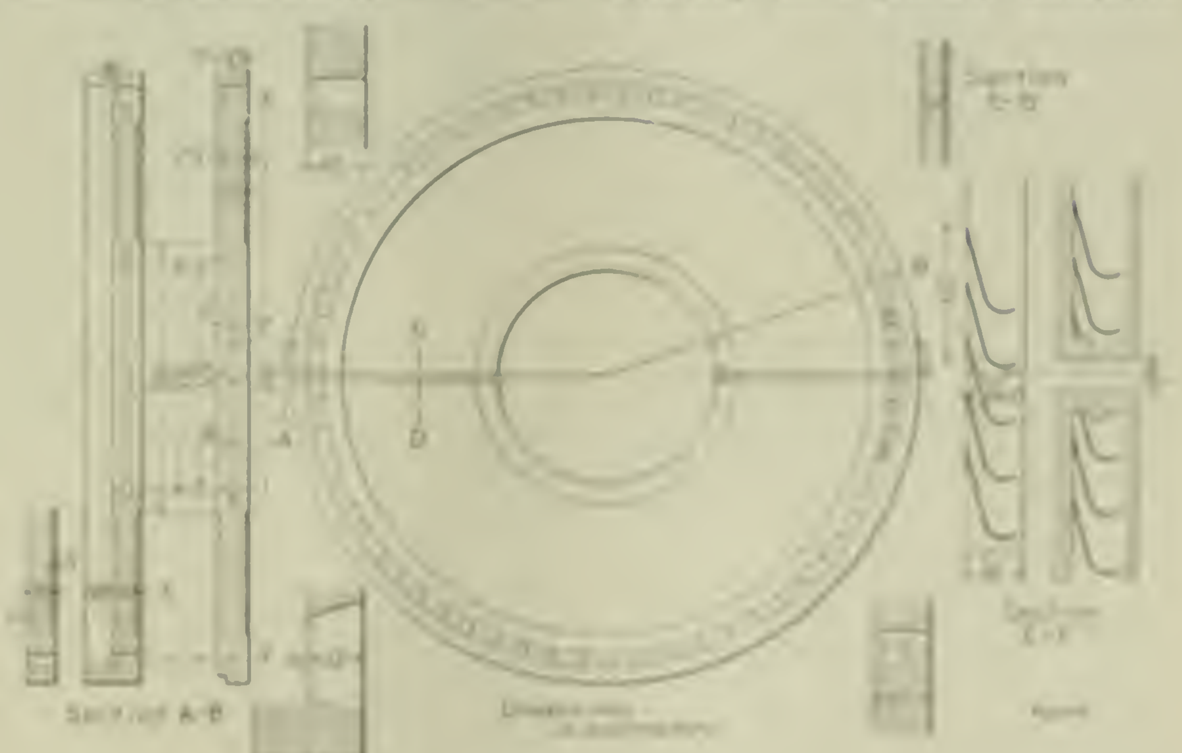


Fig. 46. Guide Disk

due consideration to the high pressures and temperatures without affecting the other castings of the turbine.

After leaving the second row of blades of the velocity wheel the volume of the expanded steam is so large that the succeeding blades can be distributed around ly utilized in wheels having only one row of blades.

The guide-blade channels which serve to impart the required velocity and direction to the steam in each stage are made of nickel steel and are cast in the circumference of the guide disks (see Figs. 46 and 47). The latter are divided in the horizontal center plane so that the upper half can be lifted together with the upper part of the casing. The hubs of the running wheels are fastened to the turbine shaft in the ordinary manner and rotate within the hub bores of the guide disks with as little play as possible and without friction. They are forged in one piece of steel with the hubs, the blades being inserted on the circumference. The cross-sections are so dimensioned that the drop of pressure occurs exclusively in the guiding channels.

The pressure on both sides of the running wheels is the same so that the disks may be bored for balancing or for equalizing minor pressure differences. There is the other advantage, previously referred to, that with the same pressure before and behind the running wheels there is no axial thrust in the system, the small thrust bearing at the end of the shaft serving no other purpose than that of keeping the running wheels in their exact position. A running wheel of the pressure stage with blades attached is shown in Fig. 48.

In order to avoid atomizing and eddying in the jet, the blade channels of the velocity wheel are accurately proportioned to the weight of steam flowing; this requires blades considerably thicker at the middle than at the edges. Until lately these blades were made of a special bronze but are now made of 25 per cent. nickel steel. In the simple pressure wheels the danger of atomizing is less imminent, wherefore the blades of nickel-steel plate are found to give satisfaction. Their method of construction is primarily dictated by the demand for light weight; yet they must be rigidly fastened on account of the stresses due to centrifugal force and possibly to friction with the stationary part of the system. The attachment of the blades is a special feature of the Bergmann turbine, being covered by a German patent. Blades subjected to stress on the testing machine show a resistance to dislodgment of 4600 pounds for each blade.

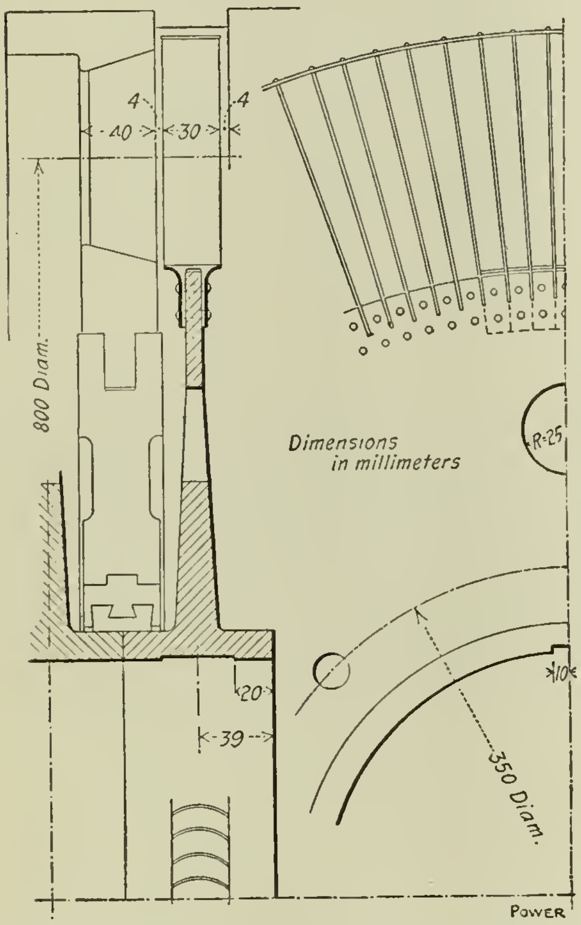


Fig. 48. Running Wheel at Pressure Stage

The arrangement of the frame and bearings is similar to that of the Allgemeine Elektricitäts Gesellschaft turbines. The two back bearings are cast in one piece with the casing, there being no possibility of any except rotary motion between the fixed and movable parts. The front bearing is centered into and bolted on the cover of the turbine casing, which is a steel casting; hence, there is no possibility of unequal expansion through influx of heat and the unavoidable play between the fixed and rotary parts can be accurately provided for. This is of importance especially where the hubs of the running wheels pass through the bushings of the guide disks, and where the turbine shaft passes through the stuffing boxes in the heads of the casing. The radial clearance between the fixed and movable wheels is only a few thousandths of an inch; nevertheless, it is a source of loss, because the steam which passes from one side of the disk to the other renders no useful work. It is therefore important to keep this clearance not only as small as possible but also as constant as possible. The same holds true of the packing boxes.

Another reason for maintaining rigidity of construction and true concentricity of position of the fixed and rotary parts lies in the movement of the shaft. Shafts of normal dimensions making 3000 revolutions per minute and over, usually run above the critical speed. The latter corresponds to the number of revolutions at which the deflection due to the centrifugal force acting on the unbalanced masses of the shaft produces the maximum vibration. Heavy shafts running above the critical speed are apt, when passing through that speed, to vibrate badly, involving serious wear upon the bushings of the guide disks. If, in addition, there is a fault in erection or a shifting between the shaft and the casing owing to unequal expansion, the clearance may become so large that the steam consumption is increased excessively. It is desirable therefore to let the turbine run below the critical speed, even when the normal speed is 3000 revolutions per minute. This means that a shaft should be designed for a critical speed of about 4000 if one takes into consideration momentary increases and unavoidable deviations of practice from calculation.

The critical speed depends solely upon the deflection of the shaft through its own weight, plus the weight of the wheels, in such a manner that with a decreasing deflection the critical speed increases. Therefore, in order to get practical speeds the deflection of the shaft must be kept as small as possible. But the deflection grows in direct proportion to the load and as the cube of the distance between bearings; hence, the weight of the rotary part, and especially the distance between the bearings, must be kept as small as possible. The Bergmann construction of blades satisfies the first requirement of light weight, while the combination of one velocity wheel with from three to five pressure wheels results in shortening the distance between the bearings, so that the shafts are moderately heavy and the critical speed lies far above the normal. Unless these precautions are taken the actual steam consumption of turbines will be considerably higher than the consumption ascertained in shop tests, upon which guarantee figures are generally based.

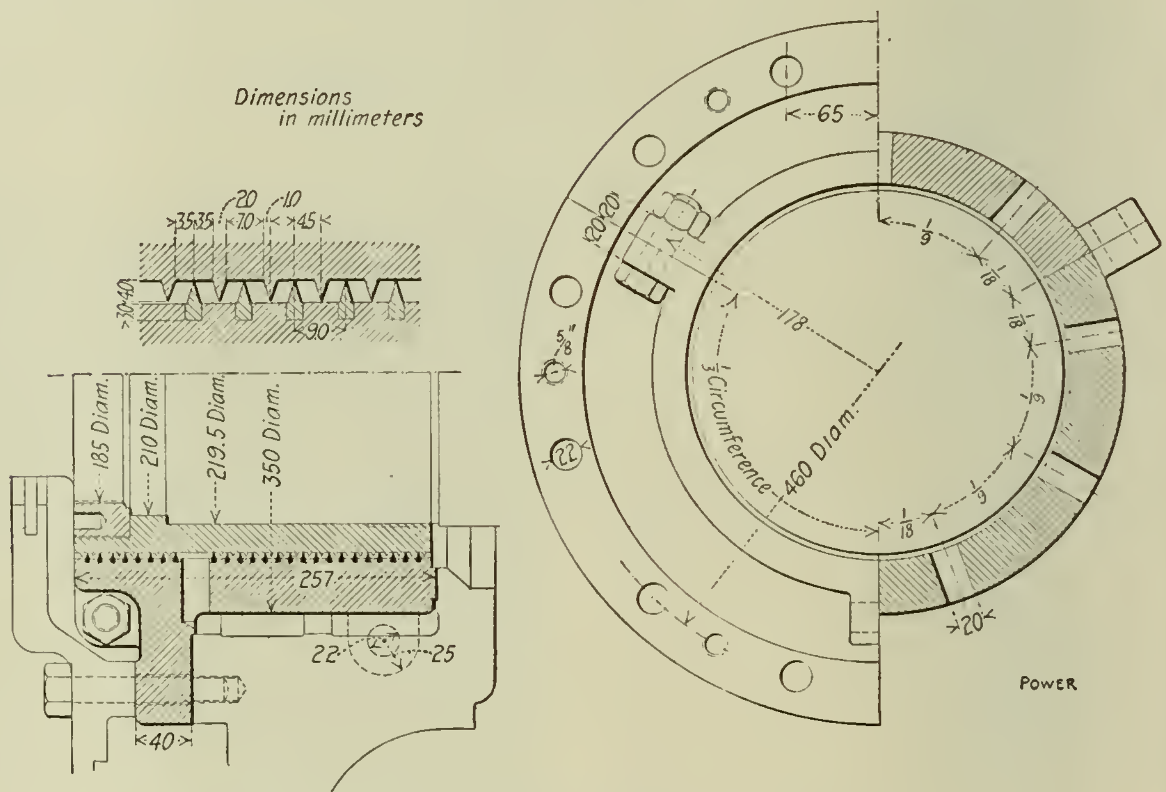


Fig. 49. Details of High-pressure Stuffing Box

The packing of the Bergmann turbine is of the labyrinth variety, both on the high-pressure side, where the pressure is about 15 pounds above the atmosphere, and on the low-pressure side, where the packing separates the vacuum space from the atmosphere. The rings on the cover which project into the annular grooves of the bushings on the shaft are divided into two groups of different sizes, the space between them connecting from the high-pressure to the low-pressure stuffing boxes. Details of the high-pressure stuffing box are shown in Fig. 49. Thus the steam emerging from the first is used in the second as a packing medium against the influx of air from without. At light loads, when there is not sufficient surplus steam in the high-pressure box, live steam can be introduced into the connecting pipe, while at heavy loads the surplus steam not utilized in the low-pressure packing box is discharged into one of the middle stages of the turbine.

The construction of the bearings does not differ from the ordinary. They are lubricated with oil which is supplied under about two atmospheres pressure by a rotary pump. After passing the bearings the oil is collected in a tank where it is filtered and used over again. The bearings are cooled partly by means of a water-jacketed worm pipe inserted between the oil pump and the bearings, and partly by water cooling the bearings themselves.

The same worm gear which drives the oil pump also serves to actuate the vertical shaft of the governor. This is of

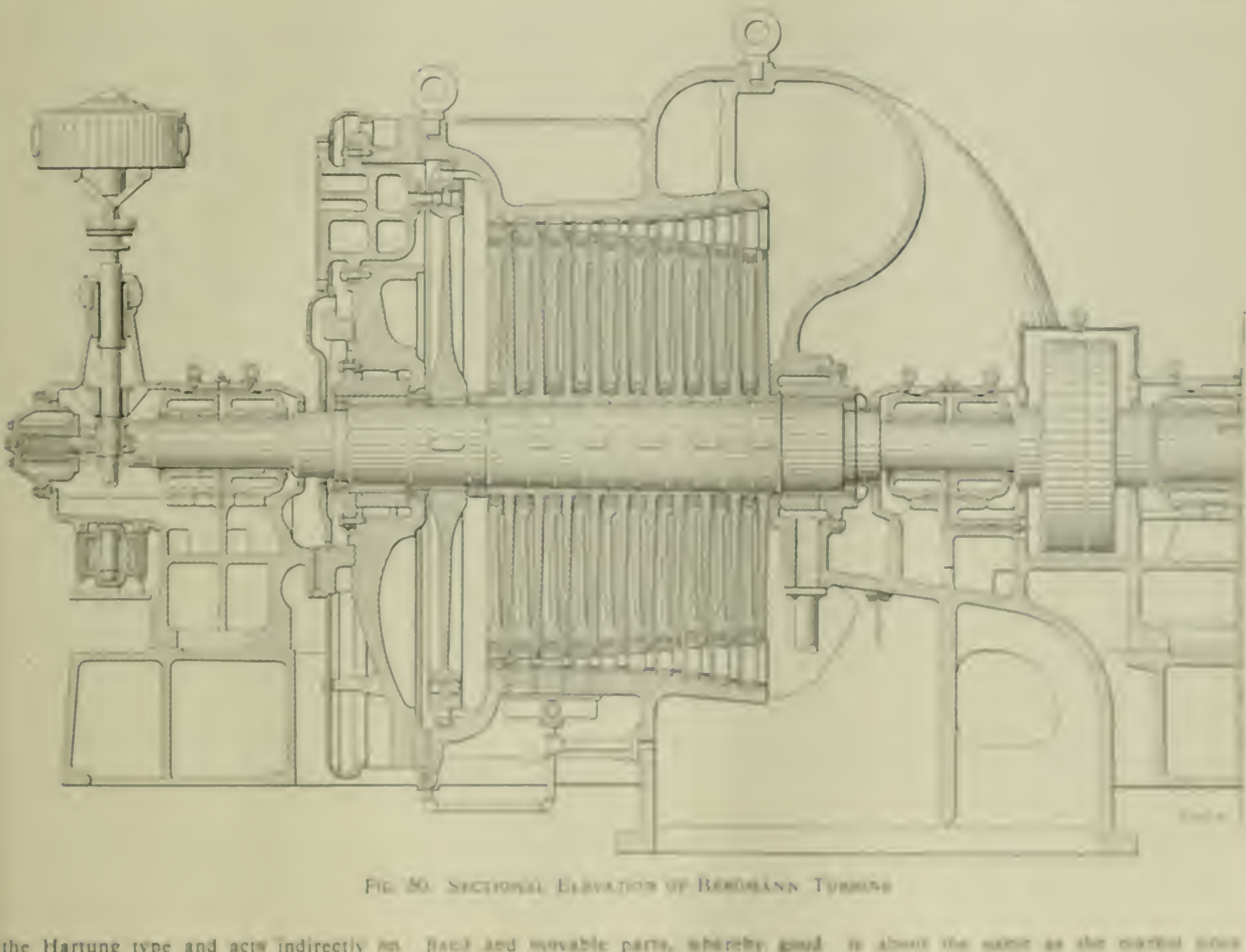


Fig. 80. Sectional Elevation of Bergmann Turbine

the Hartung type and acts indirectly on the main admission valve through a balanced pilot valve. The latter admits oil under pressure below or above the main governing piston which is fastened on the same stem with the throttle valve. In addition to this automatic regulation there is, within certain load ranges, regulation by hand, inasmuch as one or more groups of nozzles may be closed so as to obtain the benefit of the full steam pressure behind the throttle valve and therefore in front of the inlet nozzles. In addition there is the customary safety regulator closing the main admission valve automatically when the speed exceeds certain limits.

Summarizing the notable features of the Bergmann turbines, they will be found fairly representative of the standard construction of steam turbines in Germany; and are as follows: Far-reaching expansion and cooling of the steam before it enters the turbine proper, whereby moderate temperatures in the casing are secured; the smallest number of stages compatible with moderate speed, therefore short length of machine; avoidance of the critical speed and of vibration and other troubles connected therewith; the construction of the casing and bearings in one piece on a common frame plate and accurate concentric position of the fixed and movable parts, whereby good steam economy is guaranteed; no lubrication of packings and therefore no oil in the condensate; solid attachment of blades, which can be exchanged without having to dismount the turbine; and great resistance of blades against bending and shearing. Fig. 80 shows a longitudinal section through the complete turbine.

A mixture of Pintsch gas with air is explosive within a gas percentage range of 5 to 13 per cent., and it develops its maximum power at a percentage of about 11 per cent.

Metal Welding in Germany

Consul-General A. M. Thackara, of Berlin, states that there are many systems of metal-welding apparatus made and used in Germany. The use of welding apparatus has very materially increased in recent times. The quite general replacing of the older hydrogen by the acetylene apparatus makes the process not only cheaper but also more generally applicable. The calcium carbide is readily obtainable, and its generation is very simple.

In the case of the latter system, the acetylene gas is generated directly from calcium carbide by the apparatus itself. The cost of acetylene gas thus produced is about the same as the market price for hydrogen gas, but only about one-fifth as much acetylene gas is required for a given piece of welding. Furthermore, the considerably higher temperature obtained with acetylene gas makes possible the welding of metals of greater thickness. The temperature limit for hydrogen is 1900 degrees Centigrade (3452 degrees Fahrenheit) and of acetylene it is 3500 degrees Centigrade (6332 degrees Fahrenheit). The metal thickness that may be welded by the two systems are ¾ and 1½ inches respectively, leaving a margin of ¾ inch in favor of the acetylene gas.

Schedule of Flanged Fittings

The committee on standardization of the society working in conjunction with a similar committee of the National Association of Master Steam and Hot Water Fitters presented the following report on standard weight and extra-heavy flanged fittings at the spring meeting of the American Society of Mechanical Engineers:

Standard or extra-heavy reducing elbows carry the same dimensions center to face as the regular elbows of the largest straight size.

Standard or extra-heavy tees, crosses, laterals or Y-branches, reducing on run or outlets, carry the same dimensions face to face and center to face as the largest straight size.

If flanged fittings for lower working pressures than 125 pounds are made they shall conform in all dimensions except thickness of shell to this standard, and guaranteed working pressure must be cast on each fitting.

Companion flanges for these fittings must be standard dimensions.

Where long-turn fittings are specified

TABLE 1. SCHEDULE OF STANDARD WEIGHT FLANGED FITTINGS

	Elbows	45-Deg. Elbows	Long Turn Elbows	Tees and Cros'es	Laterals or Y Br'n'h's
1¼ inch					
Center to face	3¾	2	6	3¾	6¼
Face to face	....	....	....	7½	8½
Diameter of flange	4½	4½	4½	4½	4½
Thickness of flange	½	½	½	½	½
Diameter of bolt circle	3⅜	3⅜	3⅜	3⅜	3⅜
Number of bolt holes	4	4	4	4	4
Diameter of bolt holes	9/16	9/16	9/16	9/16	9/16
1½ inch					
Center to face	4	2¼	6½	4	6⅞
Face to face	....	....	....	8	9¼
Diameter of flange	5	5	5	5	5
Thickness of flange	9/16	9/16	9/16	9/16	9/16
Diameter of bolt circle	3⅞	3⅞	3⅞	3⅞	3⅞
Number of bolt holes	4	4	4	4	4
Diameter of bolt holes	⅝	⅝	⅝	⅝	⅝
2 inch					
Center to face	4½	2½	7	4½	8
Face to face	....	....	....	9	10½
Diameter of flange	6	6	6	6	6
Thickness of flange	⅝	⅝	⅝	⅝	⅝
Diameter of bolt circle	4¾	4¾	4¾	4¾	4¾
Number of bolt holes	4	4	4	4	4
Diameter of bolt holes	¾	¾	¾	¾	¾
2½ inch					
Center to face	5	2¾	7½	5	9½
Face to face	....	....	....	10	12
Diameter of flange	7	7	7	7	7
Thickness of flange	11/16	11/16	11/16	11/16	11/16
Diameter of bolt circle	5½	5½	5½	5½	5½
Number of bolt holes	4	4	4	4	4
Diameter of bolt holes	¾	¾	¾	¾	¾
3 inch					
Center to face	5½	3	8	5½	10
Face to face	....	....	....	11	13
Diameter of flange	7½	7½	7½	7½	7½
Thickness of flange	13/16	13/16	13/16	13/16	13/16
Diameter of bolt circle	6	6	6	6	6
Number of bolt holes	4	4	4	4	4
Diameter of bolt holes	¾	¾	¾	¾	¾
3½ inch					
Center to face	6	3½	9	6	11½
Face to face	....	....	....	12	14½
Diameter of flange	8½	8½	8½	8½	8½
Thickness of flange	13/16	13/16	13/16	13/16	13/16
Diameter of bolt circle	7	7	7	7	7
Number of bolt holes	4	4	4	4	4
Diameter of bolt holes	¾	¾	¾	¾	¾
4 inch					
Center to face	6½	4	10	6½	12
Face to face	....	....	....	13	15
Diameter of flange	9	9	9	9	9
Thickness of flange	15/16	15/16	15/16	15/16	15/16
Diameter of bolt circle	7½	7½	7½	7½	7½
Number of bolt holes	8	8	8	8	8
Diameter of bolt holes	⅞	⅞	⅞	⅞	⅞
4½ inch					
Center to face	7	4¼	11	7	12½
Face to face	....	....	....	14	15½
Diameter of flange	9¼	9¼	9¼	9¼	9¼
Thickness of flange	15/16	15/16	15/16	15/16	15/16
Diameter of bolt circle	7¾	7¾	7¾	7¾	7¾
Number of bolt holes	8	8	8	8	8
Diameter of bolt holes	⅞	⅞	⅞	⅞	⅞
5 inch					
Center to face	7½	4½	12	7½	13½
Face to face	....	....	....	15	17
Diameter of flange	10	10	10	10	10
Thickness of flange	15/16	15/16	15/16	15/16	15/16
Diameter of bolt circle	8½	8½	8½	8½	8½
Number of bolt holes	8	8	8	8	8
Diameter of bolt holes	⅞	⅞	⅞	⅞	⅞
6 inch					
Center to face	8	5	13	8	14½
Face to face	....	....	....	16	18
Diameter of flange	11	11	11	11	11
Thickness of flange	1	1	1	1	1
Diameter of bolt circle	9½	9½	9½	9½	9½
Number of bolt holes	8	8	8	8	8
Diameter of bolt holes	⅞	⅞	⅞	⅞	⅞
7 inch					
Center to face	8½	5½	14½	8½	16½
Face to face	....	....	....	17	20½
Diameter of flange	12½	12½	12½	12½	12½
Thickness of flange	1 1/16	1 1/16	1 1/16	1 1/16	1 1/16
Diameter of bolt circle	10¾	10¾	10¾	10¾	10¾
Number of bolt holes	8	8	8	8	8
Diameter of bolt holes	⅞	⅞	⅞	⅞	⅞
8 inch					
Center to face	9	6	16	9	17½
Face to face	....	....	....	18	22
Diameter of flange	13½	13½	13½	13½	13½
Thickness of flange	1⅛	1⅛	1⅛	1⅛	1⅛
Diameter of bolt circle	11¾	11¾	11¾	11¾	11¾
Number of bolt holes	8	8	8	8	8
Diameter of bolt holes	⅞	⅞	⅞	⅞	⅞
9 inch					
Center to face	10	6½	18	10	19½
Face to face	....	....	....	20	24
Diameter of flange	15	15	15	15	15
Thickness of flange	1⅛	1⅛	1⅛	1⅛	1⅛
Diameter of bolt circle	13¼	13¼	13¼	13¼	13¼
Number of bolt holes	12	12	12	12	12
Diameter of bolt holes	⅞	⅞	⅞	⅞	⅞
10 inch					
Center to face	11	7	20	11	20½
Face to face	....	....	....	22	25½
Diameter of flange	16	16	16	16	16
Thickness of flange	1 3/16	1 3/16	1 3/16	1 3/16	1 3/16
Diameter of bolt circle	14¼	14¼	14¼	14¼	14¼
Number of bolt holes	12	12	12	12	12
Diameter of bolt holes	1	1	1	1	1
12 inch					
Center to face	12	7½	22	12	24½
Face to face	....	....	....	24	30
Diameter of flange	19	19	19	19	19
Thickness of flange	1¼	1¼	1¼	1¼	1¼
Diameter of bolt circle	17	17	17	17	17
Number of bolt holes	12	12	12	12	12
Diameter of bolt holes	1	1	1	1	1
14 inch					
Center to face	14	7½	24	14	27
Face to face	....	....	....	28	33
Diameter of flange	21	21	21	21	21
Thickness of flange	1⅜	1⅜	1⅜	1⅜	1⅜
Diameter of bolt circle	18¾	18¾	18¾	18¾	18¾
Number of bolt holes	12	12	12	12	12
Diameter of bolt holes	1⅛	1⅛	1⅛	1⅛	1⅛
15 inch					
Center to face	14½	8	26	14½	28½
Face to face	....	....	....	29	34½
Diameter of flange	22¼	22¼	22¼	22¼	22¼
Thickness of flange	1⅜	1⅜	1⅜	1⅜	1⅜
Diameter of bolt circle	20	20	20	20	20
Number of bolt holes	16	16	16	16	16
Diameter of bolt holes	1⅛	1⅛	1⅛	1⅛	1⅛
16 inch					
Center to face	15	8	28	15	30
Face to face	....	....	....	30	36½
Diameter of flange	23½	23½	23½	23½	23½
Thickness of flange	1 7/16	1 7/16	1 7/16	1 7/16	1 7/16
Diameter of bolt circle	21¼	21¼	21¼	21¼	21¼
Number of bolt holes	16	16	16	16	16
Diameter of bolt holes	1⅛	1⅛	1⅛	1⅛	1⅛
18 inch					
Center to face	16½	8½	30	16½	32
Face to face	....	....	....	33	39
Diameter of flange	25	25	25	25	25
Thickness of flange	1 9/16	1 9/16	1 9/16	1 9/16	1 9/16
Diameter of bolt circle	22¾	22¾	22¾	22¾	22¾
Number of bolt holes	16	16	16	16	16
Diameter of bolt holes	1¼	1¼	1¼	1¼	1¼
20 inch					
Center to face	18	9½	32	18	35
Face to face	....	....	....	36	43
Diameter of flange	27½	27½	27½	27½	27½
Thickness of flange	1 11/16	1 11/16	1 11/16	1 11/16	1 11/16
Diameter of bolt circle	25	25	25	25	25
Number of bolt holes	20	20	20	20	20
Diameter of bolt holes	1¼	1¼	1¼	1¼	1¼
22 inch					
Center to face	20	10	34	20	37½
Face to face	....	....	....	40	46
Diameter of flange	29½	29½	29½	29½	29½
Thickness of flange	1 13/16	1 13/16	1 13/16	1 13/16	1 13/16
Diameter of bolt circle	27¼	27¼	27¼	27¼	27¼
Number of bolt holes	20	20	20	20	20
Diameter of bolt holes	1¼	1¼	1¼	1¼	1¼
24 inch					
Center to face	22	11	36	22	40½
Face to face	....	....	....	44	49½
Diameter of flange	32	32	32	32	32
Thickness of flange	1⅞	1⅞	1⅞	1⅞	1⅞
Diameter of bolt circle	29½	29½	29½	29½	29½
Number of bolt holes	20	20	20	20	20
Diameter of bolt holes	1¼	1¼	1¼	1¼	1¼

it has reference only to elbows, which are made in two dimensions, to be known as "elbows" and "long-turn elbows," the latter being used only when so specified.

All standard-weight fittings must be guaranteed for 125 pounds and extra-heavy fittings for 250 pounds working pressure, and each fitting must have some mark cast on it indicating the maker and guaranteed working steam pressure.

All extra-heavy fittings and flanges to have a raised surface 1/16 inch high inside of the bolt holes for a gasket.

Standard-weight fittings and flanges to be plain faced.

Bolts to be ⅛ inch smaller in diameter than bolt holes.

Size of all fittings scheduled indicates inside diameter of ports.

For outside dimension pipe use corresponding size of inside dimension fittings.

These dimensions, both standard and extra heavy, refer to either cast-iron or cast-steel fittings and rolled-steel flanges.

The committee consists of H. G. Stott, chairman, superintendent of motive power of the Interborough; E. B. Hutton, past president of the Society; I. E. Moultrop, of the Boston Edison; H. P. Norton, Bureau of Steam Engineering, Navy Department, and J. T. Whittlesey, of the Public Service Corporation of New Jersey.

TABLE 2. SCHEDULE OF EXTRA HEAVY FLANGED FITTINGS

	Elbows	45-Deg. Elbows	Long Turn Elbows	Tees and Crosses	Laterals or Y Branches
1¼ Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1½ Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2½ Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3½ Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4½ Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24 Inch					
Center to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Face to face	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness of flange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt circle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of bolt holes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Training Mr. Duffy

By Danny Hogan

"Daly do be trainin' me," said Duffy, "how to set a slide valve."

"An' what," asked Doolin, "is a slide valve? Ye have a cylinder an' a piston —to let in the steam and to let it out again at the right instant is all 'tis for. 'Tis easier than layin' out an 18-inch stack. Them engineers, Duffy, get worked up over simple matters and get stuck on others. Ask Daly when you meet him how would he indicate a turbine engine an' tell me what he says."

"About the butt-strap joints," said Duffy, "Daly said the City Hall bunch would ask all kinds of questions, as this biler matter is considered greater than the engine."

"An' right he is for once," replied Doolin. "The steam biler is the most important machine in the world. The lap-joint seam is discarded in respectable society as ondecent and the butt joint is now the rage. To explain why, Duffy, 'tis only necessary to say the lap seam is not a true circle and when pressure is on it results in a bendin' action along the seam. As the pressure varies, so does the bendin'. Ye may bend a piece of steel back and forth but at last it will break. Now the butt joint, properly made, is a true circle and hence the bendin' action is absent. To avoid bendin' stresses the shell must have all parts truly cylindrical. It's a simple truth, is it not? Now to rivet the ends of the circle together we must have straps—one inside and one outside. The common rule is to have each strap 1/16 inch less in thickness than the plate, and this is safe practice. The common practice also makes the pitch in the outer row either double or four times that in the inner row or rows. Ye noted in the table I gave you that a steel rivet in single shear is allowed 42,000 pounds per square inch and in double shear 78,000 pounds, for in the latter the rivet would be cut in half in two places and but one in the lap seam. Ye would think one could use very much smaller rivets with a butt joint as the rivets are near double as strong, but, mind ye, in all the problem a tight job is needed. True, we don't need the diameter to be

$$T \times 2,$$

but within ordinary practice we find this a good rule:

$$T \times 2 - 1/16 \text{ inch} = \text{diameter of rivet hole}$$

and gives a tight job at that.

"Suppose, now, ye have a ½-inch plate of 56,000 pounds tensile strength, an' you want a butt-strap joint triple riveted. The straps would each be 7/16 inch thick and the rivet hole 15/16 inch. In a section of the joint there would be four rivets in double shear and one in single shear an' the shear value is

$$53{,}843 \times 4 + 28{,}988 = 243{,}560 \text{ pounds}$$

"Now note, Duffy, in the single-shear joint the value of the rivet is less than the tensile strength of the plate and hence must be taken in account. But in the butt joint commonly used the shear exceeds the plate value. Therefore, we need only find a section in the outer row of rivets to give us the desired efficiency. Suppose we want an 86 per cent. joint, the outer row is the weakest section at the net plate, as the shearing value is high. If

$$\frac{P - D}{P} = \text{efficiency of plate}$$

then

$$\frac{\text{Diameter}}{1 - \text{efficiency}} = \text{pitch}$$

The diameter is 0.9375 and

$$\frac{0.9375}{1 - 0.86} = 6.696 \text{ inches}$$

Call it 6¾ inches as the nearest common fraction. Then,

$$\frac{6.75}{6.75 - 0.9375} = 86.1 \text{ per cent.}$$

The value of the solid plate is

$$6.75 \times 0.5 \times 56{,}000 = 189{,}000 \text{ pounds}$$

The shear of all the rivets is 243,560 pounds.

"This rule applies on a double, triple or quadruple joint provided, of course, ye use, within reason, the proper size rivet. The rivets in double shear will have a pitch either one-half or one-fourth of the outer row of rivets, dependin' on whether the joint is double, triple or quadruple, for by the pitch found by this rule is meant always the outer row. For instance, say ye want the ½-inch plate of 56,000 pounds tensile strength with a butt, quadruple-riveted joint with an efficiency of 94 per cent. Then,

$$\frac{0.9375}{1 - 0.94} = 15.625 \text{ inches}$$

for the outer row. The next row is 7.8125 inches and the inner row, the single pitch, is 3.90625 inches. In a double-riveted butt joint say we want an 80 per cent. efficiency. Then,

$$\frac{0.9375}{1 - 0.80} = 4.6875 \text{ inches}$$

the outer pitch, the inner being 2.34375 inches, or $4\frac{11}{16}$ inches and $2\frac{11}{32}$ inches.

"Another method is to find the pitch ratio an' multiply this by the diameter of the rivet hole. The formula, Duffy, is

$$\frac{1}{1 - \text{efficiency}} = \text{pitch ratio}$$

for any thickness of plate.

"Suppose an 80 per cent. joint is wanted. Then,

$$\frac{1}{1 - 0.80} = 5$$

and

$$0.9375 \times 5 = 4.6875 \text{ inches}$$

the desired pitch for this efficiency and this rivet hole in the outer row, or the double pitch. Mind you, Duffy, the double shear is greater than the tensile strength—and by finding the total shear an' comparing this with a pitch section of the solid plate you may design with any thickness of plate and any tensile strength, for any rivet the bull will drive. But, in shops not building Scotch marine bilers with heavy plate, they find it impracticable to drive, with a 100-ton bull, rivets much above 1¼ inches an' get a tight job. The marine shops require bulls up to 150 tons, an' ordinary shops stop at 100 tons. The rivet must fill the hole an' be allowed to shrink under pressure. True, a steel rivet don't swell when heated as an iron one did, an' in some shops the hole is but 1/32 inch smaller than the rivet instead of 1/16 inch. In this case it's easier to fill the hole."

"An' how about the distance between the pitch lines in a butt joint?" asked Duffy.

"Well," replied Doolin, "ye get good results by multiplying the pitch by 0.65 to get the distance between the rows in the inner rows of rivets in double shear. Mind that the plate edge should be planed square so that it butts solid together. This is important in allowing 1½ diameters from the edge of the plate to the first pitch line. For the other distances from pitch line to edge of plate, see you have the same allowance. For the rivets in single shear, lay out so the rivet head will clear the outer strap an' leave clearance for the die. Mind, in laying out the pitch by these methods 'tis better to have the diameter of rivet

$$T \times 2 - 1/16 \text{ inch}$$

an' the straps

$$T - 1/16 \text{ inch}$$

But, in ¼-inch plate make the straps ¼ inch, so they won't buckle and bulge when bull riveting. Indeed, it's a disputed argument among intelligent bilermakers about the thickness of the inner strap, as some claim it should be the thickness of the plate, owing to the stresses it must carry. Be that as it may, one thing I hold true, the straps should be absolutely true arcs of their respective circles in order that bending action will be eliminated. Another thing, Duffy, is that in practice the pitch of the rivets must be divided up so as to come out even in the given length of plate, else one section will be weaker than the rest. To do this it's best to measure the length and bring the odd pitch near the girth seam for, at this point, the shell is stiffened and strengthened by the hoop or girth-seam lap. In the girth seam the total lap should be three rivet-hole diameters. The gain in strength is then one diameter, or 33 per cent., at the girth as regards the cylinder, at this point.——An' there ye are, Duffy, in laying out butt-strap joints, the City Hall bunch won't have annything on ye if ye get this soaked into your system even if ye be only a sub for a Chink."

Energy Drop in Steam Turbines*

By E. Cardullo

The effect of fluid friction is to increase the total heat and the entropy of the steam as it flows through the turbine and to increase the proportion of power developed in the later stages. An empirical formula is proposed for estimating the quantity of power developed in each stage of a turbine.

There are three general methods open to the designer for determining the properties of steam during its passage through the turbine. He may make use of empirical equations giving the relation between the heat content, entropy and temperature or pressure of expanding steam, as was suggested by Doctor Steinmetz.† He may make use of Mollier's total heat-entropy diagram which gives the relation between the total heat, entropy, pressure and quality of steam. Or he may make use of a table like that of Professor Peabody's giving the relation between the temperature, entropy, total heat, quality and specific volume of steam. The last two methods are more simple and more accurate than the first one and are to be preferred.

Assume that a turbine is to be designed having n stages and that the diameters of the moving elements of each stage are the same. The heat drop per stage will be $\frac{1}{n}$ of the total heat drop. Were there no retransformation of work into heat, it would be necessary only to find from an entropy table or diagram the entropy and total heat of the steam as it enters the turbine, and the total heat, at the same entropy, of steam of the terminal pressure, to subtract the second quantity from the first in order to obtain the total heat drop, and then to divide this drop by the number of stages to obtain the heat drop per stage. The pressures in each stage would then be found by subtracting the heat drop per stage n times from the initial heat content and finding from the table or diagram the pressure of steam having the heat content so found, at the given entropy. This method may be illustrated by the following problem:

Assume that the initial steam pressure is 164.8 pounds per square inch and the final pressure is 1.005 pounds per square inch; that the steam is initially dry and saturated, and that the number of stages is two. From Professor Peabody's table, the initial entropy is found to be 1.56 and the initial heat content 1193.3 B.t.u. The heat content of steam of 1.56 entropy at the terminal pressure is 871.1 B.t.u. The difference between the initial and final heat content, or the heat drop, is 322.2 B.t.u. The heat drop per stage is one-half this or 161.1 B.t.u. The heat content of the steam entering the second stage is

$$1193.3 - 161.1 = 1032.2 \ B.t.u.$$

The pressure of steam having this heat content and the entropy 1.56 is 18.4 pounds, which would be the absolute pressure of the steam as it enters the steam chest of the second stage.

In the actual steam turbine, however, the quantity of heat transformed into work is 40 to 70 per cent. of the heat theoretically available for transformation by isentropic expansion. Most of the missing energy has been retransformed into heat by eddying, fluid friction, blade leakage, etc., and appears in the steam, increasing its entropy. Assume that in actual practice 60 per cent. of the energy theoretically developed in the first stage of this turbine, or 96 B.t.u., would be transferred to the rotating member, and about 40 per cent., or 64.5 B.t.u., would be retransformed into heat, making the heat content of the steam entering the second stage,

$$1193.3 - 96.6 = 1096.7 \ B.t.u.$$

This would give for the entropy of the steam at the pressure of 18.4 pounds, the value 1.655. The heat content of steam of 1.655 entropy and 1.005 pounds pressure is 925 B.t.u., which gives for the heat drop in the second stage

$$1096.7 - 925 = 171.1 \ B.t.u.$$

This is more than 6 per cent. greater than the heat drop assumed for the first stage. It is plain that in order to equalize the heat drop in the two stages, the pressure range in the first stage must be increased at the expense of that in the second stage.

It will be found by trial and adjustment that if the theoretical heat drop per stage, which may be designated by the symbol $\frac{\Delta H}{n}$, be multiplied by the empirical factor $(1 + K)$ the result will be the heat drop per stage which will give an actual equality in the quantity of energy developed in each stage. The value of K is found by the equation

$$K = 0.000[illegible] \left(\frac{n-1}{n}\right) \Delta H (1 - E)$$

where n is the number of stages, ΔH the total heat drop theoretically available by adiabatic expansion between the initial and terminal pressures, and E the probable thermal efficiency of the turbine. The value of E may be obtained from the equation

$$E = \frac{2545}{S \times \Delta H}$$

S being the probable steam consumption per horsepower-hour of the turbine.

In the case under consideration this efficiency has been assumed as 0.60, the heat drop as 322.2 B.t.u. and the number of stages to be two.

Substituting these values,

$$K = 0.000[illegible] \left(\frac{2-1}{2}\right) 322.2 (1 - 0.60)$$
$$= 0.0367$$

The probable heat drop per stage will therefore be

$$\frac{322.2}{2}(1 + 0.0367) = 167 \ B.t.u.$$

Allowing this drop in the first stage, the heat content after the first isentropic expansion will be

$$1193.3 - 167 = 1026.3 \ B.t.u.$$

From the entropy table, the pressure of the steam entering the second stage will be 16.86 pounds, since this is the pressure corresponding to the entropy 1.56 and the heat content 1026.3. Since the efficiency of the turbine is 60 per cent., the heat transformed into work is 60 per cent. of the theoretical heat drop and the heat transformed into work per stage is

$$\frac{\Delta H}{n} \times E = \frac{322.2}{2} \times 0.60 = 96.7 \ B.t.u.$$

Subtracting this quantity from the initial heat content, the heat content of the steam entering the second stage of the turbine is found to be

$$1193.3 - 96.7 = 1096.6 \ B.t.u.$$

Hence, the entropy of the steam entering the second stage is 1.663. Assuming the heat drop in the second stage to be the same as that in the first stage, the steam leaving the second set of nozzles will contain

$$1096.6 - 167 = 929.6 \ B.t.u.$$

The pressure of steam having 929.6 B.t.u. heat content at the entropy 1.663 is found to be 1.005 pounds, which gives a complete check on the work and shows the calculations to be correct.

If it is desired to find only the pressure of the steam as it enters each stage of the turbine, the following procedure may be employed: From the initial heat content of the steam H_1 subtract the quantity

$$\frac{\Delta H}{n}\left[1 + 0.000[illegible] \left(\frac{n-1}{n}\right) \Delta H (1 - E)\right] = h \qquad (1)$$

and write

$$H_1 - h = H_2 \qquad (2)$$

*Abstract of paper delivered at the spring meeting of the American Society of Mechanical Engineers.

†Proceedings, American Society of Mechanical Engineers, March, 19[illegible].

From the temperature-entropy table determine the pressure of steam of the initial entropy, having for its heat content H_2, which will be the pressure of the steam entering the second stage. Now subtract from H_2 the quantity

$$\frac{\Delta H}{n}\left[1 + 0.00056\left(\frac{n-3}{n}\right)\Delta H\,(1 - E)\right] = h_2 \qquad (3)$$

and obtain

$$H_2 - h_2 = H_3 \qquad (4)$$

The heat content, H_3, together with the initial entropy of the steam, will determine the pressure of the steam entering the third stage. The pressure of the steam entering the fourth, fifth, etc., stages is obtained in a similar manner except that the quantities $\frac{n-5}{n}$, $\frac{n-7}{n}$, etc., must be substituted for the quantity $\frac{n-1}{n}$ in (1) to obtain the quantities h_3, h_4, etc. When performing this operation in the case of any particular turbine, it will be found that the value of h is greater than $\frac{\Delta H}{n}$ for the $\frac{n}{2}$ high-pressure stages, and less than $\frac{\Delta H}{n}$ for the $\frac{n}{2}$ low-pressure stages.

Pressure Temperature Relations of Saturated Steam *

By L. S. Marks

Relations between the pressures and temperatures of saturated steam are accurately known for temperature ranges of 32 to 400 degrees Fahrenheit. Within this range the experimental values of Regnault and other investigators agree very closely with the recent work of Scheel and Heuse and of Holborn and Henning. At higher temperatures and pressures, however, there is no such agreement between the results of the different investigators. Of the later investigations within this higher range, the results of Holborn and Baumann appear to be the most authoritative. These covered a range between 400 degrees Fahrenheit and the critical temperature, indications pointing that the latter condition is reached at 706.3 degrees Fahrenheit with a corresponding pressure of 3200 pounds per square inch.

The measurement of vapor pressure may be by either the statical or the dynamical method. In the statical method the liquid and its vapor are maintained at a constant temperature and the corresponding pressure is measured. In the dynamical method the pressure is kept constant and the corresponding temperature is measured. The pressure is maintained by air or gas acting on top of the liquid, which is heated continuously, and the vapor which forms is condensed and returned by gravity.

The work by Holborn and Henning on saturation temperatures from 120 to 400 degrees Fahrenheit was by the dynamical method, and that of Holborn and Baumann by the statical method. As carried on by the latter investigators, water was contained in a steel vessel surrounded by a constant-temperature bath; absolute measurements of the pressure were obtained by means of a weighted rotating plunger; and the volume of water could be varied either continuously at an approximately uniform rate, or intermittently. It was noted that the water acted on the walls of the steel vessel and that after repeated heating to over 570 degrees, a small quantity of iron went into solution, the water becoming discolored upon standing exposed to the air.

*Abstract of a paper read at the spring meeting of the American Society of Mechanical Engineers.

TABLE 1. EXPERIMENTAL AND CALCULATED PRESSURES OF SATURATED STEAM FROM 400 DEGREES FAHRENHEIT TO THE CRITICAL TEMPERATURE

Temperatures, Degrees Fahrenheit	Pressures, Pounds per Square Inch			Deviation of Formula from Holborn and Baumann	
	Cailletet and Colardeau	Holborn and Baumann	By Formula	Pounds per Square Inch	Percentage
400	247.1	246.99	247.10	+0 11	0.044
410	276.4	276.34	276.47	+0.13	0.047
420	308.4	308.33	308.47	+0.14	0.045
430	343.2	343.18	343 26	+0.08	0.023
440	380.8	380.92	381.02	+0.10	0.026
450	421	421.85	421.87	+0.02	0.0047
460	465	465.95	466.04	+0.09	0.019
470	573	513.65	513.66	+0.01	0.0019
480	565	565.08	564.93	—0.15	—0.026
490	622	620.18	620.05	—0.13	—0.021
500	684	679.26	679.18	—0.08	—0.012
510	751	742.55	742 56	+0.01	0.0013
520	822	810.31	810.37	+0.06	0.0074
530	897	882.58	882.82	+0.24	0.027
540	977	959.85	960.15	+0.30	0.031
550	1062	1042.2	1042.6	+0.4	0.038
560	1152	1130.2	1130.3	+0.1	0.0089
570	1247	1223.7	1223.7	0	0
580	1349	1323.0	1322.9	—0.1	—0.0076
590	1458	1428.3	1428.1	—0.2	—0.14
600	1574	1539.9	1539.8	—0.1	—0.0065
610	1697	1657.8	1658.1	+0.3	0.018
620	1827	1782.9	1783.3	+0.4	0.022
630	1965	1915.3	1915.9	+0.6	0.031
640	2111	2055.1	2056.0	+0.9	0.044
650	2265	2203.1	2204.2	+1.1	0.049
660	2482	2359.2	2360.5	+1.3	0.055
670	2599	2523.4	2525.6	+2.2	0.067
680		2697.1	2699.7	+2.6	0.096
690		2882.3	2883.3	+1.0	0.035
700		3080.4	3076.8	—3.6	—0.117
706.1		3200.0	3200.0	0	0

Table 1 gives the results of Holborn and Baumann as compared with those of Cailletet and Colardeau and those computed by the formula

$$\log. p = 10.15354 - 4873.71\,T^{-1} - 0.00405096\,T + 0.000001392964\,T^2$$

where p is the absolute saturation pressure corresponding to the absolute temperature T.

TABLE 2. EXPERIMENTAL AND CALCULATED PRESSURES OF SATURATED STEAM FROM 32 TO 400 DEGREES FAHRENHEIT

Temperatures, Degrees Fahrenheit	Pressure, Pounds per Square Inch		Deviations of Formula from Tabulated Values	
	From Marks & Davis' Steam Tables	By Formula	Pounds per Square Inch	Percentage
32	0.0886	0.088563	—0.000037	—0.042
50	0.1780	0.17765	—0.00035	—0.196
100	0.946	0.946	0	0
150	3.714	3.707	—0.007	—0.188
200	11.52	11.504	—0.016	—0.139
250	29.82	29.802	—0.018	—0.060
300	67.00	67.00	0	0
350	134.6	134.60	0	0
400	247.1	247.10	0	0

The agreement of the pressures calculated from this equation with the experimental results of Holborn and Baumann is very striking; from 400 to 650 degrees the difference is less than $\frac{1}{20}$ of 1 per cent., and from 650 degrees to the critical temperature the maximum difference is slightly over $\frac{1}{10}$ of 1 per cent.

Below 400 degrees Fahrenheit, the agreement of this equation with the experimental results is shown by Table 2. The experimental results are those of Holborn and Henning from 120 to 400 degrees Fahrenheit and of Regnault and other investigators for temperatures below 120 degrees. The differences are very small, as expressed in pounds per square inch, but amount to nearly $\frac{1}{5}$ of 1 per cent. in some cases. This, however, is not greater than the variations among the best experimental values in this part of the temperature range.

According to a recent French patent, an aluminum solder may be made by first making a fusible alloy—which will melt in boiling water—of three parts of tin, eight parts of bismuth, and five parts of lead. The solder itself is then made by taking ten parts of the fusible alloy, 300 parts of zinc and five parts of aluminum. This is said to make a strong solder. A softer one is made by taking 160 parts of the fusible alloy, 80 parts of zinc, 25 parts of aluminum. and 80 parts of tin.

An Old Time Tide Mill

When an engineer uses Slade's mustard or other seasonings for his meat at dinner, he does not stop to think that the power to grind out these delicacies was furnished by an old-time tide mill. In 1800 the legislature passed a bill which permitted the damming of the under the mill. Recently one of the wheels required renewing, and upon looking up the records it was found that it had been in operation for a period of 25 years before the action of the salt water had deteriorated it. The cost of repairs and renewal amounts to practically nothing.

The original spice mill was bought in

FIG. 1. SLADE'S TIDE MILL, SHOWING WATER FLOWING FROM THE WHEELS AT LOW TIDE

Snake river, which runs through the towns of Chelsea and Revere. The mill building burned down twice. The present structure and a view of the tide wheels and the water escaping from them to the river are shown in Fig. 1.

The tide wheels are four in number and generate a total of 100 horsepower. One wheel is 40 inches in diameter, and three are 54 inches in diameter. These wheels are operated six hours on each tide, and a day and night crew are kept at work. When the mill is not in operation, the men are taking care of the material which has been ground; thus there is no loss of time on the part of the workmen.

In the dam a raceway has been provided, at one end of which two gates are hung, to swing from one end, so that as the tide comes in through the raceway the flow automatically opens these gates, which remain open until the turn of the tide, when the flow of water swings them closed. The average flow of tide at this point is about 10 feet, but it is not necessary for the tide on the sea side of the gates to fall below the level of the wheels before the mill can be put into operation. The mill, therefore, can be operated as soon as there is a sufficient difference in head of the water on the two sides of the dam.

The flow of water is controlled by ordinary flat gates which allow water to flow from the pond side of the dam through four penstocks to the turbine waterwheels.

Fig. 2 shows two of the waterwheels 1847 by two Slade brothers, and they were one of the pioneer companies to introduce ground spice to the trade. This mill is now the property of the D. & L. Slade Company, Revere, Mass.

Water Jacket Deductions

By Frank Richards

Some interesting facts were recently brought out in a report by A. Hoffman regarding a test of a compound steam and two-stage compressor at the shops of the Ingersoll-Rand Company. This compressor had 20- and 38-inch steam cylinders, 32¼- and 20¼-inch air cylinders and a common stroke of 30 inches, the capacity being 2000 cubic feet of free air per minute.

Much of the material in the report is in the nature of "company data," but through the courtesy of the company, I am able to give extracts concerning the water jacket and the method of accounting for the heat thereby abstracted. What follows is taken almost verbatim from the report.

"It is well known from the principles of thermodynamics that the foot-pounds of work done in the air cylinder during any period of time is equal to the product of the increase in temperature produced by compressing the air, the weight of the air, the specific heat of the air and Joule's equivalent (778). In making up the heat balance this was found to check closely with the results found in practice."

"The work done in the cylinder must be equal to the heat given to the air-cylinder water jacket plus the heat contained in the air after leaving the cylinder, above the temperature of the intake air. Therefore, the heat given to the jacket is 2070 B.t.u. per minute, which is equivalent to 48.8 horsepower. The heat contained in the air above the intake temperature of 77 degrees is 8320 B.t.u. per minute, and this is equivalent to 196.3 horsepower. The total B.t.u. is the sum of these two quantities, or 10,390 B.t.u. which is equivalent to 245 horsepower. Theoretically, this total should represent the actual horsepower indicated in the low-pressure air cylinder, and it was found that this horsepower was 243, the difference being only 2.1 horsepower. A greater difference than this might be expected because the actual amount of air was figured from the vol-

FIG. 2. NEAR VIEW OF TWO OF THE WATER WHEELS

umetric efficiency of the indicator card, which, of course, was not absolutely correct."

"There was also a discrepancy due to the radiation of the outside air to the water jacket, but this was very slight, as was shown by the fact that the temperature of the water leaving the jacket before the compressor was started was the same as the temperature of the cold water in the main."

"It was at first thought that there was something wrong regarding these results, as they showed about 20 per cent. of the total indicated work in the cylinder to be given up to the jacket water; according to this considerably better than isothermal compression should be obtained, which, of course, would be impossible. The explanation is as follows."

"Very little heat is given to the water jacket while the air is compressed, because the compression begins at a low temperature, and the maximum temperature is not reached until the end of compression, and while at the maximum temperature, the piston is traveling very fast and there is not much chance for heat to be given up. After the discharge valves open, however, a great deal of heat is given to the jackets because during this period the air is at its maximum temperature and it also comes in intimate contact with the jacket of the cylinder head in passing out through the valves; in addition to this, the piston is traveling at a comparatively slow speed toward the end of the stroke. Some heat is also given to the jacket while the air is passing out through the discharge passage."

"This explanation is sufficient to account for the large amount of heat given to the jacket, and it shows that jackets really do more good than is usually supposed. Of course, heat given to the cylinder jacket while the air is discharging does not reduce the work in the cylinder but merely lowers the temperature of the air and raises the temperature of the jacket water."

Inertia Effects and Shaft Couplings

By H. J. Smith

The various factors entering into the choice of a suitable clutch are considered and a table giving horsepower ratings and equivalent shaft diameters is presented.

The influence of inertia in the starting of heavy masses into motion is well understood in installations using electric power. An electric motor under such conditions will show disturbances at the commutator, and the abnormal current consumption can be plainly noted at the switchboard meters. Special methods of winding field and armature coils, together with the introduction of resistance or controlling devices, are made to enable the motor to pick up the load of a trolley car, elevator, or other heavy starting loads. Such installations of motors, when of sufficient magnitude, are well studied, the data are reasonably exact and the results satisfactory. But with the occasional installation, where the data are not definite, the possibility of poor operative results insures a careful investigation and a recommendation from the builder of the motor.

In ordinary power-transmission work, either by belt, rope, gear, shaft or clutch drive, little thought is usually given to inertia. Horsepower capacities of driven machines are either assumed or obtained from the catalogs of machine manufacturers. These are roughly taken as a basis, to which may be added some additional values dictated by experience, or, as ofttimes happens, simply an extra haphazard allowance to increase the factor of safety.

In general, to engineers and those conversant with power-transmission machinery, belts, ropes, gears and shafting are easily figured for a given duty because the strength of material is well known, and with a proper choice of cross-section a factor of safety can be taken which will be ample for even extraordinary overloads. Speed merely increased the capacities of any of these transmission members, and so long as the most efficient speeds are maintained or the safe limits not exceeded, speed is not a disturbing factor in the calculations. If the transmitting machinery is to start with the engine or motor, the inertia loading will be overcome gradually, provided the limits of safety of the material are not exceeded by the stresses developed. If there is no breakage or slippage, then as the speed increases the inertia stresses decrease, until at the regular speed all parts are under the least stress. The duty thereafter imposed on the parts varies only according to subsequent work performed.

Horsepower Ratings and Equivalent Shaft Diameters

Horsepower at 100 R.p.m.	Equivalent Shaft Diameters
9	$1\frac{3}{16}$
12	$1\frac{15}{16}$
15	$2\frac{3}{16}$
20	$2\frac{7}{16}$
27	$2\frac{11}{16}$
35	$2\frac{15}{16}$
45	$3\frac{3}{16}$
60	$3\frac{7}{16}$
75	$3\frac{11}{16}$
90	$3\frac{15}{16}$
110	$4\frac{3}{16}$
140	$4\frac{11}{16}$
175	$4\frac{15}{16}$
230	$5\frac{1}{2}$
350	6
480	7
625	$7\frac{1}{2}$
875	$8\frac{1}{2}$
1300	10

While these calculations are relatively simple and reasonably effective for the transmission machinery mentioned, there are no such reliable formulas in the choice of a friction-shaft coupling. The latter is a great convenience not only because of the flexibility attained in the system whereby a part (or parts) may be operated at will but because it stands between the work to be done and the engine, waterwheel or motor, and relieves the latter from heavy starting stresses. A gas engine in power-transmission work must either be under a very light inertia load at starting or be started with no load at all. With most gas engines a clutch coupling is desirable. The waterwheel receives a full draft of water from the steam, and the motor its increased current from the generator. All that is required of either are strength and endurance to meet the shock or strains of starting and carrying loads to their ultimate capacity with continuous motion; variations of load are met by governing devices.

In the transmission of energy through a friction-clutch coupling, there is no automatic device to meet overload conditions. The clutch must rely on a fixed pressure which can only be regulated when the mechanism is at rest, while every time it is engaged it losses some of this pressure through wear at the friction surfaces and thereby has its capacity reduced; yet to operate successfully the clutch coupling is expected to practically take care of itself, and to be always reliable and not the cause of shutdown.

In the usual application of a friction-clutch coupling the power end of the transmission machinery has already been brought up to normal speed and is operating under the governor, and ready for any load within maximum limits. The load end is at rest. The friction-clutch coupling must then stand the brunt of the starting load. Half of it at this moment is at speed while the other half is at rest. The full shock, therefore, of starting a great mass at rest into motion, overcoming the total friction of rest, the distortion of parts, and often in addition a part or even the whole of the maximum load resistance, is required of the friction-clutch coupling. The whole work must be accomplished by the friction surfaces of the clutch which can only be under partial clamping pressure to allow a constant slip until both members of the clutch coupling are at the same speed. This slip, which may be of short duration for light inertia loads or extend over a considerable period of time in starting heavy loads, is the one indefinite factor in any calculation involving friction-clutch couplings. While under pressure a slip of the friction surfaces (which in power-transmission mechanism are usually hard dry maple on cast iron) produces abrasion and heat which rapidly remove the wood in proportion to the amount of work done and to the length of time the slippage continues. If either or both are very great, then it is quite possible that the wood surface may be so worn away that the clutch, while able to start the mass into motion, may fail to bring it up to speed, or if it does, may slip when a later loading is placed upon it. Unlike other mentioned power-transmission members, the question of sufficient strength to transmit a given horsepower is not the main consideration. A clutch can be made large and strong enough in its parts to do any stated work; but it must also have the prime requisites of large friction surfaces to resist wear and an easy means of renewing or readjusting the friction surfaces. The pertinent questions then in determining the size of a friction-clutch coupling are:

First, the normal running load.

Second, starting inertia load.

Third, the speed of either member of the clutch coupling at the time of engagement.

Fourth, the number of engagements in a given time.

Fifth, the diameter of the shaft (or shafts) on which the coupling or either of its members is mounted.

Considering these headings in brief detail it is fairly easy to fix on the normal running load of a machine, although its capacity to consume power is often underrated. The total power for more than one machine is not exactly proportional to their number, but is something less, depending upon the inertia stored up in the revolving parts of the machines and transmission machinery. This inertia, or flywheel effect, equalizes the fluctuation of delivered power, and therefore is of direct assistance to a clutch coupling when in motion.

In starting, however, the flywheel effect is entirely potential or even negative and resists the action of the clutch coupling to set the mass in motion. If this resistance is slight, then the clutch can be engaged in a minimum time and there will be very little wear of the friction surfaces. If the resistance is more severe, then the time of clutch engagement is protracted, the wear is great and the necessity for frequent adjustment of friction surfaces is essential. If the resistance to starting is absolute, then the duration of clutch engagement is simply limited by the total loss of clamping pressure of the friction surfaces occasioned by the actual burning of the wood shoes.

From the last paragraph it is obvious that in the choice of a proper clutch coupling the number of engagements is an important factor, and directly proportional to the severity of the service.

Recognizing the fact that the size of shaft chosen is an index to the character of the work done, manufacturers of clutch couplings have given an "equivalent shaft" rating to each size of clutch listed, based on a standard of 100 revolutions a minute and a reasonable factor of safety for both. While this approximate proportioning does fairly well in practice, it must not be assumed that the clutch is really of equivalent strength with the shaft under all conditions. A homogeneous steel shaft has a greater factor of safety in its ability to resist torsion than the cast-iron clutch, while the latter, because of its inelasticity, is still less capable of withstanding shock. Therefore the "equivalent shaft" rating of cast-iron clutch couplings is simply a convenient guide to prevent underestimating the size of the clutch coupling. There are usually more reasons to make the clutch larger and very few to make the size of clutch coupling smaller than in the accompanying table.

The ratings of clutches when based on actual prony-brake tests at a speed of 100 revolutions per minute show a considerable factor of safety as far as actual strength is concerned but the factor of endurance without readjustment is much less. Within usual limits of speed each clutch can easily start its rated load from rest with a sufficient factor of endurance. In practice the ordinary requirements for starting capacity are less than for the working-load capacity, but there are very many installations in which the inertia load at starting exceeds the rated capacity of the clutch. A clogging of machines, gears that bottom, abnormally tight belts, the attempt to too quickly accelerate heavy masses, produce extraordinary strains and decrease the endurance of the clutch.

The installation that gives trouble sometimes results from insufficient information in the hands of the clutch builder, but more often follows inaccurate deductions of the purchaser on catalog ratings, speed inertia effects and price. Poor judgment may be some excuse, but to deliberately place too small a mechanism because of its cheapness is the poorest of all excuses for an unsatisfactory installation.

As a concrete example of very severe inertia loading consider the following application of a clutch coupling.

A 400-horsepower gas engine is belted to a 5 $\frac{7}{16}$-inch jack shaft and drives the latter 450 revolutions per minute. The 4 $\frac{15}{16}$-inch mill shaft extended along the line of the jack shaft and had to be connected by a cutoff friction-clutch coupling so that the gas engine could be started light and the mill afterward started by means of the friction coupling. The character of the load was severe, and consisted principally of a battery of large attrition mills. These mills, on account of their construction, high speed and liability in service to be in a more or less clogged condition in starting, offer inertia-loading conditions almost impossible to calculate. Therefore, the first step was to predicate the size of the clutch coupling on the diameter of the driven shaft already fixed by the experience of the mill man. From the table, a 175-horsepower clutch coupling is the minimum size, but a larger size is preferable on account of the shock load and the larger friction surfaces. However, even a 175-horsepower clutch coupling could not be used because of the peripheral speed (4950 feet) of its friction surfaces exceeding the maximum safe speed of 3600 feet per minute (beyond this speed, wood friction surfaces char rapidly when the clutch is engaged), and secondarily because the outer periphery of the clutch exceeded the safe speed limit of cast iron—a mile a minute. For these reasons a 140-horsepower clutch was chosen which reduced the friction-surface peripheral speed to 4500 feet per minute.

The severe conditions in this installation point the moral of inertia loading. The 140-horsepower clutch (rated at 100 revolutions per minute), which appears large enough in view of the speed of 450 revolutions per minute, actually handled the running load without the least symptom of trouble, but the heavy inertia load at starting, aggravated by the high speed of the driving-clutch member, wore the wood shoes so fast that the assistance of a mill hand pulling on the belts was necessary to start the mill and at the same time to keep the friction surfaces in good condition for subsequent loads without constant readjustment. A slower speed of mill shaft, if chosen in the first place, would have allowed the choice of a clutch of ample size for the work with a peripheral speed well within safe limits for wear of friction surfaces.

A locomotive was run into the roundhouse after its first trip since having been overhauled and new flues put into the boiler. The foreman asked the darkey fireman how it steamed, and how much pressure he was able to keep on it. The darkey replied: "Ah don't know jes how much steam Ah had on 'er, but Ah sho did keep da' needle pintin' mos' towa'ds th' [illegible]."

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Air Cooled Choke Coils

It is sometimes convenient to mount choke coils on ceilings so that the insulating-coil supports hang pendent and at other times it is preferable to arrange them so that the coil rests on the supports, as shown in the engraving. The new Westinghouse choke coil, which this engraving illustrates, can be mounted either way, because the insulating "petticoat" columns can be removed and inverted on the supporting rods.

The choke coil consists of an aluminum rod bent into a helix of about 15 inches diameter and containing about 30 turns. Bracing clamps are provided to give mechanical strength to the helix. The aluminum rod used is of sufficient cross-section to safely carry 200 amperes.

Air-cooled Choke Coil

Each of the two insulating columns is made up of porcelain insulators which, except the end pieces, are interchangeable. The number of insulators used in the column depends on the voltage of the circuit in which the coil is to be used. For floor mounting, the parts are arranged as shown here.

These choke coils are intended principally for the protection of transformers and should not be used for generators. Where greater reactance than is afforded by a single coil is desired for the higher voltage circuits, it is recommended that two or more coils be connected in series.

Factors in Good Service on Transmission Systems*

By M. Hilgen

Absolutely uninterrupted service from a transmission system is impossible. Good and commercially acceptable service can be obtained, however, from any system which is properly designed, constructed and operated. For maintaining continuity of service more can be done before the system is constructed than at any time thereafter.

The most important factors in securing good service are insulation, mechanical strength, general design of the system and methods of operation.

Insulation

Probably more line shutdowns have been produced by insulator failures than by any other cause. The general reason is that, although other engineering structures are ordinarily built with factors of safety ranging from 4 to 10, insulators, for some unaccountable reason, have been considered adequate if they had a factor of safety of 2 or possibly 2½, notwithstanding the fact that the stresses which insulators are called upon to stand are probably more variable and uncertain than those encountered by most other structures. The higher the line voltage the less the factor of safety can be. For a 100,000-volt system a factor of safety of 3 under unfavorable conditions (with the insulator wet all over) gives excellent results. For 50,000 volts the factor of safety should be 4 and for 20,000 or 30,000 volts I believe a factor of safety of 5 is about right. The reason for this is that insulators rarely fail due to the normal voltage of the system, but rather to abnormal voltages caused by lightning and power surges; these abnormal voltages are greater in proportion to the normal voltage for a low-tension than for a high-tension system.

*Extracts from a communication presented at the New York convention of the National Electric Light Association.

To obtain a proper factor of safety for a 50,000- or 60,000-volt system with pin insulators is difficult; for a 100,000-volt system it is practically impossible. This fact led to the design of the suspension insulator, the introduction of which marked an important advance in high-voltage line construction. For voltages of 20,000 and above, no other insulator should be used.

Mechanical Strength

For straight construction in level country, the stresses to which a line will be subjected can be predetermined with a reasonable degree of accuracy and proper factors of safety allowed. For extra long spans or sharp angles the stresses can also be determined in advance and special pole structures or towers can be constructed to meet the conditions.

Where a line traverses rough and mountainous country for many miles, however, and no two spans are of the same length and no two towers or poles are of the same hight, each span and tower should theoretically be treated as a special case, which is obviously impossible; general rules must be formulated for the construction of the line as a whole. Towers or poles must be selected which are sufficiently strong to stand in the most unfavorable places and these guyed, when necessary, as an extra precaution.

If wire larger than No. 6 Brown & Sharpe gage is used it should be stranded. For No. 4 a three-strand wire gives excellent results, the strands being so large that no individual wire is liable to be broken by abrasion. For sizes of from No. 2 to No. 0000, seven-strand wire should be used. Six-strand wire with a hemp center exposes more surface to wind and ice, is less flexible and tends to crush out of shape in the wire clamps.

Hard-drawn copper wire should not be drawn too hard with the idea of getting great tensile strength. Wire having an ultimate strength of 45,000 to 50,000 pounds per square inch and an elastic limit of 26,000 pounds per square inch is strong enough. Stronger and harder wire than this is liable to become nicked or scratched in stringing or injured by the wire clamps so that the actual strength of the wire when erected will be less than the actual strength of a softer wire.

Wire clamps for suspension insulators should be connected to the insulator by a hinge joint located as near as possible to the wire so that there will be little tendency to turn the body of the clamp and bend the wire when the insulator pulls in a direction other than perpendicular to the wire.

The insulators should be hung so that they can swing freely in any direction. If the connecting device does not allow perfect freedom of motion it is liable to be broken.

General Design of System

Transmission lines feeding an important load center should be in duplicate or triplicate. If they come from the same power plant they should preferably follow different routes. If this is impracticable on account of the extra cost of right-of-way and patrol, the different lines should at least be mounted on separate towers or poles, spaced far enough apart to prevent the possibility of one line interfering with another.

For convenience in locating trouble, all lines should be sectionalized by means of outdoor air-break switches, located about twenty miles apart and at patrolmen's headquarters if possible. Two long duplicate lines should be provided also with a cross-over switching station at the middle of the line with the switches so arranged that one-half of either line may be cut out and the remaining section continued in operation. This switching station may be an outdoor affair with air-break switches, or if the charging current of half of one line cannot be broken by air-break switches, oil-break switches may be used and installed indoors or out.

If the load center is supplied by two or more separate and independent plants the conditions are better, because the chances of two independent supply systems being out of commission at the same time are remote.

In any case where two or more lines supply power to the same point, the incoming lines should be controlled by reverse-current relays. The greater the number of incoming lines the better the relays will work. Grounds rather than short-circuits between wires cause the great majority of line troubles. On a Y-connected system with a grounded neutral, any other ground causes a short-circuit and takes a considerable amount of power. For this reason reverse-current relays are of greater service on a Y-connected system than on a delta-connected system. On a very extensive delta-connected system, however, one having large line capacity, a grounded wire will take a heavy current and this current, on account of the resistance of the ground and the resistance of the wire, will represent true power. A very large system with an extended network and many plants will work equally well whether Y- or delta connected.

Trouble from lightning can be guarded against by high insulation, one or more overhead ground wires and electrolytic arresters; these represent the highest development yet attained in lightning arrester construction. The ground wires should be of ample section and grounded at every support.

Operation and Supervision

In the operation of a transmission system eternal vigilance is the price of continuous service. No amount of automatic apparatus can take the place of good operators.

New operators should first be placed in the smaller and less important stations or substations of the system; as they prove their ability and as vacancies occur, they should be transferred to the larger and more important stations. Under this plan the men have always something to look forward to and do not lose interest in their work. Only the best men get to be operators in the more important stations, and the men in the larger stations have necessarily had considerable experience and are well acquainted not only with the operation of their own station but with the switching connections and method of operation of several of the other stations of the system.

In very large systems all operations should be controlled by one man, called the "load despatcher." He should preferably be located at the principal load center and be in communication with all stations through a private telephone system as well as the public systems where one is available. In smaller systems the load despatcher may also be the operator in charge of one of the large stations.

The frequency with which a line should be patrolled depends upon the importance of the line and its liability to failure. An old wooden-pole line with pin insulators may have to be patrolled every other day if it supplies power to an important load center. A well constructed steel-tower line may need to be patrolled only once a week or less.

Certain parts of a line may need closer attention than others, notably those in mountainous country and swamps. Unimportant branch lines may be patrolled once a month, or perhaps not at all. A branch line to a small power plant is less important than a branch line to a small substation.

Patrolmen should carry portable telephones and report their location to the load despatcher at regular intervals. The record of the movements of the patrolmen can conveniently be kept by the load despatcher on a "patrol sheet." This is a continuous roll of cross-section paper with a time scale on the base and a vertical distance scale. For convenience, all the stations, patrol houses and other landmarks are shown on the sheet according to their relative location along the line. The progress of each patrolman on the line is then noted by dots on the chart through which a curve is drawn, just as progress of a train is shown on a railroad-train sheet.

Patrolmen are too prone to think that their one object in life should be to cover a section of line at stated intervals and as expeditiously as possible. High-speed patrol is about as good as no patrol at all. In one case it was discovered that a certain patrolman had purchased a motor cycle and was patrolling his section of line at 30 to 40 miles per hour, following the adjacent highways rather than the line.

A slow and thorough examination of a line once a month with a sharp lookout to discover preliminary signs of weakness, such as loosening tie wires, cracked insulators, loose bolts in towers, broken wires in a strand, uneven sags in spans, settling of tower footings, loosening of guy wires, etc., will do more good than a high-speed inspection daily.

On a large system a general line inspector should be employed whose duty it is to inspect all lines, going from one to another at indefinite intervals and reporting all signs of weakness and making reports as to work of patrolmen and recommendations as to repairs, reconstruction and other necessary matters.

CORRESPONDENCE

Interpole Motor Characteristics

Referring to the discussion of Messrs. Williamson and Dean regarding interpole motors, appearing in the issue of May

Electric Motor Speed Curves

23, I beg to take issue with both gentlemen as to some of their statements. Mr. Williamson's statements that the interpole winding adds no torque or counter electromotive force and that the speed curves of the shunt-wound motor and interpole motor are very similar, are incorrect. Although the interpole winding is added primarily to improve commutation and not with any idea of changing the speed, it does affect the counter electromotive force by tending to oppose the main field and this tends to increase the speed of the motor.

The speed curve of a shunt-wound motor always droops as the load increases. With an interpole winding the speed curve will not droop so much; it may rise and in some cases the speed may become dangerous when load is put on. For this reason it is the practice of motor builders to take a speed-characteristic test on all interpole motors. Motors having a rising speed curve are not passed for shipment until the trouble, due to too powerful an interpole field, is remedied, usually by shunting part of the current around the interpole winding.

I believe that Mr. Dean is right in saying that the trouble was due to wrong connection of the series winding, and I think if Mr. Wilbraham had reversed the series winding, leaving the interpole winding connected as at first, he would have had no trouble from sparking. From my own experience and from inquiries which I have made, I should say that a motor with a variable-speed ratio of more than 3 to 1 and with a differential compound winding is poorly designed and likely to run away when load is put on, as at the high speed the weakened shunt field would be easily overcome by the series field.

I can hardly agree with Mr. Dean's broad statement that "it is primarily an error to buy a compound-wound interpole motor" as there are undoubtedly cases where a differentially connected series field winding is desirable and safe for a constant-speed motor and there are other cases where a cumulative connection, giving a decided droop to the speed curve, is very desirable. Such cases, however, should usually be referred to the designing engineer.

The accompanying chart showing characteristic speed curves will help to explain my statements.

C. A. CALL.

Schenectady, N. Y.

Central Station Service vs. Isolated Plant Operation

I have been very much interested in the various items appearing in POWER regarding the relative cost of isolated-plant operation and central-station power. Mr. Rushmore's article in the May 23 issue, to which I have referred in detail elsewhere in this issue, is but one example of the incompleteness of many of the reports made by the isolated-plant operators. On page 819 of the May 23 number, for example, A. P. Hyde states that his plant is producing electrical energy for 1.06 cents per kilowatt-hour and gives comparative coal and load data for three months of the year. If he gave a complete year's operation an intelligent comparison could be made, but the comparison as given is so incomplete as to be of little value.

Reliable and complete data of this kind would be of very great general interest and value. I believe that under certain conditions the isolated plant can produce its own power, heat and light at a lower figure than the total cost to the plant would be if taking central-station power and making low-pressure steam for heat. Under other conditions the reverse will be true. As these conditions of operation undoubtedly affect the result to such a very great extent, unusual care must be taken in accepting data, even when in complete form, and no snap judgment should be reached until the conditions have been thoroughly analyzed.

I should like to see the discussion of the relative value of the central-station service and the isolated-plant service continued even more thoroughly and in greater detail than it has been, but I would suggest that care be taken to see that no data are published which are not reliable and which do not consider all the elements of cost entering into the production of power.

R. D. DEWOLF,
Ass't Mech. Engr., Rochester Ry. and Light Company.

Rochester, N. Y.

Parallel Operation of Alternators Driven by Waterwheels

I wish to submit to practical readers of POWER a problem that has recently occasioned considerable study on my part.

We have a 200-kilowatt 2300-volt three-phase alternator of the revolving-field type coupled to a hydraulic turbine, the speed of which is controlled by a Woodward governor. The exciter is belt-driven from the main shaft of the alternator.

On the switchboard there are three ammeters, one in each lead of the generator, and a voltmeter which can be connected across any two leads. There are also a voltmeter and ammeter for the exciter as well as a field rheostat and a field switch with discharge resistance.

This unit supplies current for both power and lights and it is quite up to its capacity. In order to increase the output it is proposed to install generators to be driven by two smaller waterwheels at adjacent water sites. There have been ordered one 60-kilowatt unit to be placed about a mile from the largest installation and a 36-kilowatt machine to be located a mile farther down stream.

The question at issue is this: Is it necessary to supply the small units with governors or will the one on the 200-kilowatt outfit be sufficient? We desire the two new units to work at maximum capacity constantly and thus relieve the large unit of a substantial portion of its load. What additional instruments will it be necessary or desirable to place on the 200-kilowatt switchboard and what are necessary at each of the two small power houses?

What is the proper sequence of operations in throwing either of the smaller machines on the line when either or both the others are in operation? And, in reverse order, how may one unit be shut down without disturbing the other two?

H. T. DEAN.

Boston, Mass.

Starting Large Motor Generators

Sometimes it is found that a large motor-generator consisting of an interpole generator driven by a synchronous motor, when started from the direct-current side, takes excessive starting current. In such a case, if the generator is compound wound the best way to reduce the starting current is to reverse the connections of the series field winding so that the machine will operate as a compound motor, increasing the field excitation and thereby the starting torque per ampere of armature current. A double-pole double-throw switch can be easily connected in the series field circuit for this purpose.

C. J. FUETTERER.

Thomas, W. Va.

Sheet Steel Magnetized by Rolling?

Can any reader explain why sheet steel becomes magnetized while passing through the rolls? In the rolling mill, cold water is run over the rolls while the billet is "roughed down" and also during the subsequent passes which reduce the metal to its final thickness. After the sheet is passed through the "flattener" it is cut up, and some of it is magnetized and other parts are not. We have never detected any magnetism in steel that has been rolled without the use of water on the rolls.

I will appreciate any suggestions as to the cause of the magnetization.

A. R. COFFMAN.

Scottdale, Penn.

A new method of coating various substances with metals, the invention of a Swiss engineer, consists in reducing molten tin, zinc, copper, lead, aluminum, or other metal or alloy to a state of pulverization by pressure of an inert gas —nitrogen or hydrogen—and in that state driving it against the surface to be covered from a flexible tube with a tip like that of a large vaporizer for handling liquids.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Some Instructive Indicator Diagrams

By J. C. Parmely

The accompanying diagrams were taken from a horizontal single-cylinder single-

Fig. 1. Normal Stop Diagram

acting gas engine working on the four-stroke cycle and show very plainly the effect of changing the point of ignition on light loads. The cylinder is 18½ inches bore and the stroke is 27 inches. The engine is rated at 100 horsepower and

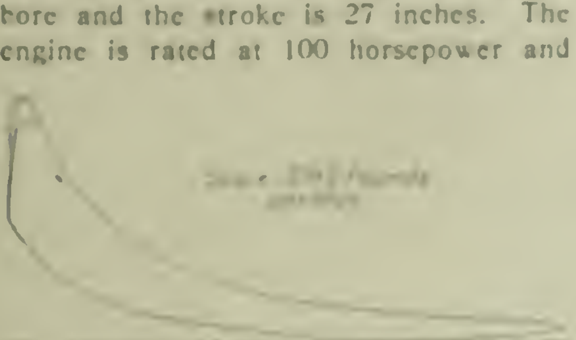


Fig. 2. Heavy Load

runs at 190 revolutions per minute at full load. The compression is 180 pounds per square inch. The engine is governed by throttling the mixture entering the cylinder, which is accomplished by a butterfly valve in the passage between the mixing valve and cylinder, controlled directly by governor.

The first three diagrams show the operation of the engine under normal conditions. Fig. 1 is a stop diagram taken with

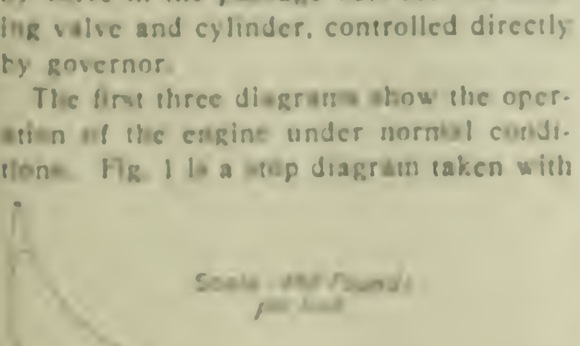


Fig. 3. Full Load

a 10-pound spring and it shows that the valves are adjusted properly, with the possible exception of the exhaust valve, which appears to close a trifle early. The rise of pressure from *a* to *b*, however, is very small, being slightly over one pound, and may reasonably be disregarded. The horizontal portion of the first part of the suction stroke, *c* to *d*, is probably due to the inertia of the incoming gases.

Fig. 2 shows a diagram taken, with a spring having a true scale of 187.2 pounds per inch*, when the engine was carrying a very heavy load. The explosion pressure on this diagram is about 370 pounds per square inch and the pressure at the opening of the exhaust valve is about 23 pounds per square inch and the diagram figures out 136.4 indicated horsepower. This engine frequently carries a load of 80 kilowatts for an hour or more.

Fig. 4. Light Load; Settings Unchanged

Fig. 3 shows a diagram taken with a spring having a scale of 240 pounds per inch.* This diagram was taken at a time when the engine was showing very slight signs of preignition, a slight thump being heard. This is indicated on the diagram by the excessive explosion pressure of one of the cycles, which is approximately 450 pounds per square inch.

The next diagram, Fig. 4, shows the effect of a light load. The load at the switchboard was 17.22 kilowatts and the indicated horsepower was 38.7, giving a combined efficiency of 59.6 per cent. for the engine, belt transmission and dynamo. This diagram was taken with a 120-pound spring* and shows a mean effective pressure of 21.0 pounds per square inch. It will be noted that the compression on this diagram is only about 140 pounds per square inch; this was doubtless due to the throttling action of the governor on the light load. The absence of pressure rise after ignition will also be noted. This is probably due to the fact that only a small amount of mixture is admitted by the governor. The action of the governor is also illustrated in this diagram by the variation of the expansion line.

The three remaining diagrams were taken when the load upon the engine was very light, to show the effect of changing the point of ignition upon the operation of the engine. These diagrams were all taken with a 120-pound spring and under conditions of steady load with gas of a fairly good quality. The temperature of

Fig. 5. Very Light Load

the jacket-water discharge was comparatively low at this time.

Fig. 5 is very similar to Fig. 4 in that there is no rise of pressure due to combustion. The ignition setting was 25 degrees ahead of dead center for both of these diagrams. The small triangular area

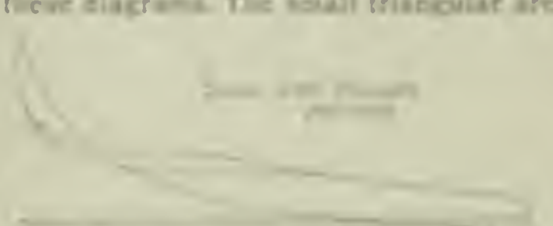


Fig. 6. Retarded Ignition

at the top of Fig. 5 was undoubtedly due to the fact that during one of the cycles shown by this diagram the mixture in the cylinder was poor and did not burn readily. This allowed the pressure to drop immediately after the ignition, causing the lower expansion line to be drawn. On light loads, occurrences similar to this are very common.

Fig. 6 was taken with the igniter retarded as far as possible from the normal

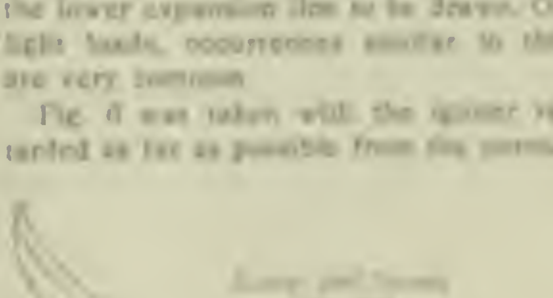


Fig. 7. Light Load; Extra Advance

operating position, which was about 25 degrees ahead of the dead center. According to the diagram, the ignition actually occurred slightly beyond the dead center and I think the igniter was set about 10 degrees past the center. The loop in the diagram is peculiar and is probably due to the cooling influence of

*The scales of all of the diagrams as printed here are twice the actual spring scales.—Ed.

the jacket water, decreasing the volume of the gas until the moment when ignition occurred.

Immediately after taking this diagram the spark was advanced ahead of the normal operating position to 30 degrees early. The engine did not run steadily at this point but speeded up and slowed down alternately. Fig. 7 shows this effect in the different areas of the two cycles which were recorded.

LETTERS

Corrosion of Water Cooled Exhaust Pipe

In Mr. Wild's letter under the above heading in the May 9 number, he does not say whether or not the exhaust pipe

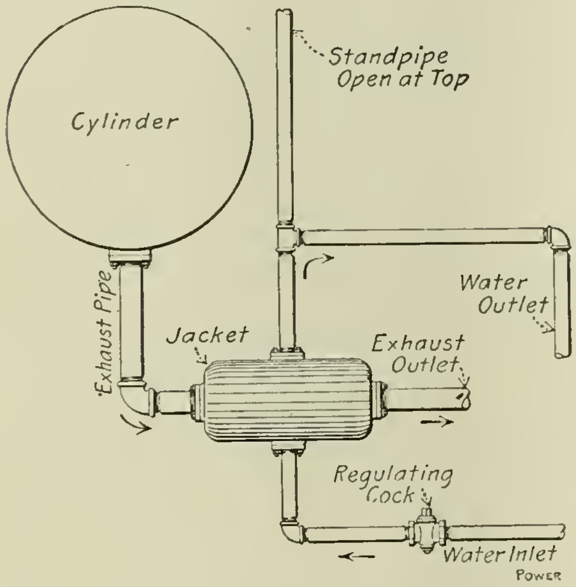


Fig. 1. Water Jacketed Exhaust Pipe

and muffler are drained to remove the water of condensation formed when the engine is not running. If the acid liquid cannot be readily discharged it is sure to eat rapidly through the metal. In any case, care should be taken to adjust the water feed to the exhaust pipe so that no excess of water is admitted; only enough should be allowed to pass to insure the water all being converted into steam. If the engine runs on a constant load, this should not be difficult of attainment, but if the load is variable, it will probably be found impracticable to vary the water supply accordingly and in this case the minimum amount of water feed will probably pay best in the long run.

A good way to cool the gases is to water-jacket the exhaust pipe, as shown diagrammatically in Fig. 1, if the water is available. It will probably be found cheaper and more satisfactory to have a short water-jacketed section cast with flanges at each end of it than to have a jacket fitted to the existing pipe, although I have seen the latter method applied with success. In multicylinder exhaust manifolds the piping may be arranged as in Fig. 2, with or without the standpipe, according to necessity.

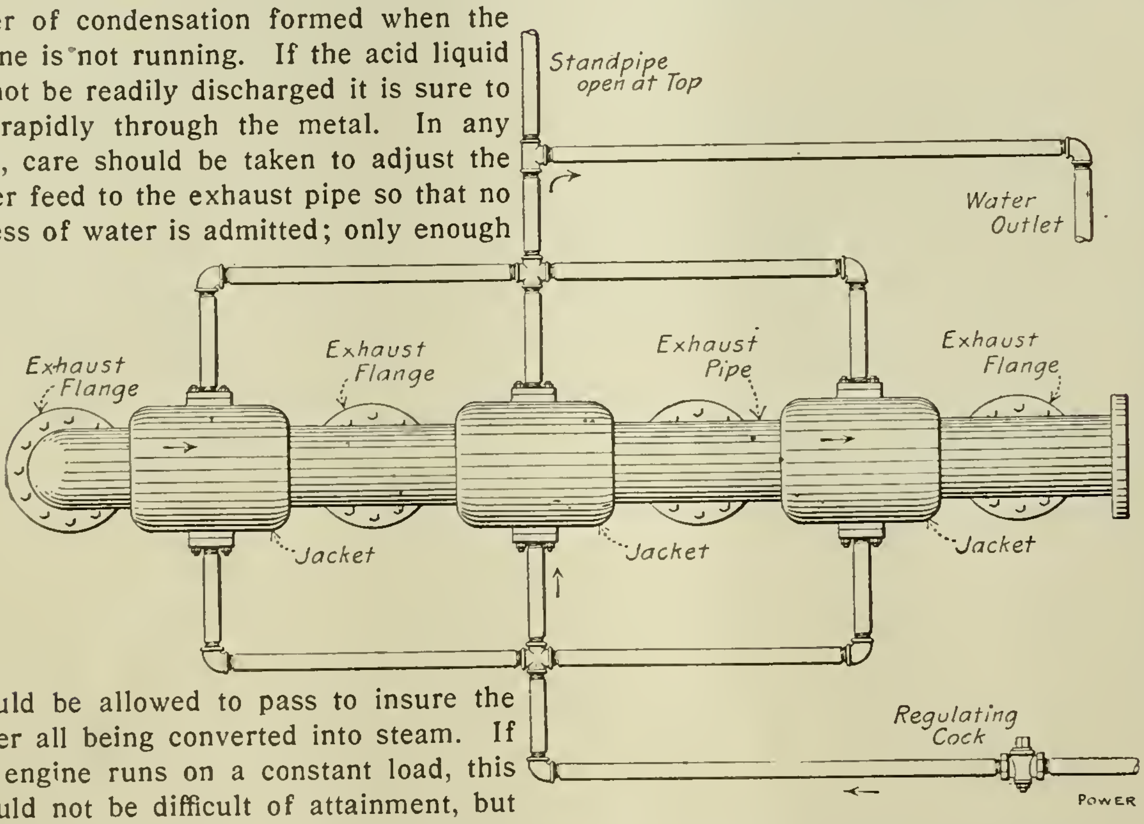


Fig. 2. Arrangement of Piping for Multicylinder Exhaust Manifolds

Another way to cool the gases and secure efficient muffling, usually adopted primarily for the latter purpose, is to provide a series of iron chambers to allow for the continuous expansion of the gases.

John S. Leese.

Manchester, Eng.

Mr. Rushmore's Operating Costs

In the issue of May 23, on page 812, appeared "A Comparison of Actual Gas Power and Central Station Figures," by Samuel W. Rushmore. I cannot agree with some of the general deductions reached by Mr. Rushmore, which seem to be more or less in line with the arithmetical errors which he has made. He gives the total cost as quoted by the central station as $555 per month and states that it would be necessary to use $125 worth of gas per month; this makes a total of $680, or 3.4 cents per kilowatt-hour. Mr. Rushmore figures this at 3.9 cents per kilowatt-hour, an error of ½ cent per kilowatt-hour. Mr. Rushmore includes no charges for repairs, cooling water or ash removal, and makes a very general assumption in regard to the fixed charges.

Apparently the standby losses included are only the night losses during the working days of the week; in other words, the standby costs from Saturday noon to the following Monday morning are not included.

The cost of the plant will be approximately as follows:

Producers, 400-horsepower at $12	$4,800
Engines and auxiliaries, 240-horsepower at $45	10,800
Foundations, settings, piping, etc., for producers and engines, 400-horsepower at $12	4,800
Building, 400-horsepower at $12	4,800
Total	$25,200

In a gas-engine plant of this character it is conservative to figure depreciation at 8 per cent., interest at 5 per cent., taxes and insurance at 2 per cent. and profit on investment at 7 per cent., making total fixed charges of 22 per cent., or $5544 per year. It is unnecessary to refer to the items on interest and insurance and taxes, as these are conservative. A plant owner would also hardly consider investing $25,000 in any branch of his business unless he expected to make some profit on the investment and 7 per cent. is a very conservative figure.

From a number of tests on operating plants, three cubic feet of cooling water per kilowatt-hour is a good average figure. During the six-day test referred to by Mr. Rushmore he would probably use 15,280 cubic feet of water, which, at 90 cents per 1000 cubic feet, comes to $14.75.

The corrected operating costs will then be:

Coal, 15,218 pounds	$21.50
Cylinder oil	3.00
Engine oil	1.25
Kerosene	0.20
Waste	0.80
Labor	33.00
Cooling water	14.75
Total	$74.50

Kilowatt-hours generated, 5094; operating cost per kilowatt-hour, 1.463 cents; fixed charges per week, $106.50; fixed charges per kilowatt-hour, 2.09 cents.

Mr. Rushmore has also figured the cost of central-station power for a rated capacity of 350 horsepower, whereas the power delivered by his gas engine was only 180 horsepower. Neither has he made any allowance for emergency service or breakdown service. A number of instances have come to my notice of gas-engine plants installed within the last few years where the emergency service has been very expensive, in spite of the efforts of capable operating engineers and a large amount of time devoted to the matter by the plant owners. To quote the words of the owner of a 240-horsepower gas-engine installation: "Our electricity did not cost us very much when we had it, but it cost us a whole lot more when we did not have it, and each time the wheels stopped going around the central-station service looked more attractive than ever, so we have sold the plant, and you can see how the factory is running."

If Mr. Rushmore's plant were located in Rochester, we could give him a rate based on his six-day plant test very much lower than 3.6 cents per kilowatt-hour. I am afraid he is leaving out many of the items entering into the total cost of his power when he makes the statement that it is not costing over one cent per kilowatt-hour. If he were considering his operating charges alone, and making no charges for repairs, or ash removal, or overtime on the part of the plant operators, and crediting the operating cost for the week, as shown above, with $30 for purchased gas, his net cost per week would be $44.50, or 0.874 of a cent per kilowatt-hour. The fixed charges on top of this makes a total of 2.964 cents per kilowatt-hour, instead of "not much over 1 cent per kilowatt-hour" as stated by Mr. Rushmore.

R. D. De Wolf,
Ass't Mech. Engr., Rochester Ry. and Light Company.
Rochester, N. Y.

Mr. De Wolf's criticism of my figure of 0.39 cent per kilowatt-hour is correct; I find I divided the total cost by the previous month's meter record of only 17,500 kilowatt-hours.

Mr. De Wolf is wrong in saying that I included no charge for repairs; I stated that our repairs and adjustments for a period of two years had not exceeded $10 per engine every sixty days.

I made no charge for cooling water because we have our own water supply and the engine consumption is a small part of our total pumpage. The coal handling and ash removal are included in the wages of the producer man; the coal is dumped directly from the railway trestle into the producer charging car, and contractors filling in land call for and remove the ashes free of charge.

I clearly stated that as we would not dismantle the gas-power plant should we adopt central-station service, therefore I did not include the otherwise important items of interest, depreciation or amortization.

I neglected to state that the central-station figures were based on the installation of a 150-horsepower alternating-current motor coupled to a direct-current generator, and were not based on the full use of the 350 horsepower total rating of our motors, although the two engines used in the test totaled 240 brake horsepower. Repairs, depreciation, interest, etc., on a motor-generator would wipe out any item I may have overlooked in present cost.

Although these two engines have been in constant service without any serious shutdown since first installed, one more than four and the other nearly two years ago, we have an additional 75-horsepower reserve gas engine and a 100-horsepower steam plant which we operate during the heating season.

We have no central-station breakdown service, yet, with the two Körting engines alone in service, our machinery has operated during the last three years with no more interruption than suffered by other shops in this district supplied by the central station.

I was a pioneer in the adoption of producer gas more than eight years ago. I have been through all the harrowing experiences and my present plant investment is probably twice as great as would be required today for equal results. Still, if I were now to make a fresh start in this locality, I would unhesitatingly install gas equipment and with the full expectation of producing power at less than half the central-station figures.

Of course, I regret that I am unable to hook on to Mr. De Wolf's busbars at Rochester, for nearly everyone knows that in that favored city central-station power is much cheaper than in most other localities.

Samuel W. Rushmore.
Plainfield, N. J.

Gas Production from Crude Oil

Reading E. C. Jones' paper presented at the San Francisco meeting of the American Society of Mechanical Engineers and printed in Power for May 2, I was somewhat surprised to note that Mr. Jones went to the expense of compressing air to 35 or 40 pounds pressure for the injection of the oil and to assist in the partial combustion of the oil in his experiments with an oil gas generator. We find it unnecessary, but prefer to use steam, as the energy to atomize the oil with it practically costs us nothing and it adds stability and volume to the generated gas. It also cuts down the nitrogen content away below Mr. Jones' figure of 70 per cent. An economizer in our exhaust gases gives us all the energy required for atomizing, and in this way heat that would otherwise be lost is utilized.

Of course, we get more hydrogen in the gas by using the steam, but I do not consider that a disadvantage. H. F. Smith, of the Smith Gas Power Company, stated in a paper read last year before the National Gas and Gasolene Engine Trades Association that he had never known of a single authentic case of preignition due to the presence of hydrogen; he had personally observed the operation of an engine on which the compression was run up experimentally to as high as 220 pounds per square inch, while supplied with gas containing 27 per cent. of free hydrogen, without any sign of preignition.

Our experience agrees with Mr. Smith's. We are now distributing to several thousand consumers illuminating gas under pressure, by means of pumps driven by gas engines running on crude-oil gas in the production of which we use steam as the atomizing agent and there is no preignition; neither is there any deposit on the cylinder wall or inlet valves. The spark plug has been in use two months at a time and on being examined has been returned for further service.

Joseph J. Nix.
Los Angeles, Cal.

Recovering Used Oil

Draining the oil channels of gas-engine beds and other means of keeping oil from flying in all directions seem to be ignored by most builders, more especially in the smaller types of engines. Though there have been feeble attempts in this direction, the results are not very satisfactory. The difficulty is increased in the vertical multi-cylinder engines using the splash system of oiling. The editorial paragraph in a recent issue of Power hits the nail on the head exactly in saying that splash lubrication is in the same class as hot-tube ignition.

I have handled several makes of gas engines and have failed to find one that could be kept clean of surplus oil any length of time. The only economical method is to use the oil over again by collecting the drips and circulating the oil through a filter. For example, if the excess oil of a single-cylinder horizontal engine were collected and filtered, the surplus from the new oil fed to the piston would provide a continuous supply for the bearings.

If gas-engine operators would figure up their oil bills, then collect all of the surplus oil and filter it, they would find that the filter had paid for itself by the time the first barrel was used.

There are various ways in which oil can go to waste. Usually the piston and the crank disks are not covered properly and the draft created by the motion of the piston will throw the oil on the flywheels. In a great many cases there is no provision for draining the channels around the base of the engine and it is a difficult task to drill and tap it for pipes if the channel is divided up by foundation-bolt bosses. In such a case, a neat job can be made with a sheet-iron trough extended along the edge of the channel supported by clips made of sheet iron. The clips should flare up at the edges and three or four strands of candlewick can be laid on the clips so that oil will drain from the channel by capillary attraction.

If the oil has a tendency to work out of the bearing along the shaft, a good plan is to make a spring wiper and fasten it to the engine beneath the shaft so it will drain into the channel.

While these simple suggestions are crude, they are effective in practice.

S. E. Whitman.
Danbury, Ia.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

This Engineer Made Good

While working in a colliery as a ventilating-fan engineer, a young man was sent to the power house to take the place of one of the engineers. He was not skilled in running electrical machinery or steam turbines, but started in to do his best.

There were two 100-kilowatt turbine sets, the bearings of which were being melted out at the rate of three or four a week and costing the company $15 for each bearing. Vanes were also broken and the shafts were sprung.

He first cleaned the dirty oil cups that oiled the bearings. As a result, during the first month only three bearings seized, but not seriously, and they were scraped and put back. He refused to take heavy oil the storekeeper gave out and by using a lighter grade reduced his oil consumption from 12 to 7½ gallons a week.

One of the centrifugal condenser pumps refused to pick up after being shut down. It was packed and repacked by half a dozen different men, but was not improved.

The young engineer, having concluded that a porous casting caused the trouble, gave the casting one coat of quick-drying iron oxide and two coats of shellac.

When the engine-room force came on at 6 a.m. the pump was working well and the trouble ceased.

A few weeks later the lights went out from loss of vacuum and low steam pressure. The regular engineer struggled along with a 15-inch vacuum and the voltage was reduced from 500 to 420. It was believed that the plant would not work under 120 pounds steam pressure.

When the regular engineer went off duty the young man noticed that the feed pump was running overfast, and that the condenser pump was running too slow. He speeded it up and got a 27-inch vacuum. As the pump had a peculiar sound he concluded that it was not getting enough water. A boy was sent to the canal to clean the strainer which was found to be covered with a mass of weeds. The result was that the feed pump was slowed down, the voltage was back to normal and the machines carried their loads with ease.

This experience goes to prove that it pays to always be on the alert and find out the why of things about the plant.

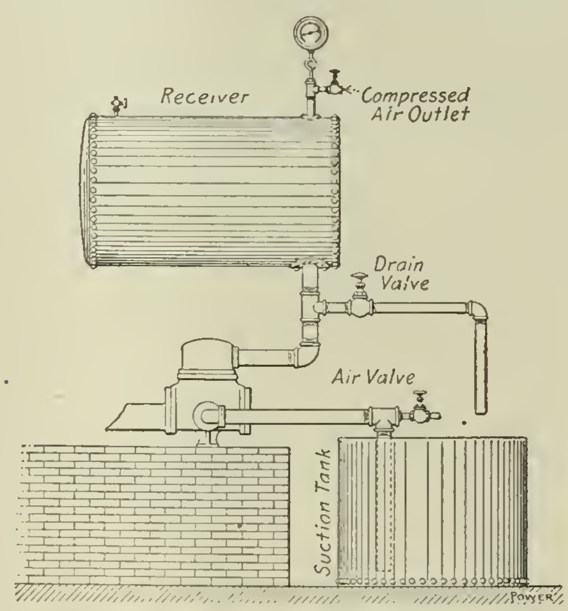
J. P. HUGHES.

Toledo, O.

Pump Used Compressed Air

Some time ago I was employed in a plant where iron barrels were occasionally tested, an air pressure of 10 or 12 pounds per square inch being necessary. The foreman said he had thought of using a small duplex pump, but he could not pump over 4 pounds of air pressure. I told him I could get all the pressure he needed and, to prove my argument, devised the scheme shown in the accompanying drawing.

The barrel to be tested is first connected by a hose to the open-air outlet



PIPING FROM PUMP TO TANKS

valve on the receiver. The drain valve is closed. The pump is then slowly started and when primed the air valve on the suction line is opened just enough to prevent the pump from entirely "losing its water." By proper regulation of this air valve the pump will take in a large volume of air with each stroke and just enough water to keep the plungers and valves fairly well sealed. When a pressure of 8 or 10 pounds is reached the air valve on the suction line is closed, the pump takes water and the receiver is nearly filled. This forces the air out of the receiver into the barrel being tested and increases the pressure at the same time.

Should more pressure be desired the air-outlet valve is closed and the receiver is drained into the suction tank. The small valve shown on top of the receiver admits air when the receiver is being drained. The operation mentioned is then repeated.

Incidentally it is not the most economical way of compressing air.

LOUIS T. WATRY.

Pueblo, Colo.

Filing Engineering Articles

One of the inconveniences in filing magazine clippings is that of having two or more articles, on different subjects and desired for filing, printed on one sheet. This precludes the collecting of all articles on one subject under a single head. The easiest plan would be to purchase as many copies as there are articles desired; but, unfortunately, few men can afford this.

The envelop system has several disadvantages: It is bulky and much time is expended in getting a clipping out of its envelop, which if used frequently is soon destroyed.

Clippings laid flat between covers and held in place as in a book are preserved with the least wear and tear. A very convenient file for this purpose is that commonly known as a loose-leaf grip file. This consists of a piece of tough manila paper, folded to form a cover. To this is securely fixed a flexible metal cup with two needles, over which the papers to be filed are placed after being perforated with a punch supplied for the purpose. The needles are then bent down and outward, the locks secured, and the filing is complete. The files, which take up only the room of the papers themselves, have expanding backs to accommodate the growth of the contents; each file holds about 300 papers.

These files are made in several sizes, but I find the 12x9-inch size the most convenient.

It is not always advisable to cut away the reading matter surrounding an article; some of these pages should be left intact and the reading matter not required crossed out. These marked pages may then be used as a background upon which to paste small clippings.

The files should have a complete and reliable index, the card index being the most suitable for this purpose. This requires blank cards on which to record the articles, a set of alphabetical guide cards, for locating the index card on which any article has been recorded, and a box in which to keep the cards.

To illustrate the use of the system, assume that it is being started with one file (marked *A*), and it is desired to file the article entitled "Condensers for Steam Engines and Turbines," by Frank Foster, printed in POWER for December, 1906. Having cut it out of the magazine, punched and filed it, and numbered the pages 1, 2, 3, 4, etc., the next step is to index the clipping. This will require four cards as follows:

ARTICLE: Condensers for Steam Engines and Turbines.
AUTHOR: Frank Foster, POWER, December, 1906.
FILE: A. PAGES: 1-4.

ARTICLE: Engines and Turbines, Condensers for Steam.
AUTHOR: Frank Foster, POWER, December, 1906.
FILE: A. PAGES: 1-4.

ARTICLE: Steam Engines and Turbines, Condensers for.
AUTHOR: Frank Foster, POWER, December, 1906.
FILE: A. PAGES: 1-4.

ARTICLE: Turbines, Condensers for Steam Engines and.
AUTHOR: Frank Foster, POWER, December, 1906.
FILE: A. PAGES: 1-4.

The titles ARTICLE, AUTHOR, FILE and PAGES on the cards should be made easily distinguishable from the rest of the record, such as underlining, the use of a different colored ink or by the use of a rubber stamp. All that remains then is locating these four cards in their alphabetical order under their respective guide cards, *C*, *E*, *S* and *T*, in the index case.

The initial cost of such a system is 78 cents.

E. A. ANDREWS, JR.

Youngstown, O.

Sump System for Oil Seepage

For some years the waters in northern California, principally the Sacramento river and its tributaries, have been polluted by seepage of fuel oil from the many industrial plants in the valley.

The Southern Pacific Railroad has been an especially large loser, and, with the view of operation economy, has, after repeated experiments, apparently solved the problem by the installation of a simple sump system at the shops.

Along the bank of the river, opposite the shops, a trench was dug for about 450 feet. In excavating, various strata of oil were exhibited, an accumulation of many years' waste, which percolated through the soil and emerged into the stream from the bedrock. The company constructed a system of seven sumps to engage the oil which, whenever conditions warrant, is skimmed from the surface of the water. For temporary experiment these sumps have been constructed of sacks of sand, but the method has proved so successful that concrete tanks will be built to act as a positive catch basin for all seepage.

To give an idea of the enormous loss of oil from this plant the company within a single week reclaimed fully 350 gallons by its skimming process. At the reduced cost of petroleum to the railroad, this amount is almost sufficient to pay for any cost of installation.

W. A. LAWRENCE.

Los Angeles, Cal.

Thin Fires

My method of obtaining economical results in the boiler room is to carry the furnace fire just thick enough to cover the grates, and to fire light and often. This gives the coal a chance to burn. I admit enough air through the fire-door baffle plates to get proper combustion.

The firemen keep the ashpit doors so adjusted that there will be an opening into the ashpit just one-fifth of the area of the flue space for the admission of air. I find this to be a very good method of regulating the air, and it saves fuel.

W. T. HUNN.

Bellefontaine, O.

Clogged Condenser Gage Pipe

Recently I had charge of a cross-compound engine and a jet condenser pump. One day as I stood looking at the vacuum gage the pointer dropped to zero and rested on the pin. The pump was working normally and the engine kept on running as if nothing had happened.

Then I said to myself, "The pump is working all right, and there is a good vacuum in the engine cylinder or the engine would let me know it very quickly. The trouble must be between the condenser and the gage."

I took down the 1¼-inch gage pipe, which was about 3 feet long, and found that it was full of mud and slime. I cleaned it and put it back; as a result I got 26 inches of vacuum on the gage.

The condensing water was taken from the north branch of the Hoosac river, which after a rain is dirty. Shortly after, I went to a larger plant. Three months later my old superintendent asked me to go down to the mill with him and look over the condenser as he could get no vacuum and the mill had been shut down. I went to the plant and found the engineer and two pipers who had inspected the piping from condenser to the engine for leaks. They found everything in good condition at the water end of the condenser pump but there was no vacuum.

I told the engineer that the superintendent had asked me to come in and help out if I could and that sometimes two heads were better than one.

We started the pump and it ran as nicely as any pump could and the quick start and slow ending of the stroke showed that it was producing a good vacuum in the condenser. The pointer on the vacuum gage never moved, however. I told the engineer that he would find the trouble in the 1¼-inch pipe between the gage and condenser.

When he took the pipe down he found it full of slime and mud. After it was cleaned out and replaced he had 23 inches of vacuum showing on the gage with the engines standing still.

The trouble was found and overcome in ten minutes by one who had had experience in that line. This incident goes to prove that to retain a competent engineer he must be paid what he is worth to his employer and outside assistance would not then be necessary.

JAMES MITCHELL.

North Adams, Mass.

Line Shaft Repair

An accident occurred in the plant in which I am employed when the main driving shaft carrying a heavy shed

BREAK IN THE LINE SHAFT AND THE REPAIRS

twisted off almost flush with the flange coupling *A*, as shown. The shaft was 4½ inches in diameter, but had been turned down to 3 inches where it fitted in the coupling. To take this shaft out would have meant shutting down the tire making departments for the rest of the week, as the next shift would have had to come off all the ropes unspliced, as well as taking off the driving pulleys for the other room.

The repair job was begun by taking out the section of shaft *B*, on which were two flange couplings and to which the coupling on the broken piece was bolted.

The flanges were removed from this shaft, and the flange *C* was then pressed on a longer section of shaft *D*, which came up to the point where the shaft had twisted off.

A compound rest was then taken from a lathe and rigged up on a staging alongside the shaft and that part of the tapered shaft at *E* was turned down to a diameter of 3 inches.

This turning was done during working hours, with the other room running at full speed, the shaft making 270 revolutions per minute.

A keyseat was cut at night in the broken shaft with a portable keyseating machine, and the two shafts were then connected by a box coupling, as shown in the lower view.

ROBERT A. BOND.

New Bedford, Mass.

Corliss Valve Setting

Methods of setting the valves of a Corliss engine have often been described, but nothing has been said that would be

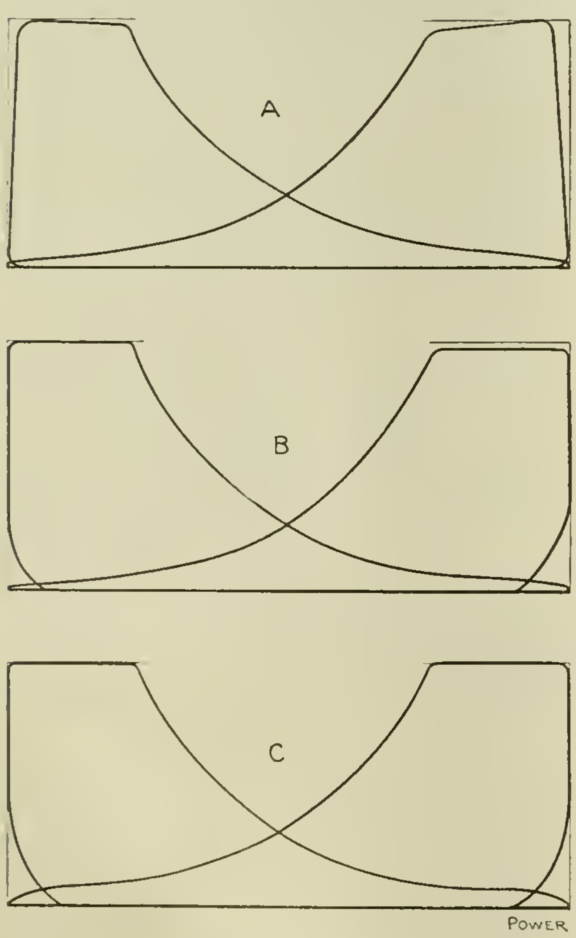


FIG. 1. DIAGRAMS TAKEN FROM THE ENGINE

of service to the average engineer if, after having set the valves according to laid-down rules, factory marks or blueprints furnished by the manufacturer, the engine would not work satisfactorily. In my experience factory marks and blueprints have often been disregarded and the valves set to suit the indicator as well as to obtain smooth running.

One engine, of the heavy-duty type, 38x40-inch cylinder, was direct connected to two double-acting 20x40-inch ammonia compressors, working against 160 to 180 pounds discharge pressure. The indicator showed an initial pressure of 110 pounds per square inch. The steam valves were of the slotted type, that is, live and exhaust steam traveled through the valve instead of over it. The directions for setting these valves were as follows:

Set the steam valve with $\frac{1}{2}$-inch lap, exhaust valve $\frac{1}{8}$ inch lap and give the steam valve $\frac{1}{16}$ inch lead. The blueprint showed the amount of travel for each valve and length of rods from the wrist-plate to the bell crank. After the valves were all set according to directions and the eccentric fastened, the engine was turned by hand to the opposite center and the lead adjusted to suit the $\frac{1}{16}$-inch mark which, of course, altered the lap slightly. The engine was started up, and if one ever heard a bad running machine this one was it. An indicator was attached and a diagram produced, as shown in diagram *A*.

I stopped the engine and examined the diagram. The thump occurred after the piston had traveled 2 inches from either end, and I wondered why the thump was not at the beginning of the stroke. If it was due to lack of compression, the thump would have happened before it reached the end of the stroke; if it were due to too much lead, it would have happened at the beginning of the stroke; but coming when the piston was 2 inches from either end, when the steam valve was nearly open, I will admit I was puzzled.

I reasoned that the thump was due to concussion by having full steam pressure admitted to the cylinder too late, as the indicator showed. I advanced the eccentric slightly and the thump lessened, and advancing the eccentric a little more the thump ceased, but the exhaust valves rattled slightly. I took another indicator diagram and *B* was the result.

I had followed the marks on the valves and cylinder, also the blueprints and instructions of the builder and I had no compression, even after altering, so to get the shaft, bearings, crank and crosshead running quietly, I started to lengthen the reach rods on the exhaust valves until both valves had $\frac{3}{8}$-inch lap. Then, to get both ends alike, I lengthened one rod until one exhaust valve had $\frac{7}{16}$ inch lap, obtaining diagram *C*.

This adjustment produced a smooth-running engine, but the speed could not be changed more than 10 revolutions per minute, and in this plant the ice machine should run at 25 as well as at 70 revolutions per minute. The regulating arm on which the weight hung for changing the speed was changed from its original shape to look like that shown in Fig. 2. Then a weight of equal size was put on each side. This arrangement worked all right at speeds from 38 to 50 revolutions per minute. I next attached a spring, as shown. This spring attachment solved the problem and the engine

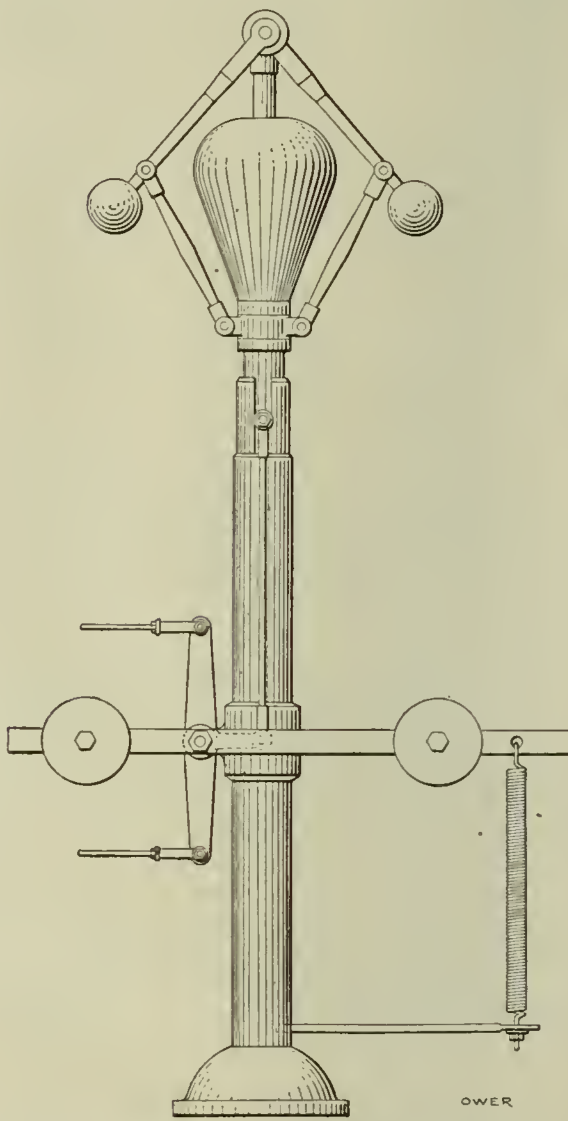


FIG. 2. SPRING ATTACHED TO THE GOVERNOR ARM

can be run from 10 to 50 revolutions per minute, with the throttle wide open and with a steady cutoff.

W. NOEYES.

Kansas City, Mo.

Reinforced Crank Pin Brasses

The crank-pin box on a small steam engine gave trouble by heating. On examination it was found that the brasses were so lightly made that under heavy loads they would spring. There was a center rib on each against which the rod end and adjusting wedge bore, and metal on each side of this rib was left very thin. As a consequence this rib was forced against the crank pin, causing the center of the brasses to wear faster than the outer ends.

The cavity on each side of the rib was cleaned, turned and then filled with hard babbitt metal. This gave a full bearing for the rod end and adjusting wedge. After making this change the box gave no further trouble.

JAMES W. LITTLE.

Fruitland, Wash.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Size of Turbine Exhaust Pipes

William Kent says that my formula, given in POWER of March 28, appears to be defective insofar as it does not include the length of the pipe and the allowable drop in pressure between the condenser and the turbine.

As to the length, I will be pleased to consider suggestions for making the area of the pipe vary with variation in the length if I am shown that this is necessary or desirable. My present opinion is that the length affects the desirable area very little if at all.

Consider an exhaust pipe 10 feet long and of any reasonable sectional area. This pipe costs a certain sum of money, and the space it occupies may cost something. If we were to reduce the sectional area of the pipe, we would reduce the cost.

The friction of the pipe causes the vacuum at the exhaust end of the turbine to be less than the vacuum at the condenser and the difference in the vacuum will depend on the area of the pipe. The pressure required at the turbine is, say, P. To obtain this pressure, a lower pressure, say, P_1, must be maintained at the condenser; and the difference in pressure, or $P - P_1$, depends on the area of the exhaust pipe.

If we were to reduce the area, we would increase $P - P_1$; and, therefore, to maintain P constant, we should require to reduce P_1 and this would involve increased initial cost of condensing plant, or increased running charges, or both. What is required is to determine the diameter of pipe at which the rate of reduction in cost of pipe with reduction in area will just equal the rate of increase in cost of condensing plant with reduction in area.

We have been considering a pipe 10 feet long but, if one only 5 feet long is taken, the variation in cost of pipe with reduction in area would be just half, while the increase in cost of the condensing plant would also just be half, so that the best area for the 5-foot pipe would be exactly the same as the best area for the 10-foot pipe. It therefore appears that the length of the pipe does not require to be taken into account.

As regards Mr. Kent's other objection to my formula, namely, that it does not include the allowable drop in pressure, it would, I consider, be foolish for anyone to state an allowable drop of pressure without considering the cost of obtaining this. The formula is intended to determine the area which will give the drop of pressure which is best in any case. The drop will, of course, be very much greater for a long pipe than a short one. For a short pipe the drop ought to be very small because it can be kept small at a trifling cost. For a pipe twenty times as long, it would be unreasonable to limit the drop to the same amount, as this could only be accomplished by multiplying the sectional area of the pipe many times and the cost would be enormously increased.

As regards the exponent 0.4 of the factor f in my formula, most formulas for the flow of fluids through pipes of circular section make the friction vary as the square of the volume of fluid passing a given point in the pipe every minute, and also make the friction vary as the fifth power of the diameter of the pipe. With nonelastic fluids weight may be, and often is, substituted for volume in the formula. If F denotes the friction, B the volume and d the diameter

$$F \propto \frac{B^2}{d^5}$$

For convenience later on, let A denote the internal sectional area of the pipe, then

$$F \propto \frac{B^2}{A^{2.5}}$$

If v denotes the velocity of the fluid

$$B \propto vA$$

Therefore

$$F \propto \frac{v^2}{A^{0.5}}$$

That is, for constant velocity the friction varies inversely as the square root of the sectional area. Presumably the reason is that the ratio of superficial area of the pipe per foot length to sectional area varies inversely as the square root of the latter, and the friction increases with the superficial area. Therefore, for pipes of dissimilar but equal sections, we can take the friction to vary as the superficial area per foot length, or simply as the internal periphery.

If f denotes the periphery in feet of a figure of the shape of the cross-section of the pipe or duct and of an area of one square foot, then for all pipes of one square foot sectional area

$$F \propto f$$

and for all pipes whatever

$$F \propto \frac{B^2 f}{A^{2.5}}$$

Therefore, for equal friction

$$A^{2.5} \propto B^2 f$$

or

$$A \propto B^{0.8} f^{0.4}$$

In my formula W (the total weight of steam per hour) is employed for convenience instead of B.

R. M. NEILSON.

Glasgow, Scotland.

Did Not Hook On

I submit the following answers to the questions of S. E. Mead as given in the May 23 number, page 814, regarding the diagram from a Corliss engine which did not hook up.

"Why does the diagram from that end include any area?"

Because the movement of the piston changes the pressure of the contents of that end of the cylinder by alternately compressing and expanding it.

"Why does not the expansion line follow back upon the same line as the compression?"

The expansion line drops down below the compression line because at the beginning of this stroke both the steam and the exhaust valve at this end of the cylinder are closed, and as the piston starts away the contents of the clearance space expand, thus losing pressure very rapidly at first, and then gradually until at about half stroke, after which point it runs nearly parallel with the line of zero pressure. Then when the exhaust valve opens it raises slightly to meet the line of lowest pressure attained by the condenser.

In explanation of this diagram I would say that it is directly opposite to the ordinary steam-engine diagram in that the expansion curve is the lower line which approaches nearest the line of absolute vacuum, and the compression curve is the upper line or the one nearest the atmospheric line. In this the diagram is very similar to the diagram of an air compressor.

The compression starts in a line very nearly straight and parallel to the atmospheric line for more than half stroke

This is because the exhaust valve is open and the piston moves against the lowest vacuum attained. Then as the exhaust valve closes, this charge of low-pressure steam is compressed, thus raising the pressure highest at the end of the stroke.

In answer to Mr. Mead's last question, I would say that the expansion line cannot be lowered as it represents the very best possible vacuum attainable with his engine.

CHARLES F. CLARK.

Hartwick, N. Y.

Boilers Foam

In the May 23 number, J. M. Stewart asks for opinions about his foaming boilers. I have had the same trouble with domeless boilers connected to hoisting engines, and have noticed that sometimes they do not furnish dry steam even on more regular service.

I believe that something serving the purpose of a dome is necessary on a horizontal tubular boiler, but I would not want a dome connected in the usual way, as it greatly weakens the shell to cut out the area necessary for the rivet holes and steam passage.

I would prefer a horizontal drum connected to one end to the boiler by a thimble and flange joint, and at the other end resting freely on a support made by riveting thimbles of the proper length to the shell of the boiler and drum.

A drum connected in this way will cause some loss from radiation but if it is properly covered the loss will be small and the extra steam space is a great gain to a boiler connected to a hoisting engine.

Mr. Stewart's trouble might be in his feed water, but if he will boil samples of it in an open vessel, he will be able to tell by its behavior if such is the fact.

H. L. TURNER.

Bartlesville, Okla.

Receiver Pressure

L. Johnson, in the May 16 issue, asserts that the most economical receiver pressure is that which causes the governor to revolve in the highest plane, basing his conclusion on the fallacy that the earlier the cutoff in the high-pressure cylinder the smaller the steam consumption. The fact is, early cutoff in the high-pressure cylinder does not necessarily mean less steam consumption, and furthermore it is possible with no change of cutoff to vary the steam consumption within considerable limits, say 10 per cent., simply by changing the receiver pressure.

The steam in the cylinder at cutoff is made up of two parts, a small amount left in the cylinder at the closing of the exhaust valve, and a larger amount which flows in from the chest while the admission valve is open. These two volumes of steam mingle in the cylinder, but they can be kept separate for purposes of reasoning. The steam left in the cylinder at compression is sometimes called cushion steam. Its volume is constant but its weight is variable depending on the density, which in turn varies with the receiver pressure. With high receiver pressure the cushion steam may be 15 per cent. of the steam at cutoff, while with low receiver pressure it may be as low as 5 per cent. These figures are based on 5 per cent. clearance and one-quarter cutoff and are to be regarded as approximate values for average conditions.

The steam consumption is measured by the steam that comes in from the chest and joins with the cushion steam to make the volume present at cutoff. Calling the weight of steam at cutoff 100 and the cushion steam 5, the balance, or steam consumption, is 95 corresponding to low receiver pressure. Calling the steam at cutoff 100 and the cushion steam 15, the steam consumption is 85 for a high receiver pressure. In this case the steam consumption is changed 10 per cent. by variation in the cushion steam, brought about by alterations in the receiver pressure and not by a change of cutoff in the high-pressure cylinder.

Experience tends to confirm the truth of the foregoing reasoning. A good illustration is to be found in some forms of pumping engines having no governor, where the high-pressure cutoff can be set by hand. Under these conditions with a steady load, if the receiver pressure is lowered the engine gains in speed, showing that it is using more steam and doing more work. If the receiver pressure is raised the engine loses speed, showing that it is using less steam and doing less work.

The simple rule quoted by Mr. Johnson is sure to lead to too low a receiver pressure and hence to poor economy. There is reason to fear that many engineers are following it, not knowing the unsound basis on which it rests. A final argument against the rule may have weight with those who do not follow the theoretical reasoning. It is that, in all trials of compound engines where the steam is measured and the best performance is desired, the highest economy is obtained with a receiver pressure giving but little drop in pressure at the end of the expansion in the high-pressure cylinder.

E. H. LOCKWOOD.

New Haven, Conn.

Who Is Responsible?

After a man has worked for you for six months or a year and shown you that he possesses the ordinary amount of brains, then when the water column becomes clogged, instead of getting word to you, unscrews the plug in the column tee and rams a rod through into the boiler, cleaning out the obstruction and also—well, you can imagine the rest; who is responsible? I know men to whom you can talk and explain till you are blue in the face and they will say "yes, yes, I know," and yet by only the fraction of a minute did I save one of them from the disastrous results of taking the top from a check valve before he had closed the globe valve in front of it. However, is there a man in the business who cannot point to some fool thing he has done at some time or other.

C. A. SCOTT.

Wales, Wis.

Relative Size of Compound and Simple Engine Cylinders

In POWER for April 25, C. E. R. asks, "What would be the comparative diameter of the low-pressure cylinder of a compound engine to develop the same horsepower as a simple engine at the same speed and steam pressure?"

The answer to the question begins with the remark: "If the work done is to be the same in both cases, the number of expansions must be the same." This is equivalent to saying that all steam engines of the same power, speed and steam pressure have the same number of expansions, which, of course, is erroneous.

The reply then continues: "Consequently, with the same initial and terminal pressures, the diameter of the low-pressure cylinder of the compound must be equal to the diameter of the single cylinder of the simple engine." This is approximately true, barring the terminal drop in the high-pressure cylinder and other losses. The question must have been misunderstood. One of the main reasons for compounding is to increase the number of expansions without shortening the cutoff beyond the economical limit, and the terminal pressure in the low-pressure cylinder of a compound may be, and practically always is, considerably lower than that of a simple engine working between the same pressure limits.

As an example, assume a simple noncondensing engine of 500 indicated horsepower, with 140 pounds absolute initial pressure, 16 pounds absolute back pressure; a clearance of 5 per cent. and compression at nine-tenths of the stroke. Cutoff at one-fourth stroke is common for the rated load of such an engine. Then with a diagram factor of 0.85 and a piston speed of 750 feet per minute, the cylinder is 22 inches in diameter. A compound, noncondensing engine of the same power and piston speed, with the same pressure limits, clearance, compression and diagram factor, but with a terminal pressure of 20 pounds absolute, would have for the diameter of the high- and low-pressure cylinders respectively, 17 and 29 inches. Or, using Tribes tables with a still lower terminal pressure, the cylinders would be 18 and 30 inches in diameter.

Twin engines are sometimes converted into compounds by replacing one of the cylinders by a low-pressure cylinder, the size of which depends on whether a condenser is used; but in all cases it is larger than the cylinder it replaces.

William E. Ninde.

Syracuse, N. Y.

Water in Oil

R. C. Monteagle recently made a statement about water in fuel oil putting out a fire and overflowing from the furnace onto the fire-room floor. In externally fired boilers there is danger of such an accident only when starting the fire and the brick is cold. It is then necessary to watch the burner closely, as the flame may go out and allow oil to flow into the furnace. If the torch is applied there will be, of course, an explosion, as the combustion chamber and tubes will be filled with oil vapor. After the oil has been burning for some time, water may put the fire out, but the oil will instantly ignite, as the brickwork is at a white heat. There is usually some water in fuel oil, but not enough to interfere with the operation of the fire.

Norborne, Mo. Andrew Blair, Jr.

Cooling Hot Bearings

In regard to the cooling of hot bearings, I would like to submit my cure which has never failed and which works quicker than anything I have tried.

Mix half and half by volume No. 6 Keystone grease and ammonia and feed through the oiler as fast as possible by drops. If No. 6 grease is not available, common engine oil will do, but it will have to be stirred almost continuously.

Theodore L. Darling.

Pascoag, R. I.

Antifriction Metals

In the May 16 number of Power, Charles H. Taylor has a letter on the so called antifriction metals which was of unusual interest to me, especially the part in which he states that the general composition for a nonfriction metal should be 76 parts lead to 24 parts antimony. I cannot understand how Mr. Taylor is going to make this metal stand up under all conditions. It is not to be expected that a bearing running at a fair speed, and with little or no shock, will need the same quality of babbitt as a bearing which is operating under severe conditions. I believe if Mr. Taylor would modify his composition to the proportions of not over 20 parts antimony to 80 parts lead he would have a bearing metal that for light high-speed service will be found to give very satisfactory results.

A composition that has given good service under trying conditions is one composed of 5 per cent. copper, 8 per cent. antimony and 87 per cent. tin. Ordinarily this composition is almost prohibitive on account of the cost, and if allowed to run loose for any length of time it will certainly fracture. If it is kept tight on the journal at all times, that is, just free enough to run, it will be found to be all right.

Another composition that will give very satisfactory results when the shock is not too great consists of 20 per cent. tin, 15 per cent. zinc and 65 per cent. lead. It will improve the wearing quality if the metal is covered with a coat of fine charcoal during the time it is in the melting state.

I. B. Green.

New York City.

The Institute of Operating Engineers

There has been considerable criticism of the Institute of Operating Engineers, but if I fully understand the working of the organization it is certainly worthy and along the right lines. No one has anything to say against the homemade engineer. He is usually a good kind, and this association will only help him to be better. I see no need in his feeling that anyone is working a scheme to manufacture engineers to take his place. The homemade engineer who will be alert and look out for his duties and the welfare of his plant need not fear such an association. In fact he might easily better himself by joining the order.

The association presents an opportunity for progress to those who are willing to study and are reaching upward for the rung on the top of the ladder. Pushing ahead is no disgrace, and those who are contented might well allow progressive engineers this privilege. The Institute of Operating Engineers is the center of a good movement and if some engineers do not appreciate it and fail to join, there is no occasion to retard the movement.

C. R. McGahey.

Baltimore, Md.

Vacuum Cleaner

S. G. Rose, in the May 2 number, asks how to remove the dust from floors, ceilings, etc., without sweeping. He practically answers his question when he makes inquiry about a vacuum cleaner. I would advise him not to attempt making a homemade affair, when vacuum-cleaning outfits at small cost can be bought ready for use.

It is a well known fact that dust causes much damage to generators and other appliances and it is a common sight to see an attendant around working at generators and motors trying to dislodge the dust with a bellows or a stream of air from a compressor. A brush fitted to a long handle which is hollow and this handle fitted in turn to the vacuum hose will soon remove all dust from the high spots. A regular vacuum broom attached to the hose will be all right for the floor. The principal items necessary are a dust-settling chamber, a brush or cleaner by which the dust is collected and directed into the hose and an exhaust blower.

James E. Noble.

Toronto, Can.

Scale in Feed Pipe

In a recent issue an engineer stated that he had a great deal of trouble with scale in the feed pipe of his boilers. In two different plants with which I have been connected we had the same trouble with the internal feed pipes of Heine and of Babcock & Wilcox boilers. The water was taken from the same river and contained a great deal of scale-forming matter which was mostly carbonates and sulphates of calcium.

In one plant the external feed pipes were made of brass and gave no trouble, but the feed pipes inside the boiler were of iron and became plugged up solid in a very short time. The iron pipes were finally replaced by brass pipes of the same size, and there was no further trouble from scale.

In the other plant the external pipes were of iron and after a short length of time became pitted full of holes from 3/16 to 1/2 inch in diameter, while the internal pipes of the same material became closed up with scale. As there are two internal pipes in the Babcock & Wilcox boiler we renewed one with iron and the other with brass. In a few weeks the iron pipe was plugged up and the brass pipe remained clear. It was then decided to use brass in all of the boilers, which, as far as I know, never gave any further trouble.

An 8-inch high-pressure brass pipe was considered too expensive for the main feed line, so we used extra-heavy steel pipe, and it is doing fairly well.

I have never been able to find out why the scale did not adhere to the brass pipe as it did to the iron pipe, but in this case brass pipe solved a very dangerous as well as troublesome problem. I would suggest that the engineer above referred to try brass pipes in one boiler and note the results, which will give him an idea as to whether or not this will solve his difficulty.

J. Case.

Hyattsville, Md.

I am interested in several letters under the above title and think there is quite a little to be learned. I do not agree with Mr. Jahnke as to his two-pipe system, especially the one connected to the blowoff pipe. Combinations usually mean complications. The following system is better than any other which I have seen or heard of:

It is unnecessary to have two separate feed lines to a boiler, but take care of the one. Always enter the feed pipe somewhere on the top of a return-tubular boiler, as it is perfectly accessible, both inside and outside. If hot or warm water is used all the time, it is unnecessary to have a long pipe inside, as it is apt to cause more trouble than it is worth. Run the pipe down to the flues, then use an elbow and a horizontal piece of pipe not over 3 feet long. To avoid depositing the impurities which the heaters and purifiers have failed to collect, on the flues or sheets, fasten a pipe of not less than 3 inches diameter to the flues so that the feed pipe will discharge into it, carrying in with the discharge a quantity of the boiler water. The impurities will collect inside of the large pipe and may be easily removed on cleaning day with a hose or hammer. Let the feed pipe enter the large pipe only a couple of inches; the large pipe should be not less than 4 feet long. If a pipe above 4 inches in diameter is used, place the collector pipe at an angle so that the water will take a spiral course through it.

Ray Gilbert.

Virginville, W. Va.

Boiler Design

Having read with interest "Desirable Improvements in Boilers," on page 761 of the May 16 number, it would seem that the correctness of the title in every particular might be questioned when viewed in the light of practical experience in boiler operation. Mr. Dean has adopted an old form of longitudinal joint which he believes is best for boiler work. It has overcome one disadvantage in the former style of joint he recommended in reducing the pitch of the rivets along the calking edge, for this must have been a disadvantage in manufacture even when using heavy butt straps.

While it is hard to see any real advantage in Mr. Dean's new selection of joint over the kind of butt-strapped joint in common use in the United States, it would be interesting to know if such a form of joint really shows under test the calculated strength he gives it. The committee of research on riveted joints of the Institute of Mechanical Engineers found that to obtain the full strength of a double-riveted lap joint it was required that the two rows of rivets be sufficiently separated to prevent the joint breaking zigzag, and making sure that the joint would break straight across; the net section of metal measured zigzag should be 30 to 35 per cent. in excess of that measured along the seam. While Mr. Dean's joint omits the figures to determine whether the zigzag distance is what is required or not, it appears to the eye as if he had neglected to consider this fact in designing his joint, and that he had bunched the rivets too nearly together girthwise.

Mr. Dean's attack on the Manning boiler seems entirely unwarranted; it is true that the ogee flange as originally designed was very thin and of such shape that all the movement due to pressure was concentrated along one line around the flange. A few of the flanges of this design cracked in service, but after the thickness was increased and its form changed none have failed; therefore, his remarks on this score do not apply at all to the Manning boiler as now constructed. Anyone of experience can take direct issue with Mr. Dean when he says that the Manning boiler is unquestionably dangerous. It is only dangerous in the sense that any steam generator is dangerous, and it is far safer than the average boiler. Mr. Dean speaks of the behavior of the ogee flange on a destructive test of this type of boiler, and he doubtless refers to the test made at the Bigelow plant last summer. The writer had the pleasure of witnessing this test and he distinctly remembers that the center of the ogee flange rose only about ¼ inch under a pressure of 700 pounds, while at 450 pounds the movement was not measurable. As a check on this the overall length of the boiler did not change until after a pressure of 400 pounds was reached, and it amounted to less than ⅜ inch at 700 pounds.

As boilers of any type are rarely operated for general purposes at pressures exceeding 200 pounds, I think Mr. Dean is drawing entirely on his imagination when he asserts that the explosion at the Amoskeag mills was caused by pressure on the ogee flange. I am ignorant of any facts that will establish his claim, and the long record of the Manning boiler with a minimum of accidents absolutely refutes his statements implying that this boiler has inherent structural weakness as constructed today.

If Mr. Dean was versed in practical boilermaking he would hardly suggest a coned sheet in place of the ogee flange, for any boilermaker can tell him of the difficulties encountered by the introduction of such a shape. While Mr. Dean's intentions are good in advising that many more tubes than customary may be put in horizontal tubular boilers, I think he is considerably exceeding good practice in this direction. It is a well known fact that a large body of water directly over the fire is desirable in this type of boiler, aside from the need of room sufficient to permit ready access below the tubes. With the number of tubes he recommends for the different-sized boilers, the required space would not be available at this point. The water line in his layouts would also be considerably higher than practice has demonstrated to be required for good service. With a 1-inch space between tubes it is difficult to clean a scaled tube sheet, and reducing this distance by 25 per cent. would certainly make it much more difficult, besides weakening the bridging between tubes. I hardly think many engineers will agree with Mr. Dean that his suggestion along this line can be considered an improvement in boiler design.

J. E. Terman.

New Haven, Conn.

How to Condense Steam

In answer to E. G. Eldred's question, "How to condense steam," I think the best plan is to take a barrel that will hold water, fix an overflow to it and let the water enter through a pipe at the bottom of the barrel. Then make a coil of ½-inch or ¾-inch pipe of a few turns that will go in the barrel easily. Put the bottom end of the coil through the side of the barrel with lock nuts and connect the top to the steam pipe.

I have tried this method and considerable steam can be condensed in a short time. If the water is allowed to drip a few inches through the air it will get some air in it and help the taste of it.

E. V. Chapman.

Decatur, Ill.

Oil Fuel for Steam Boilers

In the May 16 number Mr. Collins says that in burning oil a boiler can be brought up to 150 pounds steam pressure from cold water in less than half an hour if necessary. This may be possible, but it is certainly not the right thing to do. In an externally fired boiler it will take half an hour to get the furnace hot enough for economical combustion. In my experience with burning oil I have found that it takes from two to four hours to get up steam to working pressure from cold water. I do not agree with his statement that 35 per cent. more capacity can be obtained with fuel oil than when burning high-grade coal. This, at least, has not been my experience.

Andrew Blair, Jr.

Norborne, Mo.

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POWER

Accidents and Education

There are two movements in which the engineer is either consciously or unconsciously interested, for they touch his vocation in vital points. These movements are industrial education and the prevention of industrial accidents.

By industrial education is meant that vocational training which gives the worker a knowledge of the principles underlying his trade or calling as well as the definite and complete manual skill which marks the difference between the master workman and the unreasoning routine drudge. The growing importance of the work of the engineer in the industries of production, transportation and distribution is beginning to be recognized by the general public and by those directly interested, and this recognition manifests itself in attention given to license and inspection legislation and in the establishing of schools, classes and lectureships in universities and other institutions for the purposes of giving practical instruction in steam-power plant operation.

It is plain that the engineer is, or should be, interested in this as it tends to put within easier reach than ever before the systematic education needed to advance him in that intimate knowledge of his vocation that makes for success.

This relates directly to the prevention of accidents in an industry that is as wide as the continent. Steam boilers under pressure are no safer in the care of incompetent operators than is dynamite in the hands of children.

Knowledge of the expansive force of steam, of the potential energy of a mass of highly heated water in a boiler and of the inherent weakness of certain forms of construction—with the ability to calculate the strength of materials and joints and the effects of the repeated distortions of the shell of the lap seam—reduces the hazard of this form of construction and discourages its installation.

With every engineer familiar with the weakness of this type of joint and with the courage that comes with knowledge opposing the making and installing of such apparatus and the operation of that already installed, one class of industrial accidents will be materially reduced.

These are subjects which should not be lightly dropped; on the contrary, they should be weighed with careful judgment if the great body of engineers desires to place the vocation of steam-engine operation in the position, in the estimation of the public, to which it is entitled by its importance.

It is a calling that confers dignity on its followers who give to it the best that is in them.

The New York Edison Company's Advertisement

The question of the isolated plant versus the central station is becoming a burning one the country over. Engines are replaced by motors, engineers by switch-pulling janitors, and every small plant shut down or precluded by central-station service means losses of sales of engines, boilers, pumps, heaters and auxiliaries in connection with, and of oil, packing and all sorts of supplies continuously. There is therefore little sympathy for the central station among operating engineers and manufacturers of material used in isolated plants. The following letter, recently received, is a manifestation of this lack of sympathy:

> New York City, June 14th, 1911.
> To the Hill Publishing Co.,
> New York City.
> Gentlemen:—
> I, as well as the business people who use your paper for advertising, also the steam engineers of the city of New York, believe that it is harmful and detrimental to publish advertisements of the New York Edison Company, a company that is absolutely taking the bread from many engineers and firemen, as well as our business from us the manufacturers.
> If in the next number of POWER you have another advertisement of the New York Edison Company, the matter will be taken up by all the engineers' locals of this city and other States as well as the manufacturers, asking them not to take POWER, and declaring the same a paper that is against the engineer and manufacturer. Every engineer will be asked to cast out POWER from his engine room as an enemy.
> It is the duty of your paper to help the engineer to fight and make resistance against the usurpations of the New York Edison Company, which is a monopoly and detrimental to all. Why not from this date start an article, and help the engineers who are your friends, with an article "The Little Engineer vs. The Big Engineer" (the Big Engineer is the New York Edison Company). If you do all of this it will help you to [illegible] them [illegible].
> Yours very truly,
> C. A. of K.

We have received numerous other admonitions by mail, telephone and word-of-mouth against the continued publication of this advertisement.

There are two separate, distinct departments in POWER. Into the advertising pages anybody may come at the regular rate, and say anything that is not libelous or indecent and is in the line of power-plant practice. On the other hand, nobody can buy at any price any space or utterance in the reading columns. What POWER says editorially is based upon the best information obtainable, and inspired by the ambition to offer the best in the way of analysis, suggestion and observation which its editors with their facilities and in the light of this information can produce. It is by these utterances and not by what appears in its advertising columns that the attitude of a paper should be judged. And what has been the editorial attitude of POWER upon the central-station question? Have you read the "Foreword," October 25, 1910; "Central Station versus Factory Plant," February 14, 1911, and March 21; "The Cost of Power," "Interest and Sinking Fund," March 21; "Will an Isolated Plant Pay?", "The Marginal Principle," March 28; "The Central Station versus Isolated Plant," April 18; "The Central Station Could Not Meet His Figures," April 25; "Isolated Power Plant Makes a Good Showing," May 9; "The Cost of Industrial Power," May 30; "Foreword," June 6; "Central Station Failure," June 20, and the "Central Station Viewpoint," June 20. These are only a part of the references which might have been given, but a reading of the above articles will show the stand we have taken on this subject.

We take it that even the members of the I. A. of E. (we regret that we do not know what the initials stand for) recognize that there are places where the central-station service can be used to advantage, and that their organized opposition to the extension of that service applies to situations where power can be produced cheaper than the central station can legitimately supply it. In opposing the aggressions of the central station beyond its legitimate field; in opposing rate discrimination and subterfuge whereby additional load is taken on at less than the cost would be if charged with its proportion of the fixed charges, as are the services of the small consumer; in exposing the sophistries of the solicitor whose gentle job it is to convince a customer that he can make money by buying current for more than he can make it, the engineers and manufacturers of the whole country—for the question is not a local one—will find POWER with them all the time, and if our unknown correspondent has anything which will help in the process we shall be glad to see it.

Peat as gathered contains a large percentage of moisture. To dry it by exposure to the sun and air takes a long time, and to dry it artificially takes a good deal of heat. An attempt has been made at Emden, Germany, to utilize this heat by drying the peat in a closed vessel under pressure, the steam driven off being available for power and other purposes.

Engineering Graduates

Once more the season of college commencements is at hand and hundreds of young men are about to start on an engineering career. The increasing popularity of the engineering courses, as compared with the older professions, gives rise to the remark so often heard: "The field is being overcrowded." Some will contend that such overcrowding is sure to result in fewer opportunities for advancement and lower salaries, while others will argue that there is always room for good men in any field.

Among the large number graduated every year there are undoubtedly many that fail to make good. This, however, is usually attributable to one of two causes: either the individual has not the qualities that make for success, in which case he would have failed in any other line of work, or he has chosen engineering without seriously consulting his natural inclinations. In this connection, it may be said that fully fifty per cent. of the students when entering college do not really know what line of work they want to make their life's vocation. A course is often chosen because it appears popular, its name is attractive, or some friend has had success in that particular line.

A factor responsible for this condition is the age at which the average student enters upon a technical course. If those who intend taking up engineering would spend two or three years, after leaving high school, in shops or construction work before entering college, they would soon find wherein their inclinations lie; they would get more out of their college course, and would be better prepared to attack practical engineering problems after graduation.

It would appear then that some are doomed to failure through causes independent of the supply and demand; but to offset this the demand for technically trained men has greatly increased during the past few years.

Very often the mistake is made of expecting too much of the technical graduate, and much misunderstanding and criticism of the whole educational system result.

Inefficient Equipment

Economy is the watchword in the power plant where the management and the engineers are wide awake. In others, economy is a meaningless term, and extravagance takes its place.

Most men will have the hole in their pocket sewed up as soon as it is discovered, for fear that a few cents may be lost, but these same men, if owners of a steam plant, will contentedly watch a fireman shovel dollars into a boiler furnace and make no effort to save any of them. A growl will be heard when the amount of the yearly coal bill is ascertained, but beyond "jumping on" the fireman no effort is made to detect and remedy the cause of excessive coal consumption.

Power plants of less than five-hundred horsepower contain engines, pumps, heaters and other power-plant apparatus which are wasteful in the extreme. But the engine turns the wheels, the pump manages to keep water in the boiler and the heater warms the water a trifle above its normal temperature, all of which seems to satisfy those "higher up."

For years the feed water in a certain electric-light plant was sent to the boilers by means of an injector, the water passing through a heater which had become so foul with scale that the water entering the boilers received practically no additional heat above that imparted to it in passing through the injector.

In another small steam plant an old cylinder heater, about ten feet long, lies on the floor alongside the engine. It is inefficient and, although it does take the chill from the water, much of the heat in the exhaust steam that could be utilized if a proper heater were used escapes to the atmosphere.

These two instances illustrate the manner in which the operating costs of a steam plant can run above normal when apparently everything is all right. But if the men who were financially interested in these plants had taken the trouble to look into the matter of feed-water temperatures, as obtained under the conditions found, and compared them with the temperatures obtained in other plants, their eyes would have been opened to the waste of heat and coal.

Thousands of people are ailing more or less—few are physically whole—but they do not know it. When they do, a doctor is consulted in order that the trouble may be removed.

It is the same with steam plants. Few are operating under economical conditions in every particular, and many are "real sick." Their case is not diagnosed, and their ailment is allowed to grow worse day by day.

When power-plant owners and engineers look upon a steam plant as a source of expense, as not producing a finished product, and make up their minds that it can be operated efficiently, the central station will loom less prominently before the engineer's vision and the owner will have the satisfaction of knowing that he can produce power in his own plant cheaper than he can purchase it elsewhere.

The Institute of Operating Engineers has the support and indorsement of able and clear-thinking men. If you are an operating engineer or hope ever to be one it might be worth your while to investigate it. The secretary's office is in the Engineering Societies building, New York City. He answers questions.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Flywheel Proportions

I have a side-crank engine 11½x16 inches which is direct coupled to a fan and which I wish to reinstall to drive a laundry requiring 45 horsepower. The engine is designed to run at 120 revolutions per minute but can be adjusted to run faster. The steam pressure is 75 pounds.

I have two wheels 66 inches in diameter, 15-inch face, weighing about 1300 pounds, and would like if possible to use one or both of them. I have applied several formulas found in handbooks and none of them agree within several thousand pounds. The speed variation is not important and it would be possible to run the engine at a higher speed than stated to permit a lighter wheel.

L. C. R.

Flywheel formulas vary according to the conditions under which the wheel is to be used, and which must be known before the proper one can be selected. A flywheel suitable for a plain slide-valve engine driving a stone crusher might be only quarter heavy enough for a Corliss engine of the same power in an electric-lighting plant. For a plain slide-valve engine doing ordinary work, use the formula

$$W = 350{,}000 \frac{d^2 S}{D^2 R^2}$$

in which

- d = Diameter of the cylinder in inches;
- S = Stroke of the piston in inches;
- D = Diameter of the wheel in feet;
- R = Number of revolutions per minute;
- W = Weight of the wheel in pounds.

Substituting the numerical values in the equation it reads

$$\frac{11.5^2 \times 16}{5.5^2 \times 120^2} \times 350{,}000 = 1700 \text{ pounds}$$

the weight required in a flywheel 66 inches in diameter. If the wheels weigh 1300 pounds each, both will fill the bill very nicely or a slight increase in the number of revolutions will make one suitable.

Constant-current Transformer Working

How can I tell when a constant-current transformer is overloaded? Why do the secondary windings break down if left on open circuit?

T. F.

If it regulates properly, a constant-current transformer cannot be overloaded in the secondary windings because the secondary current remains practically constant at all loads. The primary winding can be overloaded by increasing the resistance in the secondary circuit a good deal beyond that for which it was intended; this will cause the current in the primary winding to increase beyond the rated current. When the secondary circuit is opened, an excessive potential is induced in the secondary winding because the transformer automatically increases the secondary e.m.f. as the secondary resistance increases, in order to keep the current constant. The excessive e.m.f. caused by opening the secondary circuit breaks down the insulation.

Effect of Low Shaft

What effect, if any, will a shaft 11/16 inch low from a line drawn through the center of the cylinder and guides have on a simple engine running over?

J. M. P.

On the out stroke the crank pin would travel over more than one-half of the crank-pin circle while on the return stroke it would travel over less than one-half of the circle. The effect would not be appreciable, or even measurable by any ordinary methods.

Motor Balancer Functions

When two machines with coupled shafts are used to balance a three-wire direct-current circuit, do both work as motors or as dynamos, or is one a motor and the other a dynamo?

A. H. J.

With an unbalanced system, one machine acts as a motor and the other as a dynamo. Which is which depends on the load conditions; the armature connected to the lightly loaded side of the system runs as a motor and the other one as a dynamo, these functions changing automatically as the unbalancing changes. When the two sides of the system are equally loaded, both machines run as motors.

Bad Speed Regulation

A 250-kilowatt and a 125-kilowatt generator driven by separate engines run in parallel without difficulty but when the large machine is cut out, leaving the smaller one to carry the load, the voltage drops from 125 to about 75 or 80 volts for a few moments and then comes up to normal. When the small machine is disconnected from the load, its voltage runs up beyond the range of the voltmeter. What is the cause and how can it be removed?

W. H. L.

The cause is a sticky governor on the small engine. It seems evident that it is a shaft governor and the bar does not swing freely on the pivot pin. The remedy is obvious.

Constant-current Transformers

Why are constant-current transformers used to connect a circuit of arc lamps to a primary alternating-current circuit? Could not 30 or 35 inclosed arcs requiring 65 volts each be connected in series directly across a 2300-volt primary circuit without using a transformer?

W. H. K.

For two reasons: First, in order to put any desired number of lamps in one circuit regardless of the voltage of the main supply circuit; second, in order to obtain regulation of the arc-lamp current. Thirty-four 65-volt lamps could be supplied directly from the 2300-volt circuit if the current would remain constant through the arcs, but by interposing a transformer any number of lamps can be supplied in a single circuit and the current will be kept practically constant by the transformer, no matter whether the lamps regulate accurately or not or whether they are all burning or some of them are cut out.

Direct-current Motor on Alternating-current Circuit

What changes in connections are necessary to make a shunt-wound direct-current fan motor work on an alternating-current circuit of the same voltage?

K. E. T.

Changing the connections will not produce the desired result. If the motor will not run on the alternating-current circuit as it is, which is very probable, it will have to be rewound. Instructions for rewinding cannot be given without complete knowledge as to the dimensions and magnetic character of all parts of the magnetic circuit of the machine.

Refrigeration Department

Principles and operation of ice making and refrigerating plant and machinery

Double Pipe vs. Atmospheric Condensers

By R. P. Kehoe

The popular favor with which the double-pipe type of condenser was accepted, was not due to increased efficiency nor cheaper first cost, but because it was something new and it looked nice. The water was not visible; no pan was necessary; and the condensers could be placed anywhere in a building. Furthermore, the water enters at one end and the ammonia at the other, introducing the countercurrent principle and thus promising extraordinary results.

It was these facts which gave the chief impetus to the sale of double-pipe condensers, and while there is no question about their advantages under a few favorable conditions, it is usually a mistake to adopt them on account of the disadvantages which are herein pointed out.

Faults of Double-pipe Condensers

One of the worst features of this type is its inability to handle river water that is not absolutely free from vegetable matter or sewage. If only a small percentage of such impurities are contained in the water they will quickly collect in the fittings and pipes, causing a rapid decrease in efficiency and final stoppage if the pipes are not frequently cleaned.

A formation of the same thickness of scale on the atmospheric condenser and in the double-pipe condenser is more serious in the latter case. The scale in the atmospheric condenser gathers on the outer surface of the pipe and consequently increases the cooling surface, while the scale in a double-pipe condenser forms on the inner surface of the water pipe and decreases the cooling surface. Furthermore, less scale is required to form a certain thickness of deposit on the inner surface than on the outer surface of a pipe. The decrease of the transverse area of the water pipe from scale in a double-pipe condenser requires an increase in power to circulate a given quantity of water through it, or else if more power is not available, the quantity of cooling water is decreased. In an open-air ammonia condenser cooling water simply overflows the slotted-pipe gutter, and whether the scale is heavy or light on the pipes, the free flow of water either to the distributing gutter or over the condensing surface is not affected.

With the atmospheric condenser any deposit on the pipes is quickly perceived and may be readily scraped off, even while the condenser is in operation, whereas the double-pipe type must be discontinued from service while it is being cleaned.

In a cooling tower advantage is taken of the reduction in temperature resulting from the evaporation of some of the water to be cooled by a natural or forced air current. The more the evaporation the greater is the amount of heat carried off in this way. This principle is employed in an atmospheric condenser and figures largely in its high efficiency. This advantage is lost in the double-pipe type.

Also, in view of the great affinity of anhydrous ammonia for water, a leak in a double-pipe condenser may remain undiscovered for a long time.

During a recent winter, the engineer of a large brewery failed to drain all the water from a battery of double-pipe condensers when the plant was idle, and the water froze, resulting in many split pipes and fittings, and making it necessary to practically rebuild the condensers.

This type of condenser is usually placed inside the building, while atmospheric condensers are installed outside. In this respect, the latter naturally secure an advantage from the cooling effect during cold weather which is almost entirely lost by the former.

The efficiency of the double-pipe type can be maintained only by forcing the condensing water through the pipes at a fairly rapid rate, and due to the friction in the pipes a large amount of power is required for this purpose.

First Cost

The comparative first cost of the two types f.o.b. cars at the factory is approximately as follows:

	Atmospheric Type	Double-pipe Type
Diameter of pipes, inches	2	1½ and 2
Number of pipes in hight of standard condensers	24	12
Length in feet	20	18
Square feet of cooling surface	300	80
Approximate cost of one condenser	$150	$150
Cost per square toot	$0.50	$1.87

From these figures it will be seen that the first cost of the double-pipe condenser is nearly four times the cost of the atmospheric style per square foot of cooling surface.

The number and size of sections of both types usually furnished for each 100 tons refrigerating capacity per 24 hours are as follows:

	Atmospheric Type	Double-pipe Type
Number of sections	8	8
Number of pipes in hight	24	12
Length in feet	20	18
Total cooling surface, square feet	2400	640
Total cost	$1200	$1200

Comparative Efficiency

In spite of the many faults previously mentioned, the double-pipe condenser has a high efficiency when operated under favorable conditions, such as good water, clean pipes and a high velocity of the condensing water. Good water, however, is available only in certain places; clean pipes are seldom found except in new plants and the velocity is naturally limited by a reasonable amount of power for pumping and the use of a reasonable amount of condensing water.

Giving the double-tube type the benefit of the most favorable conditions in practical operation, the comparative efficiency of the two types expressed in the number of B.t.u. exchanged per square foot of cooling surface per hour is as follows: Atmospheric, 60 B.t.u. per degree difference; double pipe, 100 B.t.u. per degree difference, with cooling water flowing at 250 feet per minute.

This greater efficiency makes it possible to use about 40 per cent. less surface but this is offset by the fact that the cost per square foot is increased nearly 300 per cent. Furthermore, in the average plant this efficiency would not be maintained because the tubes are not kept clean enough.

Advantages of Double-pipe Condensers

In small plants up to 10 or 15 tons capacity it is often advantageous to use double-pipe condensers. They are small and compact, can be located close to the machine and, in view of the saving of connections and a condenser pan, are cheaper than the atmospheric style. Furthermore, when using city water that must be paid for, its merit is apparent, as no dirt is accumulated and the water consumption can be reduced to a minimum. It also has a field where the water is used again for other purposes.

After fairly summing up the advantages and disadvantages it is apparent that double-pipe condensers are not the best type to adopt in the usual refrigerating or ice-making plant except under special conditions. The practical faults alone should be sufficient to condemn them especially in ice plants, where all the apparatus is subjected to rough usage and where great cleanliness is not often practised. The simplest and most accessible apparatus should be preferred and while open-air condensers are not as pretty to look at, their simplicity is unquestionable.

There are several designs of the latter type which will be discussed.

Atmospheric Types

The cheapest design of condenser is that in which the hot ammonia gas is led into the highest pipe in each stand and the liquid drawn off from the lowest pipe. It is also the least efficient not only per square foot of surface but in the head pressure maintained. The term "cheapest design," however, must not be misunderstood; it merely refers to the cost per square foot of cooling surface.

One of the most important considerations in the efficiency of a condenser is the head pressure. A few pounds difference in this pressure against which the compressor must work may mean hundreds of dollars every year either saved or thrown away. The heat transmission per square foot affects only the first cost and a few dollars more or less in the initial expense is not as vital as a loss that might go on year after year through high head pressure.

The pressure in a condenser is consistent with the temperature at which the ammonia begins to liquefy. The object, therefore, in an efficient design is to make this temperature as low as possible. With the type in which the gas enters the top pipe the condensing water is at first heated by the absorption of the superheat in the hot gas coming direct from the compressor. It is only after this heat has been removed that the ammonia can be brought down to the point of liquefaction, but then the temperature of the water has risen considerably and the ammonia must liquefy at a relatively high temperature. The result is a higher pressure than would be attained if the initial temperature of the water had been brought to bear on the ammonia at the point of liquefaction.

Another type of condenser is constructed with the gas entering the lowest pipe, from where it ascends through four pipes and then passes through a standpipe to the highest pipe. The ammonia then proceeds downward and the liquid is led off from the fifth pipe from the bottom. The theory upon which this condenser is based is that the four lower pipes (called the forecooler) will remove all the superheat and bring the gas very nearly to the point of liquefaction before it enters the top pipe, where the gas encounters the coldest water and then begins to liquefy at the lowest possible temperature. The practical faults of this type are that the four lower pipes, or the forecooler, cannot be depended upon to just remove the superheat.

Consider the difference in the amount of gas to be condensed according to the capacity developed; the difference in the temperature of the condensing water during all seasons of the year; and the variations in superheat of the gas in every plant. As these upset the theory unquestionably, it might be well to inquire into the result.

If all the superheat is not removed, the balance must be taken out after the gas has risen to the top pipe, and the same fault then exists to some extent as when the gas enters directly into this pipe from the compressor. The operation is much worse, however, if the conditions produce liquid in these lower pipes, which remains pocketed and interferes with the flow of gas until conditions change and it is regasified. To partly obviate this fault some designs provide a small connection from the lower pipes or precooler to drain off the liquid which may form. This special drain pipe is connected to the liquid main.

Reverting to the first principle of this design, it was the object of the precooler to deliver the gas to the top pipe at or near the point of liquefaction, so that it would liquefy at the lowest possible temperature. The introduction of the special liquid drain admits the fault of liquid forming in the lower pipes where the water is at the highest temperature. As a result, this liquid must govern the head pressure because liquefaction takes place here at the highest temperature. Therefore, the primary object of the design is entirely lost, as the head pressure corresponds with the temperature of the water leaving the condenser and not with the initial temperature. Under these conditions the precooler condenser will not do as well as the concurrent condenser.

Countercurrent Atmospheric Condensers

As already pointed out, the double-pipe condenser owes its efficiency entirely to the fact that it is countercurrent in principle and can bring the temperature of the liquefying ammonia as nearly as possible to the initial temperature of the water. A countercurrent atmospheric condenser will therefore offer the same efficiency as the double-pipe type without the practical faults of the latter.

The countercurrent open-air condenser is arranged with the gas entering the lowest pipe and the liquid leaving through several drains at various levels. The superheat is removed in the lower pipes as in the precooler type and as the gas ascends it encounters the effect of colder and colder water. There is no space wasted by the accumulating liquid, which flows off as fast as it forms.

Such a condenser will meet every condition and can always be depended upon to give the best results. It never should be over 18 pipes in hight, as more than this are superfluous on account of the efficiency of the countercurrent effect. In fact the hight may be less. If the initial temperature of the water is high, it will be an advantage to make the stands only 12 or 14 pipes high and provide a greater number. More water is used if this is done, but the head pressure is lower because of the greater amount of work accomplished by the water.

Not long ago an experiment along these lines was attempted by the chief engineer of a large brewery. The plant was equipped with several countercurrent atmospheric condensers, each 24 pipes in hight; 12 pipes were removed from every stand and the condenser pressure was found to be exactly the same. Later on the pipes which were removed were reerected in the form of additional stands and as soon as these new stands were put in operation the pressure dropped from 10 to 20 pounds.

A comparative test of the concurrent atmospheric condenser, with the gas entering the top pipe, and the countercurrent type, just described, will show that the latter can produce the same head pressure with nearly 20 per cent. less condensing water. If the same amount of condensing water is used, the head pressure will be reduced 10 pounds.

Hence, the countercurrent style will afford greater economy under all conditions. If water is scarce it can produce good results with a smaller quantity and if there is plenty of water available, it will reduce the head pressure and cut down the coal bill.

Yet it will be found that many of the large packing houses throughout the country use the open-air condenser of concurrent design almost exclusively. Some of these plants have one hundred or more condensers, all with the gas entering the top pipe, using more water and maintaining a higher head pressure than necessary. The only reason for this is that the operators have become accustomed to this style and do not like to change.

A recent patent describes a direct method for the production of ammonia by the passage of a mixture of hydrogen and nitrogen over finely divided osmium or uranium, or other similar catalytic material. The operation is conducted under about 1000 pounds pressure, and the ammonia is separated from the uncombined gases by cold.

LETTERS

Cutting Packing Over a Wooden Mandrel

In the April 25 issue selling section, I read with interest the talk on packing, by "Old Bill," of the Thermoid Rubber Company's advertisement. The wooden mandrel is all right and there should be several in every engine room, one for each machine, as the mandrel saves time and money.

In the plant in which I am working we have two ammonia piston rods of different sizes; one is 1/16 inch smaller than the other. I got a mandrel made

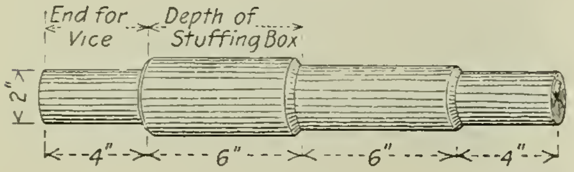


Fig 1

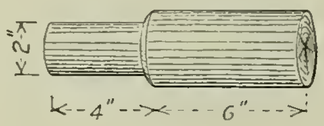


Fig. 2

out of hardwood, like the accompanying Fig. 1, for the ammonia piston rods and one like Fig. 2 for the steam piston rod.

The smaller ends of the mandrel shown in Fig. 1 will serve to put in the vise, and also the small end of Fig. 2. The enlarged parts may be as long as the stuffing boxes are deep. The diameter is to be 1/32 inch less than the diameter of the piston rod, so that there will be some space between the ends of the ring, when it is cut and placed over the rod. When the packing is warmed up, expansion will bring the ends together. In case the packing fits tight in the stuffing box, the space between the ends should be a little more.

The mandrel may be marked, for example, "No. 1 Machine; depth of stuffing box, 8 inches; nine rings of ¾-inch spiral." When cutting the packing, put the mandrel in the vise, take a thin wire nail and fasten the end of the spiral packing to one end of the mandrel, wind the former around the mandrel until it is all covered and fasten it with another nail at the end of the last ring. The packing may be cut straight across or on a slant.

For pumps the mandrel is very handy. It may be made to suit the size of the plunger, piston rod and valve stem. When packing the plunger with duck packing, more space must be allowed between the ends, and the follower plate should not be screwed up too high. The mandrel can be made in a short time by any engineer who has a lathe and knows how to use it.

William L. Keil.

Philadelphia, Penn.

Air in Ice Water System

It is my opinion that Mr. Johnson's suggestion to prevent air in his ice-water system will not remedy the trouble. On account of the hight of the building, say 100 to 110 feet, and the design of the piping system, air will be drawn into the piping under certain conditions of operation. No means is provided to rid the system of this air and it is churned around in the centrifugal pump with the water, causing the latter to become milky. My suggestions would be: First, to get rid of the centrifugal pump and put in a triplex pump. Second, to discharge the cold water into a tank as high above the main on the tenth floor as possible and feed the system from this tank. A float should be provided in this tank to regulate the supply of fresh water taken in from the supply tank. The cold-water supply tank should be made flat like a pan and insulated. This will give a large disengaging surface for the air.

Fred Ophuls.

New York City.

Opening an Ammonia Joint

At a certain plant my assistant engineer was instructed to break an ammonia joint. It was necessary to take out an ell and replace it with a tee and flanged valve so as to extend the coils in the cooling rooms. He claimed that the coils had been thoroughly pumped out.

I gave him a helper and he took all of the bolts out of the flanged ell and was prying the joint apart with a small bar, when it let go with a loud explosion and a shower of oil and muddy substances. A yell from the engineer followed and the next thing I knew he was all in a heap on the floor, choking with ammonia. I grabbed him and made for the open door.

The room was full of the fumes of ammonia and a hissing sound denoted a serious leak. I rushed for the valves in the engine room to isolate that coil and found one valve partly open. None of us was ever able to account for that open valve. My assistant had mistaken the valves and pumped out the wrong coil.

I started the machine and pumped some of the ammonia from the coil into the system, but soon stopped as I did not want to get air into the system.

As the engineer's lips, eyes and tongue were badly burned by the ammonia, he was taught a lesson which he will not forget.

The moral is, never remove all of the bolts on a joint at one time, but loosen them all a little and break the joint gently; then in case of a serious loss of ammonia, the bolts can be tightened up with safety and an investigation made.

D. L. Fagnan.

New York City.

Clearance in Compressors

In designing ammonia compressors it has been the practice of most of the manufacturers to cut down compressor clearance to the smallest possible degree in order to obtain what is commonly believed to be the maximum capacity per cubic foot of compressor displacement. Several other factors, however, should be considered in this connection which tend to militate against the successful working of a compressor under the above conditions. Prominent among these are safety of operation and the superheating of suction gas as it enters the compressor.

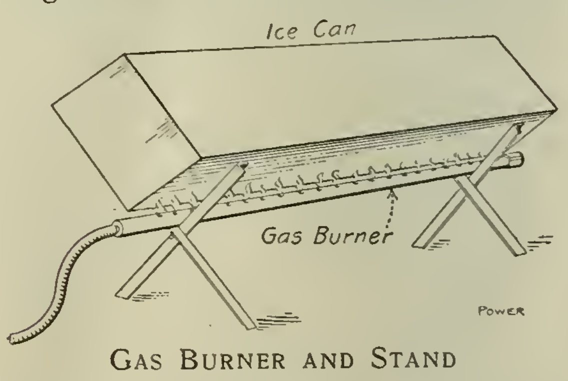
Dwelshauvers-Dery has demonstrated that the cylinder walls of a compressor have a very considerable thermal influence upon the working medium, which influence depends in amount on the conditions of operation and not upon the size of the compressor. It is a well known fact that, although clearance reduces the apparent volumetric efficiency, the horsepower necessary to compress 1 cubic foot of gas in a compressor with reasonable clearance remains the same as in a compressor without clearance. The reason for this is that the cylinder walls of a no-clearance compressor will superheat the gas more, and thereby reduce the capacity to a greater extent, than will a compressor with clearance reduce the apparent capacity. It is the effect of cylinder superheating which must be fully understood before the proper size of the clearance can be determined upon in the design of a compressor.

E. A. Murphy.

New York City.

Temporary Can Repair Kink

The following method was employed by an ingenious engineer to solder leaky cams. It is inexpensive and has prolonged the lives of cans as much as two



Gas Burner and Stand

years. The materials used are an equal mixture of turpentiine and beeswax.

To apply this mixture a gas burner made from a 1-inch pipe the same length as the can to be repaired is used. The pipe is perforated with small holes and mounted on a rack which is also built to hold a can in such a position that the corner will be directly over the jets. The mixture is poured in hot so that it will penertate the smallest crevices.

Edward T. Binns.

Philadelphia, Penn.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Improved Flow Meters

The General Electric Company, Schenectady, N. Y., has developed several types of flow meter of approved design and high efficiency. These include both the recording and indicating types, the former making a continuous graphic record of the rate of flow and the latter giving readings of instantaneous values of the same. The unit of measurement varies with the commodity measured, being pounds per hour for steam, cubic feet per minute for air and gas and gallons per minute for water.

The recording water-flow meter, shown in Fig. 1, comprises a nozzle plug for screwing into the pipe at the point where the flow is to be measured, thus being exposed to the pressure of the water, a meter element which measures the pressure set up in the nozzle plug and a recording mechanism which makes a graphic record of the rate of flow.

The nozzle plug, shown in Fig. 2, has two sets of orifices: the leading set, located parallel to its axis extending across the main and facing the direction of flow, and the trailing set, consisting of three holes located on the opposite side of the plug near the middle and at right angles to its axis. The two sets of orifices open into separate longitudinal chambers leading to the outer end of the plug. The nozzle plug is arranged for use on either vertical or horizontal mains and its introduction is said to cause no appreciable drop in static pressure even at very high rates of flow.

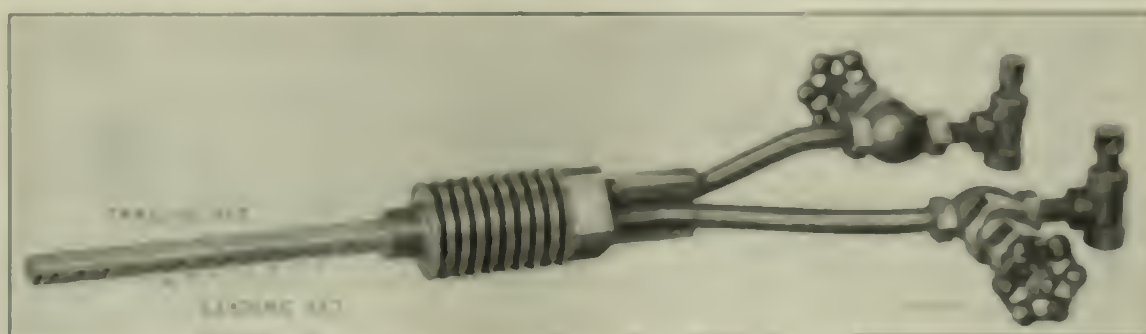


FIG. 2. NOZZLE PLUG AND PIPING FOR WATER-FLOW METER

When the plug is inserted in the main, the water impinging against the orifices of the leading set develops therein a pressure equal to the static pressure plus a pressure due to the velocity head, while the pressure set up in the orifices of the trailing set is equal to the static pressure minus the pressure due to the velocity head, thus causing different pressures in the longitudinal chambers leading to the outer end of the plug. The different pressures are communicated to the meter through pipes attached to the outer end of the plug and connected to flexible steel tubing placed within the meter case.

The meter element consists of two vertical cups or hollow cylinders connected at the bottom by a tube. The U-tube thus formed is filled with mercury to about half the hight of the vertical cups and the whole arrangement is supported and is free to move about a set of knife edges like an accurately constructed balance.

The different pressures in the two sets of orifices in the nozzle plug cause the mercury to rise in the left-hand cup and to fall a corresponding amount in the right-hand cup until the unbalanced mercurial column exactly balances the difference in pressure. This action causes the beam carrying the cups to descend on the left-hand side of the knife edges until the moment of the weights on the right-hand side exactly balances the moment caused by the displacement of the mercury into the left-hand cup. The motion of the beam is multiplied by means of levers and actuates the recording pen, the movement of the latter being proportional to the amount of mercury displaced.

The chart carrying the recording paper is driven by an eight-day clock. The paper is calibrated to record the flow in gallons per minute and the rate of flow may be read at any instant, or the average rate determined for any given length of time.

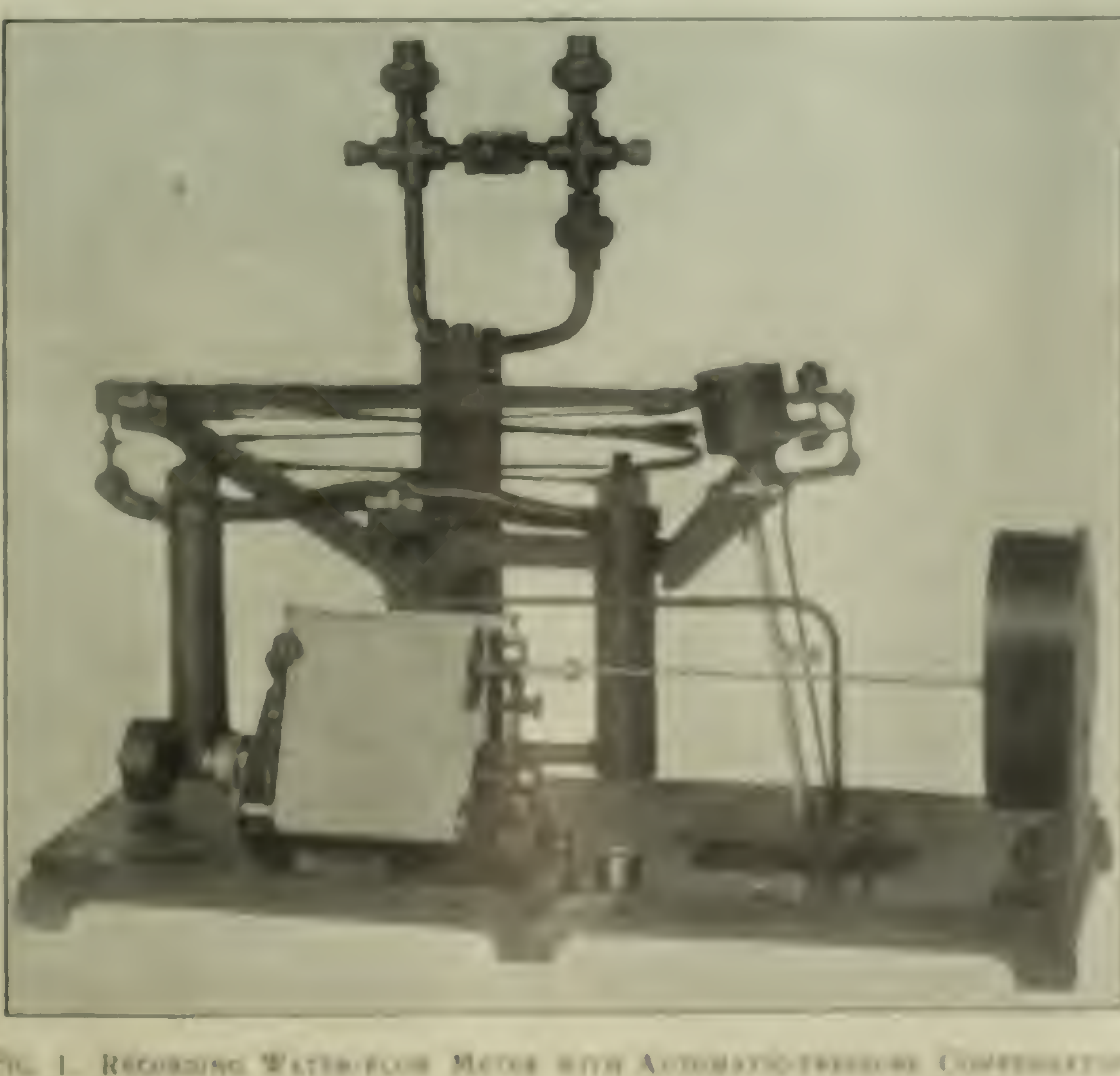


FIG. 1. RECORDING WATER-FLOW METER WITH AUTOMATIC-PRESSURE COMPENSATION

The standard paper furnished is calibrated for a rate of feed of 3 inches per hour, but paper for feeding at a rate of 1 inch or 6 inches per hour can be supplied if desired. The meter is equipped with a spring-operated reroll device capable of holding one complete roll of paper.

Although the meter is calibrated to record the rate of flow in gallons per minute at 39.1 degrees Fahrenheit, suitable means are provided for readily setting it for different temperatures, pipe diameters and rates of flow. In order to measure the flow under normal conditions in any number of different pipes, it is only necessary to use nozzle plugs of sufficient length to extend across the pipes and record paper of suitable calibration range.

This meter is useful for ascertaining the output of pumping plants, the total amount of water consumed by a municipality or the amount distributed to different sections thereof, the input to water turbines and their loss of efficiency, the amount of water consumed in manufacturing processes, the amount of feed water delivered to boilers, the amount of

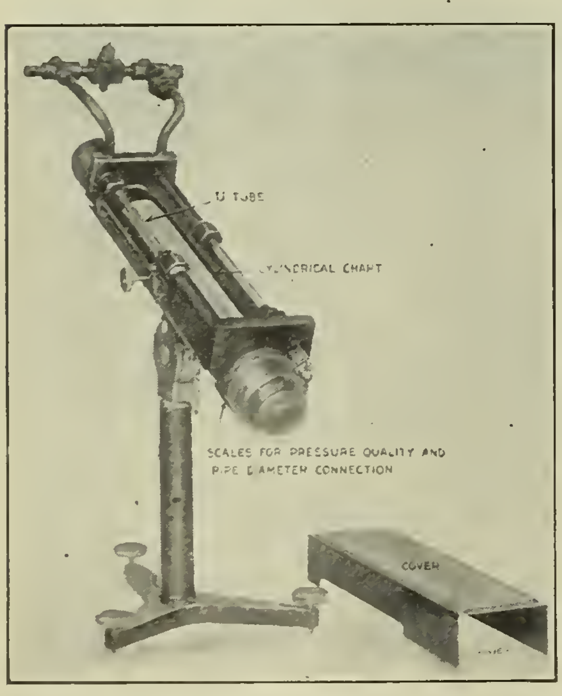


Fig. 3. Indicating Steam-flow Meter, Showing Scales

cooling water used in condensers, the slippage in pumps due to leaky plunger packing or worn-out valves, and for discovering losses due to leaks in water mains.

The recording air-flow meter, suitable also for measuring steam and gas, operates on the same principle as the recording water-flow meter and is practically similar in all details of construction.

The indicating steam-flow meter, shown in Fig. 3, is designed for testing work and other purposes, such as locating trouble due to leaks, determining efficiency of boilers, etc., where accurate, instantaneous readings of the rate of flow are desirable.

This type of meter operates on the same principle and employs the same type of nozzle plug as the recording meter, but differs considerably in details of construction. It can be readily adjusted for various rates of flow and indicates the instantaneous rate of flow in pounds per square inch of pipe cross-sectional area for steam, or in cubic feet of free air at 70 degrees Fahrenheit, for air.

An Oil Eliminator for 66-inch Exhaust Pipe

The accompanying illustration shows a steel shell oil eliminator of the right-angle type recently built by the Hoppes Manufacturing Company, of Springfield, O., for the Milwaukee Electric Railway and Light Company, Milwaukee, Wis.

This apparatus is designed to remove the oil and water from 385,000 pounds of exhaust steam per hour before it passes to and is used in the operation of two 7500-kilowatt low-pressure turbine units. It embodies all of the Hoppes principles of construction for this type of eliminator, having large internal areas for the free and unrestricted flow of the steam and being thoroughly equipped with intercepting troughs partly filled with water to catch and remove all entrainment. The cylindrical shell of this machine is 10 feet in diameter and 23 feet long and when in place will stand vertically. The exhaust steam from the reciprocating engines enters at the side near the top and the purified steam passes out at the bottom.

Some idea of the enormous capacity of this machine may be had from the fact that the exhaust inlet flange is 5 feet 6 inches in diameter, the eliminator being installed in an exhaust pipe line of like dimension. The large special tee at the bottom for connecting to the turbines is not shown in the photograph.

Large Oil Eliminator in Course of Shipment

Boiler Explosion at Alton, Ill.

By H. R. Rockwell

A serious accident recently occurred at the power plant of the Illinois Glass Company at Alton, Ill., in the shape of a rupture of a 66-inch by 18-foot horizontal tubular boiler. This boiler was one of a battery of four of the same class, all connected to one common 12-inch header. The shell plate was of ⅜-inch steel. The writer was unable to find any brand on the plate signifying its tensile strength, but from the appearance of the ruptured plate it seemed to be of first-class material. The longitudinal seams were of the double-strap butt type triple riveted and the boiler contained 54 four-inch tubes.

The boiler is composed of two 9-foot sheets. The front plate was split from end to end, and 43 rivets were sheared on the girth seam and 23 on the head. About one-third of the flues were pulled from the front head and several were jammed through the back head of the boiler, which was raised bodily from its setting and badly damaged a steel roof truss about 20 feet above it. One of the other three boilers was thrown out of its setting and the remaining two were twisted enough to break the 12 and 12 by 6-inch tees which connected them to the header.

Two men were seriously scalded and one of them has since died. The accident happened just at 6 a.m. as the night and day shifts were changing. This very probably accounts for no greater fatality.

The man who was in charge of the boilers claimed that about 15 minutes prior to the accident he blew down the boilers and walked along the front and blew out each water column. The water rose to its proper level in each boiler.

The writer had charge of the plant and upon his arrival, about one hour after the accident occurred, he found that the water-column connections on the exploded boiler were open and the blowoff valve was closed just as they should be.

My theory of the accident is that a large quantity of scale was precipitated from the shell and tubes of the boiler and settled on the lower sheet over the fire, which allowed the sheet to become overheated sufficiently to start the initial rupture. Some seem to think that the explosion was a case of no water, but the damage to the boiler was too great for me to think that there was not plenty of water in it at the time.

Water Works Association Convention

About five hundred delegates and guests attended the thirty-first annual convention of the American Water Works Association at Rochester, N. Y., June 6 to 9. At 10 o'clock on Tuesday morning, Mayor Edgarton gave a cordial welcome to the association in the banquet hall of the Powers hotel, to which John W. Alvord, president of the association, responded.

Some seventy manufacturers of waterworks appliances were represented with exhibits which covered stands and lined the corridor and sample rooms. After the routine business was despatched, the presentation of papers relating directly to water works was begun.

Pumping-station Management

Thomas McMillan read a paper on pumping-station management in which he traced the history of the Milwaukee, Wis., water works from 1872 down to the present, giving short descriptions of the additions made from time to time, coupled with statements of the cost of operation for each ten-year period. The methods followed in the purchase and handling of coal were minutely described, as were also the boilers and the details of their operation. He described the special arrangements in steam and water piping for facilitating repairs, feeding the boilers and for increasing the temperature of the feed water, the cost of the installation and the operation of the oiling system, the auxiliaries and appliances for making and handling repairs and the general manner in which the operating force was managed in the apportioning and arrangement of the work.

Panama Canal

Tuesday evening, Dabney H. Maury, one of the engineers appointed by President Taft from the American Engineering Society to make an investigation of conditions at the Panama canal, gave an illustrated lecture in which he spoke especially of the economy which is being practised in building the canal and of the sanitation methods instituted to make conditions such that the men employed are better fitted to work. He said that the canal will be finished much sooner than expected. On June 1, 1913, it will be practically complete, and on that date vessels of 20-foot draft will be able to pass through. These vessels will thoroughly test out the canal until January 1, 1915, when the formal opening to all vessels will be made.

Emergency Intakes

W. P. Mason, speaking on the above subject, said that when the water supply of a municipality is changed it is the common practice to allow the old connections to remain as an emergency supply. Such practice may reduce insurance rates, but it increases typhoid risks, and the question becomes, which is better to lose, a house by fire or a life from fever?

Numerous instances were cited where the use of an emergency intake in the case of fire was followed by an epidemic of typhoid because of the polluted water which was pumped into the regular water mains.

Steel and Cast-iron Water Pipes

This topic was discussed by Allen Hazen. When large steel plates became available their fitness for use in the manufacture of high-pressure water mains was investigated. Steel pipe 30 inches in diameter costs about two-thirds as much as cast-iron pipe of equal strength and is believed to be in most places equally lasting, while because it is malleable it is much more reliable in trenches where bending and deformation from settling or shifting are liable to occur.

With the hundreds of miles of steel pipe in service there is no record of a destructive failure, while a break in cast pipe is invariably destructive and the flow continues until the reservoir is empty or the water is shut off. Steel pipe has not been standardized, but the earlier installations were designed by able men who established good precedents.

Surrounding steel pipe with concrete adds to its stability and durability and increases its cost, but not to the extent that will equal cast iron.

Fire-line Meters

In this paper, by George Housted, attention is called to the fact that many if not all of the insurance companies object to all types of water meters except one in fire lines on the ground that they catch trash.

Question was raised as to whether the particular meter named was not also a trash catcher in that it allowed debris to pass into the branches of a sprinkler system and choke the smaller pipes.

It was suggested that with the current type of meter on a sprinkler system any matter that would choke the smaller pipes would be caught by the meter, and even though it stopped the rotation of the propeller blades it would still allow enough water to pass to extinguish an incipient fire, while with the favored meter the matter that would choke the sprinklers would pass the meter only to stop the flow where it was most needed. Citation was made of a specific case in which there was no meter in the line and the pipe leading to a single room was choked as soon as a few sprinklers opened, causing a property loss of about $40,000.

Hot-water Troubles

George C. Whipple read a paper on the troubles that come from rusty hot water, due to the corrosion of iron and steel service pipes, tanks and boilers. The list of natural waters which cause corrosion included nearly if not quite all not distinctly alkaline. No one remedy is suitable in all cases, but, where practicable, lime or soda ash and the use of appropriate materials in pipes and heaters is advised.

The Purification of Drinking Water

The above was the subject of a paper by John L. Leal. As about 70 per cent. of the weight of the human body is water the importance of wholesome water is evident. It should not contain either organic or inorganic matter enough to interfere with its inherent properties, nor should it carry specific germs of disease.

Rain water, when it reaches the earth, is already fouled by impurities taken from the air, and in soaking into the ground is still further polluted by bacteria and soluble matter in the upper layers of soil. Filtration, which purifies it to some degree, takes place as it passes through the pervious soil to some impenetrable stratum along which it flows until it reaches its lowest level, where it is held or finds its way to the surface at some point below the ground level. Such water is usually of a high degree of purity, though due to a loose, shallow soil and crevices, springs which are fed by what is practically surface water may supply water impregnated with typhoid germs.

Sedimentation, said [illegible], mechanical filtration with coagulation, aeration and sterilization or disinfection have all been successfully adopted as means of water purification.

Sedimentation is an old method practised in ancient Babylon and Egypt. Sand filtration dates from 1829. In mechanical filtration and coagulation, the water is usually first treated with sulphate of alumina and then filtered through gravel and sand.

There are upward of 600 plants of this type in operation in the United States, and there seems to be little doubt that it is the most suitable practical system for water purification.

Oxonation has never been practically tested on a large scale, and sterilization has had only a limited application, the first time it was ever used in a continuous process being at Boonton, N. J., in 1908. However, the sterilization process marks a great step in advance on account of cheapness, simplicity, efficiency and certainty.

Wisconsin N. A. S. E. Convention

Eleven years ago Milwaukee was the scene of the national convention of the National Association of Stationary Engineers. During those eleven years there has been wonderful progress in the growth of the organization and it was freely said by those who had attended the national meeting that the late State meeting held there June 8, 9 and 10 was larger and better in many ways.

H. J. Mistele, chairman of the local committee, presided at the opening exercises and introduced Mayor Emil Seidel, who delivered the address of welcome. The response was by State President A. A. Schroeder, of La Crosse, following which Fred W. Raven, national secretary, spoke on the "National Association of Stationary Engineers."

E. P. Gould, secretary of the Central States Exhibitors' Association, was also called on for a few remarks regarding the business end of convention work, and R. D. Tomlinson, of the Allis-Chalmers Company, who is a past national president of the organization, gave a short address.

Educational work was prominent during the convention. John W. Lane, editor of the *National Engineer,* in an address on the subject, gave many valuable suggestions for increasing the value of this department to the organization.

"Heat and Ventilation" was the subject of a lecture by B. J. Miller, of Milwaukee, some of the fundamental principles of this subject being taken up and explained in detail. Another lecture, that on the "Nonreturn Stop Valve," by E. P. Gould, of Chicago, contained a clear and concise statement of what this important piece of equipment should be and of some of the defects which are commonly found in its operation.

On Friday afternoon a visit was made to the plant of the Richardson-Phenix Company. The smoker given by the Central States Exhibitors' Association in the main dining room of the Plankington house on Saturday night was presided over by Royal D. Tomlinson, and proved a great success in promoting good fellowship and good cheer between the engineers and the supplymen.

On Sunday morning a baseball game between the engineers and supplymen was the principal event of interest; the game was won by the former by a score of 12 to 3.

Officers for the ensuing year were elected as follows: William Classman, of Milwaukee, president; Henry Holst, of La Crosse, vice-president; Robert Fenn, of Sheboygan, secretary; John Murphy, of Madison, treasurer; H. Breitbach, of Stevens Point, conductor, and Dan Dreger, of Manitowoc, doorkeeper. The place of next meeting will be decided by the State officers.

The Wisconsin Delegation at State Convention

Exhibitors at the convention were as follows: Allis-Chalmers Company, American Steam Gauge and Valve Manufacturing Company, J. Andrae & Sons Company, V. D. Anderson Company, Chase Brothers Company, Crandall Packing Company, George B. Carpenter Company, G. M. Davis Regulator Company, Dearborn Drug and Chemical Works, Garlock Packing Company, Greene, Tweed & Co., Philip Gross Hardware Company, Hawk-Eye Compound Company, Hills McCanna Company, Hoyer Metallic Packing Company, Jenkins Brothers, H. W. Johns-Manville Company, Keystone Lubricating Company, Lunkenheimer Company, Lyons Boiler Works, Mechanical Appliance Company, Milwaukee Factory Supplies Company, Michigan Lubricator Company, *National Engineer,* Osborne High-Pressure Joint and Valve Company, Perfection Heater and Purifier Company, William Powell Company, Power, *Practical Engineer,* Richardson-Phenix Company, Scott Valve Company, Fred Sprinkman & Son, Steam Appliance Company, Swift Fuel Company, Vilter Manufacturing Company, Wadhams Oil Company, Western Iron Stores Company, Wickes Boiler Company.

Identification of Power House Piping

The committee of the American Society of Mechanical Engineers on the identification of power-house piping recently turned in the following report:

In the main engine rooms of plants which are well lighted, and where the functions of the exposed pipes are obvious, all pipes shall be painted to conform to the color scheme of the room; and if it is desirable to distinguish pipe systems, colors shall be used only on flanges and on valve-fitting flanges.

In all other parts of the plant, such as boiler house, basements, etc., all pipes (exclusive of valves, flanges and fittings), except the fire system, shall be painted black, or some other single, plain, durable, inexpensive color.

All fire lines (suction and discharge), including pipe lines, valve flanges and fittings, shall be painted red throughout.

The edges of all flanges, fittings or valve flanges on pipe lines larger than 4 inches inside diameter, and the entire fittings, valves and flanges on lines 4 inches inside diameter and smaller, shall be painted the following distinguishing colors:

DISTINGUISHING COLORS TO BE USED ON VALVES, FLANGES AND FITTINGS ONLY

Steam division	High pressure—white Exhaust steam—buff
Water division	Fresh water, low pressure—blue Fresh water, high pressure boiler feed lines blue and white Salt water piping—green
Oil division	Delivery and discharge—brass or bronze yellow
Pneumatic division	All pipes — gray
Gas division	City lighting service aluminum Gas engine service-black, red flanges
Fuel oil division	All piping—black
Refrigerating system	White and green stripes alternately on flanges and fittings, body of pipe black
Electric lines and feeders	Black and red stripes alternately on flanges and fittings, body of pipe being black